MARINE ECOLOGY AND FISHERIES IMPACT ASSESSMENT STUDY FOR THE PROPOSED OFFSHORE PRODUCTION RIGHT AND ENVIRONMENTAL AUTHORISATION APPLICATIONS FOR BLOCK 11B/12B

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Report prepared for:

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EXECUTIVE SUMMARY

Introduction

Anchor Environmental Consultants (Pty) Ltd (Anchor) was appointed by WSP Group Africa (Pty) Ltd to undertake a Marine Ecological and Fisheries Impact Assessment specialist study for an Environmental and Social Impact Assessments (ESIA) submission on behalf of TotalEnergies E&P South Africa B.V. (TEEPSA). This ESIA is for an Environmental Authorisation application required in terms of the Production Right application submitted to TEEPSA for the offshore Block 11B/12B Production Right Application Area (hereafter the Application Area). The Application Area is approximately 75 km offshore from Cape St Francis to the east and 120 km offshore from Mossel Bay to the west and extends over an area of 12 000 km^2 at depth of between 500 m and 2 300 m. The Block is divided into two areas of interest – a western Project Development Area, and the eastern Exploratory Priority Area.

The proposed project activities are divided into Construction, Production, Exploration, Closure and Survey phases.

Construction activities include the drilling of up to six development and appraisal wells and the installation of subsea infrastructure. The subsea production system (SPS) will be installed to collect gas and condensate at the wells located within the Project Development Area and a subsea pipeline will be installed to carry the gas and condensate to the existing F-A Platform for further processing. Given that the Project Development Area is approximately 109 km southeast of the existing F-A Platform, this facility will be used to process the gas and condensate flowing from the wells, following which the products will be exported onshore via the existing PetroSA pipelines. Exploration activities in the eastern Exploratory Priority Area include the drilling of up to four exploration wells, vertical seismic profiling (VSP), well logging and testing. Marine surveys (bathymetry and sonar surveys, seafloor sampling surveys and metocean surveys) are also proposed. Closure activities will commence at the end of the Production phase, with the decommissioning and removal of infrastructure in accordance with Good International Industry Practice. Survey activities include the deployment of buoys with instrumentation to measure metocean conditions. The data will serve to increase the understanding of the oceanographic and meteorological conditions in the Application Area.

This report serves as the Marine Impact Assessment of all proposed project activities throughout the lifespan on the project on the coastal and offshore marine environment of the South Coast. Ecological impacts are assessed alongside impacts on ecosystem services and resources (i.e., fishing) under both normal and unforeseen operating conditions (i.e., well blowout, pipeline rupture etc.).

Data sources

Much of the information on the receiving environment is sourced from previous specialist studies supporting various Environmental Authorisation (EA) applications for the Block 11B/12B Application Area, as well as the existing literature. A number of modelling studies (noise modelling, drill discharge modelling and oil spill modelling) were undertaken to inform an assessment of impacts on the marine environment. Below follows a summary of data sources, both desktop and in situ:

- While the assessment of the offshore infaunal benthic biodiversity on the Agulhas Bank is largely desktop based, some new preliminary in situ data was made available for this assessment. Data on benthic habitats and biodiversity are sourced from Sink *et al.* (2010), Atkinson (2010), Shipton & Atkinson (2010) and Quick & Sink (2005), and the Deep Secrets Offshore Research survey undertaken by the National Research Foundation and African Coelacanth Ecosystem Programme in 2016 (Sink *et al.* 2021). This data was supplemented by preliminary results of a benthic infaunal and epifaunal assessment of the Application Area and proposed pipeline servitude as part of a regional Environmental Baseline Study undertaken in 2022 (aboard the Bourbon Evolution 807). The wider regional campaign, undertaken from mid-November to mid-December 2022, included surveys conducted in the Application Area and a small portion of the adjacent Block 9. The Environmental Baseline Study aimed to document any pre-existing pollution and existing anthropogenic impacts within the Block, identify sensitive habitats or species susceptible to disturbance from drilling related activities; as well as establish an understanding of the natural variation in environmental conditions against which the environmental impact of future oil and gas operations can be assessed.

- Spatial data sources include the National Framework on Marine Spatial Planning in South Africa, the Marine Spatial Planning Act, 2018 (Act No. 16 of 2018), the National Biodiversity Assessment (NBA) (2018) specifically regarding provincial spatial biodiversity plans for Critical Biodiversity Areas and Ecological Support Areas as well as SANBI's Biodiversity GIS (BGIS) data layers. A marine threat layer (Sink *et al.* 2019) that incorporates current pressures, habitat types, ecological sensitivity and current status was used to indicate the threat status of ecosystems, and specifically the degree to which ecosystems are still intact or losing vital aspects of their structure, function, or composition.

- The Department of Fisheries, Forestry, and the Environment (DFFE) has spatially referenced up-to-date data on catch and effort for most commercial fisheries in South Africa. This fisheries data was acquired through a PAIA (Promotion of Access to Information Act) submitted by Anchor.

- Data on the impacts of the noise generated by the proposed project activities (and in particular, drilling and sonar surveys) on various marine groups (marine mammals, fish, turtles, diving birds) was generated by an underwater noise modelling study. These results were used to inform the assessment of underwater noise impacts due to drilling and exploration (Vertical Seismic Profiling and sonar surveys).

- Impacts of the discharge of drill cuttings and water-based muds resulting from the proposed drilling activities were modelled for drilling in both the western Project Development Area, and the eastern Exploratory Priority Area. The impacts of the introduction of drill cuttings and muds on both sediment and water quality, oxygen levels, deposition of particle matter on the sea floor and changes in sediment grain structure were assessed.

- Oil spill modelling based on predetermined loss of containment scenarios associated with oil and gas well and subsea production system operations was undertaken for gas and condensate spills in the western Project Development Area, and for crude oil spills in the eastern Exploratory Priority Area. For the western area, two modelling scenarios were analysed across four seasons: 1) a Block 11B/12B blowout at the wellhead, and 2) full pipeline rupture of condensate in the middle of the Critical Biodiversity Area. For the eastern wells, four scenarios for two eastern pseudo-sites were modelled for the four quarters of the year. These results were used to inform the assessment of the impacts of an unforeseen event (well blowout/pipeline rupture, and the resulting oil spill) on the marine ecological systems and beneficial users of the environment (fishing, protected areas etc.).

Legislative context

The key South African legislation that is applicable to the environmental impacts of the proposed production and exploratory activities are presented in the report. These acts and their related regulations govern the legal requirements, the application processes to be followed and stipulate where exploration activities may or may not occur. Relevant international conventions and treaties regarding the prevention or management of marine pollution which have been ratified by the South African Government and which have become law through promulgation of national legislation are also defined in the report. This assessment was undertaken in line with international best practice IFC Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts) and IFC Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources).

Affected environment

The dominant oceanographic feature of the Application Area is the warm, southward flowing Agulhas current. Block 11B/12B falls within the warm temperate south coast, a region characterised by high diversity, with components of both the cool temperate and subtropical marine faunas, as well as high levels of endemism (species with distributions restricted to the bioregion). According to the most recent biogeographic divisions, the Application Area falls into within the Southwestern Indian Ecoregion and the Southwestern Indian upper and lower bathyal ecozones. Communities within this marine habitat are ubiquitous throughout the southern African South Coast region, being particular only to substrate type or depth zone. The biological communities occurring in the Application Area consist of many hundreds of species, often displaying considerable temporal and spatial variability.

The benthic habitat types within the Application Area and both proposed pipeline routes include (from south to north) Southwest Indian Lower Slopes, Southwest Indian Mid Slope, Southwest Indian Upper Slope, with intersection with Agulhas Rocky Shelf Edge, Eastern Agulhas Outer Shelf Mosaic and Agulhas Blues in the vicinity of both pipeline routing options. This means that most of the Application Area is a mosaic of both rocky reef and areas with sparse sediment cover, with the northern area characterised by hard sediment, meaning that a narrow layer of unconsolidated sand sits atop a denser clay layer. The area beyond the 1 000 m depth comprises of unconsolidated sediments, and along the eastern half of the South Coast, the seabed is predominantly rocky reefs. Most of the Application Area is classified as "Southwest Indian Unclassified Slopes", rocky area in the north-western side of the Production Right Application Area ("Agulhas Rocky Shelf Edge") and along both proposed pipeline routing options ("Agulhas Mosaic shelves"). In situ validation of these habitat types was undertaken as part of the 2022 Bourbon Evolution 807 benthic epifaunal assessment of the Application Area.

The diverse seabed habitats on the Agulhas Bank within the Application Area support diverse benthic invertebrate communities. Benthic habitats type directly affects community composition. There were 412 macrofauna taxa recorded as part of the 2022 environmental survey campaign of the Block 11B/12B and pipeline servitudes. The majority of these were annelid (segmented and unsegmented worms) species (52.3% of the total individuals), followed by arthropods (125 species, 32.2% of the total individuals), molluscs (53 species, 6.7% of the total individuals) and echinoderms (32 species, 3.0% of the total individuals).

More species were recorded at sites in the upper shelf (<500 m) compared to sites deeper than 500 m, a pattern that has been reported from other offshore areas of the South African south coast. Indeed, differences in communities between the sites appear to be driven predominantly by depth, with 'community 'clusters' separating out according to the NBA (2018) sediment ecosystem types, with a transition from the continental shelf to bathyal zone across the survey area. These results demonstrate the importance of depth and environmental conditions to community structure and function and confirm the separation of South African benthic ecosystem types as delineated by Sink *et al.* (2019). A cautious interpretation of a Marine Biotic Index (AMBI) showed that 'disturbance sensitive species' were the dominant group in the Sandy Outer Shelf (59%), Hard Outer Shelf (54%), Hard Shelf Edge (46%) and Southwest Indian Lower Bathyal (37%) ecosystem types.

In contrast, the Sandy Shelf Edge was dominated by 'disturbance indifferent species' (62.60%), although this result is somewhat skewed by the very high abundance of one annelid species *Diopatra papillosa*.

Both existing data and preliminary ROV results from the 2022 Bourbon Evolution 807 campaign survey show high benthic epifaunal and mobile biota diversity across both Block 11B/12B, and Block 9 (for the pipeline routing), with 357 taxa reported from 11 phyla reported by the 2022 environmental survey campaign. The high diversity in both Blocks can be attributed to the numerous substrate types (unconsolidated sediments, soft and hard clay, nodules and cobbles to dispersed boulders, small coral outcrops to dense coral reefs/fields) observed over depths ranging from relatively shallow waters on the continental shelf (lowest average depth 117 m) to deep waters off the shelf (maximum average depth ~1 800 m). The preliminary results of the number of epifaunal taxa across Block 11B/12B show that the diversity of taxa is highest on the west and particularly the south-west corner, dropping in the middle of the Block and then increasing again (although not as high) to the east of the Production Right Application Area.

The substantial shelf areas of the Agulhas Bank support rich, deep-water communities of filter-feeding corals and sponges. Of particular interest in this area are the extensive reef framework–forming cold-water corals. Arguably the most three dimensionally complex habitats in the deep ocean, these reefs provide niches for many species, including commercially important fish species, with diversity that may be comparable to tropical reef systems. These corals are long-lived (hundreds of years old) and can form large reef frameworks that persist for millennia. In recognition of these habitats, the 2018 NBA denotes the Kingklip Corals' Ecologically or Biologically Significant Marine Area (EBSA) to the north of the Concession Area as a Vulnerable Marine Ecosystem (VME), as defined by Atkinson & Sink (2018). This area was specifically highlighted for the high number of VME indicator species on rocky substrate at 150-800 m depth. Species of importance observed in Block 11B/12B and Block 9, highlighted by Atkinson & Sink (2018) as potential indicators of VMEs, and recorded during the 2022 ROV campaign, include the reef-building cold water coral *Lophelia pertusa*, right angle corals Dendrophylliidae: *Cladopsammia* and *Eguchipsammia* sp., zigzag corals *Enallopsammia rostrata*, bottle brush sea fan Primnoidae, *Thouarella* sp., sabre bryozoan *Adeonella* sp., and the honeycomb false lace coral *Phidoloporidae* sp. These VME indicator species were found across the Block 11B/12B Production Right Application Area and both pipeline routing corridors. Preliminary results of the benthic ROV survey results suggest a hotspot of VME indicator species at sites in the south-east west of the Block. VME indicator species were found at sites that which fall within both the proposed Basecase and Option pipeline routes. The area of proposed production drilling at the western Project Development Area discovery falls within the Southwest Indian Mid Slope benthic habitat and VME indicator species were only observed in one of the five ROV transects undertaken in this habitat type. No VME indicator species were observed in the transect undertaken closest to the western Project Development Area discovery site.

The South Coast ichthyofauna community is comprised of both temperate and tropical species because the region forms the transition zone between the warm south flowing Agulhas current and the cool upwelling Benguela Current System on the West Coast. This results in a productive system and diverse fish community which is supported by the species-rich benthic habitat present in the area. The area of the Agulhas Bank east of Cape Agulhas between the shelf-edge upwelling and the cold-water ridge (where copepod availability is highest) is a spawning ground for many commercial important fish stocks, including sardines, round herring and the demersal Cape hakes. The nursery grounds for these hake species are located off the west coast, and fish move southwards onto the Agulhas Bank as they grow, with juveniles of both species occupying shallower waters than the adults. Kingklip spawn off the shelf edge to the south of St Francis and Algoa Bay, on the eastern edge of the Application Area, while squid spawn principally in the inshore waters (<50 m) between Knysna and Gqeberha, with larvae and juveniles spreading westwards. Commercially important linefish species that migrate and spawn along the South Coast include elf, geelbek, yellowtail, kob, seventy-four, strepie, and

Cape stumpnose. The inshore region of the Agulhas Bank is an important nursery area for linefish species such as elf leervis or Garrick, geelbek and carpenter. The large migratory pelagic fish species most likely to occur offshore, and in the Application Area include various tunas, billfish and sharks, many of which are International Union for Conservation of Nature (IUCN) listed species. Populations of migratory pelagic species are facing declines on a global scale because their biology, behaviour and migratory nature make them particularly vulnerable to threats throughout their life history, with knock effects on ecosystem function.

Turtle species that could be encountered in the Application Area include the loggerhead turtle *Caretta caretta*, the leatherback turtle *Dermochelys coriacea* and the green turtle *Chelonia mydas* (these three species of turtle that breed in South African waters), along with visiting olive ridley turtle *Lepidochelys olivacia* and the Hawksbill turtle *Eretmochelys imbricata*. Leatherbacks in particular tend to move south with the Agulhas Current to forage in deeper waters offshore, with some individuals following the Benguela Current along the west coast of South Africa.

Some 60 seabird species have been recorded or are considered likely to occur on the south coast of South Africa. These include resident species that breed along the coast (including the African penguin *Spheniscus demersus* and Cape gannet *Morus capensis,* both of which are listed as Endangered by the IUCN), migratory species that visit the coast to overwinter, breed and feed (like Damara tern *Sternula balaenarum*), as well as rare vagrants, which are species that stray outside their expected breeding, wintering or migrating range. There are African penguin colonies along the South Coast at Dyer Island, east of Cape Agulhas, Cape Recife, and on the islands in Algoa Bay (St Croix Island, Jaheel Island, Bird Island, Seal Island, Stag Island and Brenton Rocks), with a new colony established in the De Hoop Reserve east of Cape Agulhas.

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Southern Benguela and Agulhas Bank. Most of the species in the region reach highest densities offshore of the shelf break (200-500 m depth), with highest population levels during their non-breeding season (winter). During Marine Mammal Observer (MMO) surveys within Block 11B/12B from 28 November 2022 to 9 December 2022, a total of 14 bird species (1 384 seabird individuals) were counted. The most abundant of which included Cory's shearwater, the Endangered Cape gannet, the Vulnerable white-chinned petrel and the great-winged petrel.

Based on historic sightings or strandings records, as well as habitat projections of known species parameters, an estimated 35 species of cetaceans (whales and dolphins) are thought to occur (or are likely to occur) in the waters of the South Coast. One resident species of coastal pinniped is present (the Cape fur seal), while vagrant records include southern elephant seal, subantarctic fur seal, crabeater seal and leopard seal. Based on occurrence probability data and MMO observations, the species most likely to occur in the Block include humpback whales in the summer (slightly less so in the winter), sperm whales year around, killer whales, Risso's dolphin, striped dolphin, long-beaked common dolphin, common bottlenose dolphin, pilot whale, False killer whale and Sei whales (Endangered). While Southern right whales are the most abundant baleen whales off the coast of South Africa, they have not been recorded in the Block during the 2019-2020, or 2022 MMO surveys.

The coastal environment is an important breeding area for several seabirds (for example, a number of highly important African penguin colonies, and the bulk of the South African population of the Damara Tern breeds between the Sundays River and Woody Cape). The South Coast is also host to a number of estuaries, highly productive systems that offer rich feeding grounds, warmer temperatures and sheltered habitat for many organisms. The high productivity is exploited by many line-fish and harvested invertebrate species either as a nursery or later in life either directly through habitat availability or indirectly through the contribution to overall coastal productivity. The contribution of the estuarine nursery function has been estimated as R960 million in 2018 terms (equivalent to over R1 billion in 2020) to the South African economy. There are 46 estuarine systems along the South Coast coastline between Cape Agulhas and Gqeberha, of which 23 are classed as Natural or Near Natural, three are listed as Endangered and 20 others are listed as Vulnerable. The Heuningnes estuary has been proclaimed as a Ramsar Site, while 13 fall within National Parks and four others are protected within local or provincial nature reserves. The Knysna Estuary is one of only three large, permanently-open estuarine bays along the South African coastline and considered to be the most ecologically significant estuary in South Africa, representing 42.8 % of all estuarine biodiversity.

Red listed species

As per the International Union for Conservation of Nature (IUCN) Red listing, leatherback and loggerhead **turtles** are both described as Vulnerable, and the green turtle is Endangered on a global scale. As a signatory of Convention on Migratory Species (CMS), South Africa, as a nation, is therefore committed to the protection of all species of sea turtles occupying its national waters, whether they are non-resident nesters (loggerhead and leatherback turtles) or resident foragers (green turtles). The NEM:BA Threatened or Protected Species Regulations (2007) list leatherback *Dermochelys coriacea* and loggerhead *Caretta caretta* turtles as Critically Endangered Species and the green turtle *Chelonia mydas* as Endangered.

Numerous **seabird** species have shown a steady deterioration in status around the world and South Africa, reflected in the upgrading of some species to the IUCN Endangered list (2023), including the African penguin (upgraded from Vulnerable to Endangered in 2010), the Cape Gannet (upgraded from Vulnerable to Endangered in 2010), and the Cape Cormorant (upgraded from Near Threatened to Endangered in 2013). These declines have not been equal across space in South Africa, with the bulk of declines occurring at West Coast colonies. The Eastern Cape African penguin population (specifically Algoa Bay) has become increasingly important in terms of its relative contribution to the global population. In a similar way, >70% of all Cape Gannets (i.e., the global population) now nests at Bird Island/Algoa Bay, at the eastern extremity of their breeding distribution. Other IUCN listed seabird species have been observed in the Application Area include the Shy albatross (Near Threatened), the Endangered Indian yellow-nosed albatross and Atlantic yellow-nosed albatross, the Vulnerable Spectacled petrel and Leach's storm petrel.

Of the 35 **cetacean** species listed as present/likely to occur in South Coast waters, the blue whale is listed as Critically Endangered, the sei whale and Indian Ocean humpback dolphin are considered Endangered, while fin, Bryde's (inshore), Humpback (B2 population) and sperm whales are considered Vulnerable. Although listed as Near Threatened in the IUCN Red Data book, the Indo-Pacific bottlenose dolphin is listed as Vulnerable in the South African Red Data Book, while the migratory subpopulation is considered Endangered.

Many of the **large pelagic fish** species likely to be encountered are considered threatened by the IUCN, primarily due to overfishing. Tuna and swordfish are targeted by high seas fishing fleets and illegal overfishing has severely damaged the stocks of many of these species. Globally, the Southern bluefin tuna is considered Endangered, while bigeye tuna and blue marlin are Vulnerable and Striped marlin is Near Threatened. Of the eleven **shark** species likely to occur in the Block 11B/12B Production Right Application Area, five are listed as Endangered by the IUCN Red List (the pelagic thresher shark, dusky shark and whale shark as well as the shortfin and longfin mako shark), while the great hammerhead shark and oceanic whitetip shark are listed as Critically Endangered (IUCN 2023). The great white shark *C. carcharias* is a significant apex predator in the Algoa Bay area, and while listed as Vulnerable by the IUCN (2023), it is species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II as a species in which trade must be controlled in order to avoid utilization incompatible with their survival and has been a Protected species in South Africa since 1991 (Pisces 2019). The bronze whaler shark is also listed as Vulnerable by the IUCN (2023).

Fisheries

The productive system and diverse South Coast fish community supports a diversity of commercial, recreational and substance fisheries. The large pelagic longline sector has the greatest spatial overlap with the Application Area and pipeline routing area, with a small overlap with offshore demersal trawl fishery and the Chokka squid fishery effort to the north and northeast of the Block, respectively. A brief overview of these fisheries follows below:

- The pelagic longline fishery targets large, predatory, highly mobile fish including bigeye tuna, yellowfin tuna, southern bluefin tuna and swordfish. The main *bycatch* species are albacore tuna, blue shark shortfin mako shark. Sixty new large pelagic longline fishing rights were allocated in 2017, for a period of 15 years, with 34 domestic South African registered vessels and three chartered (foreign) vessels. This fishery is distributed nationally, with many vessels reported to fish near the edge of or on the continental shelf.

- The deep-sea sectors of the South African hake demersal trawl fishery targets the Cape hakes *Merluccius capensis* and *M. paradoxus*. Valuable bycatch of the trawl fisheries include monkfish, kingklip, panga and snoek. The deep-sea trawl fishery is active between Namibia and East London, but the majority of fishing effort is focussed on the west coast of South Africa. The deep-sea trawl sector takes around 88% of the hake catch, with total catches over recent decades fluctuating around 150 000 tonnes per year. In 2005, 15-year rights were allocated to 52 rights holders in the hake deep-sea trawl sector, consolidated to 30 operational rights holders (the latest rights allocation took place in 2021, but these have not yet been finalised). The hake deep-sea trawl industry employs approximately 12 400 South Africans and contributes more than half of the total value of all commercial fisheries. In 2018, the TAC of ~112 000 tonnes had a landed catch value estimated at USD 280 million (assuming a 50:50 split in small: large hake with small hake selling at USD 2.5/kg and large hake at USD 2.9/kg).

- The commercial squid jig fishery is concentrated in inshore Eastern Cape Waters between Plettenberg Bay and Gqeberha where the squid breeding aggregations occur. The fishery currently comprises 109 rights holders, 136 vessels and 2422 crew. Since 2010, an average of 530 individual fishing trips per year have been undertaken within the north-east border of 11B/12B Production Right Application Area, amounting to 111 fishing hours (average per annum) and yielding 218 tonnes of squid catch (average per annum). This is equivalent to 2.4 % of the overall total squid fishing effort and 2.91% of overall squid catch landed by the sector.

- Mariculture species farmed in South Africa include dusky kob, abalone, Pacific oysters, Mediterranean mussels and black mussels, among others. South Africa's aquaculture sector is relatively small, contributing about 0.8% to the country's fish production, accounting for less than 0.2% of the national GDP. South Africa is, however, one of the largest producers and exporters of abalone *Haliotis midae*. The country produces about 1 700 tonnes of abalone per year. Globally, abalone are one of the most expensive seafood products, with high demand specifically in the Asian countries because of the cultural, traditional, and medicinal qualities associated with abalone. In South Africa, the abalone industry has experienced rapid growth and development, and today is considered one of the most important and valuable species to the South African aquaculture industry. Eighteen abalone farms were identified in 2015, 12 of which are land-based facilities with independent hatcheries Three farms were registered as ranching operations. There are four farms in the Northern Cape, twelve farms in the Western Cape and two farms in the Eastern Cape. Together these operations produced an estimated farm gate value of US$ 42.3 million. There is no spatial overlap with proposed offshore infrastructure or routine production activities and any mariculture activities.

The south coast area in closest proximity to the Application Area has several recognised small-scale fishing communities. These communities comprise estuarine fishers (42%) and marine fishers (58%) which target a range of intertidal invertebrates (marine and estuarine) and fish (undefined). There is no anticipated overlap with the Application Area and small-scale fishers operating close to the shore. There may however be a handful of small-scale rights holders that operate further from shore, accessing offshore fishing grounds either through cooperative means or as crew on existing commercial linefish or squid fishing vessels. There may therefore be some overlap between the area of operation of these fishers and the Application Area. These fishers are expected to access mostly linefish and squid resources. In November 2019 and March 2020, the DFFE granted 15-year small-scale fishing rights to 73 small-scale fishing co-operatives in the Eastern Cape. The basket of species granted to these fishers included squid, hake hand line, traditional linefish, seaweed, South Coast Rock Lobster and abalone ranching. The majority of species applied for were linefish species, some of which required use of a vessel. Small-scale fisheries were allocated 15% of the squid catch in 2021, while in 2023, small scale allocation for hake handline was 2 081 tons (1.5% of the total TAC). There is no specific small-scale allocation for South Coast Rock Lobster (2022), with 359 tons and 2 525 Sea Days allocated across the whole fleet. While spatial activity and catch data for these fishers is lacking, and the outcomes of the right allocation appeals process are also currently not known, it is likely that Block 11B/12B activities will overlap with existing spatial footprints for these resources, given that fisheries, both "traditionally commercial" and small-scale, are likely to operate where the resource is present. Given that the TAC for these small-scale offshore fisheries operations will come from the existing commercial sector, the overlap with the Application Area is considered to be suitably captured in the commercial linefishing and squid assessments, with impacts proportional to the proportion of TAC allocated to the small-scale sector in question:

- Small scale allocation for hake handline in 2023 allocation was 2 081 tons (1.5% of the total TAC). There is no overlap between the Production Right Application Area and commercial line fishing effort (which includes hake handline). Thus, it is unlikely that there will be any overlap with the offshore small-scale line fishery.
- There is an overlap of 2.4% of the overall total squid fishing effort and 2.91% of overall squid catch landed with the Application Area. If 15% of the squid TAC is allocated to the small-scale sector, and impacts are assumed to be directly proportional, this equates to an overlap of 0.44% of the squid catch landed by the small-scale fisheries.

Spatial constraints and management

The habitat threat status (as per the 2018 NBA) of most the ecosystem types within the Application Area and proposed pipeline routing is Least Concern. The Agulhas Blues habitat to the northwest is considered Near Threatened and the Agulhas Coarse Sediment Shelf Edge is Vulnerable. The Kingklip Ridge habitat type to the northeast falls within the Port Elizabeth Corals Marine Protected Area and is considered Endangered.

Offshore Marine Protected Areas (MPAs) near Block 11B/12B include the Southwest Indian Seamounts MPA (Notice No. 42478) to the southwest of Block, and the Port Elizabeth Corals MPA (Notice No. 42478) to the northeast. There is no overlap of the proposed production area or pipeline corridor with any offshore MPAs. There are also several MPAs closer to shore to the north of the Application Area that are of particular importance for the protection of over exploited, endemic seabream fish species and a nursery ground for a number of commercially important species. These include the Tsitsikamma MPA, Sardinia Bay MPA, Robberg MPA (also host to a Cape fur seal breeding colony), Goukamma MPA (an important breeding area for the African black oystercatcher and host to a rare Near Natural estuary), the De Hoop MPA (an important site for southern right whales which arrive from the south in May and June to give birth to their calves, the Endangered Indian Ocean humpback dolphin and the Vulnerable smooth hammerhead *Sphyrna zygaena*), and the Addo Elephant National Park Marine Protected Area (which also protects breeding and important feeding grounds of the Endangered African penguin and Cape gannet).

The principal objective of Ecologically or Biologically Significant Marine Areas (EBSAs), as defined by the Convention on Biological Diversity (CBD), is the identification of features of higher ecological value that may require enhanced conservation and management measures. The northern border of the Application Area falls alongside the full extent of the 'Kingklip Corals' EBSA, and the Block lies just to the northeast of the Shackleton Seamount Complex EBSA. While the base case route for the pipeline is located approximately 16 km from the Kingklip Corals EBS, the proposed alternative pipeline route passes through the southwestern corner of the Kingklip Corals EBSA.

A Critical Biodiversity Area (CBA) assessment presents a spatial plan for the natural environment, designed to inform planning and decision-making in support of sustainable development, and CBA maps are developed using the principles of systematic biodiversity planning. Both proposed pipeline routing options pass through a CBA, specifically a CBA Natural area (a Biodiversity Conservation Area, as per the Proposed Approach to Spatial Development and Management for South Africa's Marine Planning Areas 2019 and the Draft Marine Sector Plan for the Biodiversity Sector 2023). While the delineated CBA areas stop at the borders of the Application Area, the preliminary in situ ROV campaign results suggests that the CBA areas should extend into the Block in the southwest corner, at minimum.

The IFC Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources) defines "critical habitat" as habitat (both natural and modified) of high biodiversity value that includes areas required for the survival of critically endangered or endangered species (as defined by the IUCN Red List of Threatened Species or as defined in any national legislation), areas having special significance for endemic or restricted-range species, sites that are critical for the survival of migratory species, areas supporting globally significant concentrations or numbers of individuals of congregatory species, areas with unique assemblages of species or which are associated with key evolutionary processes or provide key ecosystem services, and areas having biodiversity of significant social, economic or cultural importance to local communities. Based on these criteria and applicable thresholds, both benthic and pelagic habitat of the Application Area Block is deemed Critical Habitat. In addition, the Application Area, as well as the pipeline corridors outside of the CBA Natural areas, are delineated as Natural Habitat.

Ramsar sites along the coast in the vicinity of the Application Area include De Hoop (~160 km from Block 11B/12B, ~130 km from the proposed pipe routing), De Mond (~220 km from Block 11B/12B, ~200 km from the proposed pipe routing), and Wilderness Lakes (~130 km from Block 11B/12B, ~106 km from the proposed pipe routing). These Ramsar sites are important wintering, staging and feeding areas for several species of breeding birds and locally migrant waterbirds.

The Impact Management zones of EBSAs and the CBAs and ESA areas are encouraged to be managed by place-based regulations, informed by the reasons for their classification. A range of sea-use activities and recommendations as to their permissibility subject to compatibility with different Critical Biodiversity Areas is defined by Harris *et al.* (2022), the Draft Marine Biodiversity Sector Plan (2023) and the Proposed Approach to Spatial Development and Management for South Africa's Marine Planning Areas (2019). Activities that were assessed as being compatible with the management objectives of CBAs and EBSAs are recommended to be permitted in those areas according to the existing rules and regulations for that activity; activities that are not compatible are recommended to be prohibited. In this case, the development of the subsea pipelines associated with oil and gas processes are considered **non-compatible** within the CBA Natural areas (i.e., Biodiversity Conservation Areas). The environmentally preferable option is to reroute the pipeline to avoid CBA areas. However, avoidance may not be feasible, because all routing options from the western Project Development Area within the Application Area to the existing F-A gas platform pass through a CBA area. There is provision made that, should significant mineral or petroleum resources be identified during prospecting/exploration within a CBA area, alternative CBAs and/or biodiversity offsets are to be identified to meet targets for the same biodiversity features that are found at the site. This provision would apply to the development of pipeline infrastructure critical to the production phase of this project.

It is critical to note that the **non-/restricted compatibility** of the activity in CBAs refers to the location of the biodiversity disturbance rather than the location of the petroleum resource. Therefore, while the likely direct impacts on the substrate as a result of pipeline construction are expected to be short-term, and of low impact (due to the sufficient adjacent habitat to allow for rapid recolonisation), operational impacts related to oil spills are considered of critical concern. As such, a comprehensive oil spill risk assessment has been undertaken, and a proactive and adaptive management plan must be implemented to manage and mitigate the potential risks.

Noise modelling and results

Anthropogenic noise in the marine environment can have both direct and indirect negative impacts on marine fauna, by causing direct physical injury to hearing or other organs, (including permanent or temporary threshold shifts), causing disturbance resulting in behavioural changes or displacement from important feeding, breeding or spawning areas, and through masking or interfering with other biologically important sounds (e.g. communication, echolocation, signals and sounds produced by predators or prey). The main adverse impacts of underwater sound on marine species can be broadly summarised as auditory injury (either permanent or temporary), and disturbance. The proposed activities in the Application Area are expected to result in mostly non-impulsive noise pollution of variable intensity and frequency.

An assessment of underwater noise impacts from the project was undertaken by WSP (2023a). Two scenarios were modelled: 1) a worst-case scenario, where an animal would be exposed to drilling noise for the entire 24 hours, and 2) an exposure to drilling noise of 30-minute period across 24-hours, assuming the likelihood that an animal would move away from the source of the noise. The study considered the effects at three sites (close to shore and far offshore in the western Project Development Area, and close to shore in the eastern Exploratory Priority Area). To assess the effect of anthropogenic sound on **marine mammals**, thresholds were defined for onset of temporary threshold shifts (i.e., temporary loss of hearing sensitivity, TTS), permanent threshold shifts (i.e., permanent loss of hearing sensitivity, PTS), and behavioural response in marine mammals due to both impulsive and non-impulsive noise sources, as well as injury criteria for impulsive sounds. The disturbance (behavioural response) threshold for all marine mammal species was set as 160 dB re 1 μPa (SPL_{rms}) for impulsive noise (e.g., VSP, sonar surveys) and 120 dB re 1 μPa (SPL_{rms}) for non-impulsive noise (e.g., drilling). The behavioural disturbance noise thresholds for **sea turtles** for both impulsive and non-impulsive sources was set at 175 dB re 1 μPa (SPL_{rms}), with sea turtle functional hearing is limited to frequencies below approximately 2 kHz. **Fish** with no swim bladder are less susceptible to injury from underwater noise exposure, although some injury may still result from exposure to sound pressure. Fish with swim bladders in which hearing both does and does not involve the swim bladder are both susceptible to injury although hearing, although the latter only detect particle motion, not sound pressure, while the former detect both. For fish, masking and behavioural effects are assessed qualitatively, in terms of relative risk (i.e., high, moderate, and low) at distances from a noise source (i.e., near, intermediate, and far). Sound exposure thresholds for **penguins** and other **diving birds** were based on recent studies that have examined the behavioural response of penguins to impulsive noise, and a conservative behavioural threshold of 120 dB re 1 μPa (SPL_{rms}) was applied for impulsive and non-impulsive noise. In applying this threshold, a frequency weighting was considered to reflect the hearing sensitivities of penguins and diving birds.

The model results indicate that the peak pressure levels generated by the drilling units are sufficient to cause permanent (permanent threshold shifts) and temporary direct physical injury (temporary threshold shifts) to hearing in marine mammals, and sea turtles, as well as death or injury to fish, depending on the proximity of the animal to the drilling source. Worst-case direct impacts are only likely to occur very close to the noise source, while behavioural impacts are expected further away.

Based on the worst-case 24-hour exposure noise modelling results for drilling, baleen whales (southern right whale *Eubalaena australis*, humpback whale *Megaptera novaeangliae*) and very high-frequency cetaceans (pygmy sperm whale *Kogia breviceps*, dwarf sperm whale *K. sima*) are likely to be impacted the most with temporary impacts modelled to occur at 9 km and 8.6 km respectively, and permanent injury thresholds predicted to occur at distances of about 250 m and 50 m respectively. The impacts on high frequency cetaceans (common dolphin *Delphinus delphis*, killer whale *Orcinus orca*, Atlantic bottlenose dolphin *Tursiops truncatus*, short-finned pilot whale *Globicephala macrorhynchus*) is much smaller, with temporary impacts at distances of less than 400 m, and permanent injury thresholds predicted to occur at distances of about 10 m. For turtles, permanent injury is predicted to occur at 10 m from the source of noise, while temporary impacts are expected within 330 m. Temporary effects (TTS) and permanent effects (PTS) are much smaller for the 30-minute exposure scenarios. The maximum 30-minute exposure TTS distance was modelled as 790 m for very high-frequency cetaceans, and 380 m for frequency cetaceans, while the maximum 30-minute exposure PTS distance was modelled as 20 m for low frequency cetaceans and very high-frequency cetaceans.

For fish with a swim bladder, drilling noise TTS impacts (i.e., a temporary loss of hearing sensitivity) is predicted to occur only very close to the drilling activity (within 160 m), and 30 m for a recoverable injury. The maximum thresholds of behavioural disturbance from the drilling source were shown to be 66 km for marine mammals in all hearing groups, 11.8 km for penguins / diving birds, and 10 m for turtles.

Based on the noise modelling results for Vertical Seismic Profiling (VSP) and sonar exploration activities, the maximum thresholds of behavioural disturbance from the source were shown to be 2 km for marine mammals in all hearing groups, 350 m for turtles, and 19.2 km for penguins / diving birds. Since four exploratory drill sites are proposed for the Project exploratory activity, and assuming only one well is drilled and assessed at a time, the maximum impacted area for behavioural disturbance at any point in time will equate to some 1 158 km^2 for penguins / diving birds. Model results show that cumulative impacts (for the estimated 250 pulses over a 24-hour period) had a greater extent of impact, with temporary damage occurring at up to 2.2 km for baleen whales and at 170 m for turtles, with permanent damage predicted at a distance of 200 m for baleen whales. For fish, cumulative impacts of 250 pulses over 24-hours predicted temporary damage to fish both with and without swim bladders at a distance of 370-400 m, and mortality and potential mortal injury of both fish, fish eggs and larvae at 10-30 m.

Drill discharge modelling and results

The proposal to drill up to six development and appraisal wells in the Project Development Area and the drilling of up to four exploration wells in the Exploratory Priority Area is expected to result in a discharge of drill cuttings and water-based muds. Water-based muds will be used in the initial stages of well drilling (riserless stage) and in the subsequent riser stage of drilling. Drilling muds are used to lubricate the drill bit and to maintain well pressure. Once complete, as much of the drill fluids as possible are recovered, and the reminder, along with the drill cuttings (to which some drill fluid inevitably remains adhered) and chemical additives of various compositions is disposed of, either onshore in authorised land fill sites or discharged at sea. Drilling materials can impact both water and sediment quality through the introduction of toxic compounds, decreased oxygen levels, deposition of particle matter on the sea floor and changes in sediment grain structure.

The DREAM (Dose-related Risk and Effects Assessment Model) model was used to assess deposition, spreading and potential environmental risk (and the associated Environmental Impact Factor (EIF) values) for the water column and the sediment caused by the planned drilling operations. Environmental risk is calculated on a number of factors, including Predicted No Effect Concentration (PNEC). For the Project Development Area, two discharge points (Discharge-4 and Discharge-5) were simulated across four seasons, at depths of approximately1 200 m, and 1 800 m respectively. As the exact locations of the wells to be drilled within the Exploratory Priority Area are as yet unknown (and still dependent on exploratory outcomes), two discharge points (Discharge -1 and Discharge-2) were simulated across four seasons (four base-case runs, and one optional run) at depths of approximately1 254 m, and 690 m respectively. Impacts on the upper water column, lower water column and sediment were assessed. Two types of discharges were simulated, namely the cuttings discharges at the start of the drilling process, which will be discharged directly at the sea floor, as well as the discharges from the drilling of the deeper portion of the well which will be released from the drilling rig 10 m below sea surface.

For the discharges in the Project Development Area, model results indicate that, for the upper water column (0-100 m depth), the discharge from the rig 10 meters below sea-surface sinks down to about 40 meters depth and dispersed by the predominant S/SW currents. In the lower water column (1 100-1 300 m depth for Discharge-4), the finer particle discharge from the drilled top-hole sections remains in suspension and is transported along the seabed with the ambient currents. For Discharge-5 however, the plume becomes "attached' to the benthos immediately after discharge, and the total extent of the plume is smaller than that of Discharge-4. The model results indicate that the primary environmental impacts of drill discharge and cuttings release in the upper water column are linked to the release of barium sulfate (i.e., barite) (PNEC of 0.115 mg/L), and to both barite and bentonite (PNEC of 0.170 mg/L) in the lower water column. Concentrations in the water-column are shown to spread rapidly and dilute with the currents. The maximum 'impact' occurred at Discharge-5 during spring (conservative estimated area of impact = 126 km^2) and lasted for two days. In the lower water column, the maximum 'impact' occurred at Discharge-4 during autumn (conservative estimated area of impact = 64 km^2) and lasted for 2.5 days. While Discharge-5 has a lower maximum 'impact' in the bottom waters, with an estimated area of impact of 44 km^2, the duration of the impact is longer, with worst-case conditions persisting for approximately five days across all seasons. Assuming one well is drilled at a time, no more than ~126 km^2 of water in the upper water column, and no more than 44 km^2 of bottom water column will experience elevated concentrations of barite and bentonite for more than 5 days at a time. Cumulatively, should all six production wells be drilled, the impact will last for a total of 30 days. Drill discharge modelling results show that, depending on the Well location, potential impacts can extend beyond the confines of the Application Area, with the worst-case upper water column impacts' intersecting with the Southwest Indian Seamounts Marine Protected Area to the southwest of Block 11B/12B. The area where cumulative environmental risks are expected within the modelled plume covers ~5-10% of the surface water area of the MPA, and ~2.5% of the bottom water area of the MPA.

The model results indicate that deposited material in the sediment will occur within a radius of 250-300 meters from the discharge point, with the thickest areas of deposition areas closest to the well. The primary environmental impacts of drill discharge and cuttings release on sediments is burial, and grain size change. Simulations shows that impact on the sediment caused by discharge from rig are negligible for all seasons. Impacts from top-hole discharge are also low, with the maximum area of impact estimated at 150 m^2. Assuming no simulation of sediment redistribution (i.e., a highly conservative estimate), results show that, at the end of 10-years, there will be a worst-case deposition of 30 mm thick in an area of ~5 000 m^2 around the drilling site, with a sediment deposition of 10-30 mm thick covering an area of ~2 500 m^2. PNEC for burial (6.5 mm) is predicted to cover an area of ~25 000-175 000 $m^{2,}$ depending on the drill site.

For the wells in the Exploratory Priority Area, model results indicate a significant risk in the water column as a result of riserless drilling (the initial stages of the drilling) occurs 8.5-9.5 km away and at depths of 1 200-1 300 m (depending on the season), following the deep-sea current to the west / south-west. The risk is predominantly linked the quantity of Barite to be used in the mud of the riserless sections. The worst-case EIF occurred in winter. A significant risk due to the discharge of the sections drilled with a riser extended 18-34 km away from the discharge point (in winter and autumn, respectively) toward south-west (at 0-100 m depth below sea surface). For Discharge-2, significant risk in the water column as a result of riserless drilling occurs up to 35 km away and at depths of 600-700 m (in winter), following the deep-sea current to the west / south-west, while in the spring, this plume extends 12 km west and 5.5 km south-east. The worst-case EIF occurred in spring. A significant risk due to the discharge of the sections drilled with a riser extends 10-24 km away from the discharge point (in winter and autumn, respectively) toward south-west (at 0-100 m depth below sea surface). For both wells, these risks are linked to the quantity of Barite to be used in the mud of the riserless sections, and due to the hydrochloric acid present in the Clayseal Plus to be used in the riser sections. For both Discharge-1 and Discharge-2, this risk, while significant, is intermittent, and limited scale (restricted to small patches around the drill site) and duration, persisting for 11.8-13.5 days and 4.2-15.9 days respectively (when EIF>0) and disappearing completely after operations end (in both cases, after 43 days). For Basecase drilling during summer, the maximum cumulative area of impact (i.e., PNEC > 5) for drilling at Discharge-1 was estimated as 19.75 km^2, and as 76.64 km^2 for Discharge-2. There is no overlap of the area of modelled impact with the Kingklip Corals EBSA for drilling during summer at either Discharge-1 or Discharge-2.

Modelled results show that, across all scenarios, oxygen depletion (i.e., anoxia risk) in the sediment is close to zero for both Discharge-1 and Discharge-2. Deposited material in the sediment is modelled to occur relatively close the discharge point for Discharge-1 (up to 225 m around the well in the spring) but extend further away for Discharge-2 (400 m to the west/south-west in autumn), with grain size change assessed to be the primary environmental impact. The impacts on the sediment caused by discharge from rig at the eastern wells are higher than that of the western wells (Discharge-4 and 5) across all seasons, with EIF > 1, and are higher overall for Discharge-2 (EIF = 2-6 for base case simulations, and 11 for extended drilling). The area of risk (where PNEC >5) for sediments is lower for Discharge-1 than Discharge-2, with an area of impact of 2 500-5 000 m^2 for the former, and 5 000-10 000m^2 for the latter (base case drilling). The extended drilling scenario results in a much larger area of impact of 27 500 m^2 for Discharge-2. For both eastern drill sites, model results show that sediment deposition occurs predominately around the drill site, with a worst-case (autumn) deposition within a 105-150 m radius around the discharge point (without smoothing) for an area of impact of 0.03-0.07 km^2 (unsmoothed) four years after the operations, after which there is no more environmental risk in the sediment).

Oil spill modelling and results

The greatest environmental threat from offshore drilling operations is the risk of unplanned hydrocarbon release in the form of a subsea blowout or subsurface pipe rupture. Any release of liquid hydrocarbons has the potential for direct, indirect and cumulative effects on marine fauna (and associated habitats) and the fishing industry in the offshore, nearshore and coastal environment. Spilled hydrocarbons move according to the prevailing weather conditions with the greatest possible impact realised if it makes landfall. Spilled hydrocarbons can have toxic and/or smothering effects on organisms in the path of a spill, with coastlines being particularly vulnerable. These effects include physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton (particularly copepods), pelagic eggs and fish larvae, and habitat loss or contamination. Spills can also have socio-economic implications if fisheries and coastal tourism (among others) are disrupted.

The quantification of this risk, through an assessment of the extent of potential spill and duration thereof from production activities in the Project Development Area, was undertaken by DHI (2023) using SATOCEAN input and the MIKE Oil Spill (OS) module from the MIKE suite. Two spill scenarios were considered: a deep-sea blowout at a capping stack, and a full rupture of a pipeline in the first year of operation. For each spill scenario, 400 simulations were selected and distributed across the modelling period (2012-2016) and across four seasons. For the Exploratory Priority Area wells, a crude oil spill of 69 000 barrels/day was modelled by H-Expertise Services S.A.S (HES 2020c, d) using the Oil Spill Contingency and Response (OSCAR) module from MEMW software (v11.0.1). A crude oil spill was considered at two sites that represent worst-case scenarios, considering depth (Discharge-1 and Discharge-2, located at 1 254 m and 690 m, respectively), distance from the coast (89 km and 98km from the nearest shore, respectively) and proximity to areas of sensitivity and significance. For each spill scenario, 90 simulations were selected and distributed across the modelling period (2012-2016) across four seasons. It should be noted that these modelling outputs are conservative predictions without the benefit of mitigation or response activities. In the modelling analyses discussed here, it has been presumed that no spill response has been applied either at the spill source or at distal locations. In the event of an oil spill, response procedures would reduce the volumes spilled and/or the oil dispersion and transport from the spill site.

Thresholds used for this study for surface oil thickness, the No Observed Effect Concentration (NOEC) for acute exposure to dispersed oil in the water-column, and shoreline oiling (defined based on existing literature and best practise) and were set as 5 µm for surface oil, 10 g/m^2 for shoreline oiling, and 58 ppb (0.058 mg/L).

Model results show that, over approximately four months (i.e., one season), evaporation is the most important weathering process for gas and condensate, as evaporation starts immediately after loss of containment. Indeed, most of the total gas and condensate released evaporates over the modelled time frame while biodegradation, sedimentation and photooxidation contribute less than 10% of the total mass balance of the oil spill.

Within the Project Development Area, a well blow out worst-case model result indicates that there is a 90% probability that a spill will extend 250-290 km from the rupture point to the southwest, depending on season, with a 1% chance that a spill will extend 490 km west for all seasons, and 750-950 km to the southwest, dependent on season. Indeed, these results show that for all seasons, a well blowout would result in oil reaching waters beyond the South African EEZ (i.e., international waters). Offshore, surface oil (>5 µm thick) is projected to intersect (>75% probability) with several EBSAs and MPAs, including almost the entirety of the Southwest Indian Seamounts MPA and large portions of the Shackleton Seamount Complex EBSA and the Mallory Escarpment and Trough EBSA to the southwest. In autumn and winter, the northwestern portion of the Southwest Indian Seamounts MPA is modelled to overlap with the >75% probability plume. In winter, there is also a large overlap with the Kingklip Corals EBSA to the northeast of the blowout site. The model results show that oil (>10 g/m^2) is expected to reach shore in 2-4 days in every season except summer (December-February, when no oil is expected to come ashore) The highest probability of oil-shoreline impact after a well blowout occurs in winter (Season 3, June-August), with >10 g/m^2 oil predicted to potentially impact some 64 km of shoreline. The maximum oil amount found on shore based on the worst-case scenario (deterministic simulation) is 1.2-2.8 tons, with a probability of 1.1-4.8%. The probability of oil reaching shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) is, however, very low (4.8% for the worst-case, and 1.3% across all seasons). Taking the full area into account, worst-case model results indicate that, in winter, there is a 1-5% probability that surface oil > 5 µm thick will overlap with the south-eastern corner of the Tsitsikamma MPA (an area of 109.1 km^2, or 36.6% of the MPA) and a 1%

probability that the surface oil will overlap with the southern half of the Robberg MPA (an area of 10.4 km^2, or 39.7% of the MPA).

In a pipeline rupture scenario, worst-case model results indicate that there is a 90% probability that a spill will extend 10 km from the rupture point all seasons, with a 1% chance that a spill will extend 490 km west for all seasons, and 145-230 km to the northeast, and 155-485 km to the southwest, dependent on season. Offshore, surface condensate (> 5 µm thick) is projected to intersect (30-40% probability) with the Kingklip Corals EBSA to the northeast of the 11B/12B Production Right Application Area. The model results show that condensate (>10 g/m^2) is expected to reach shore in 1-1.5 days in winter and spring. The highest probability of condensate-shoreline impact after a pipeline rupture also occurs in winter (Season 3, June-August), with oil >10 g/m^2 predicted to potentially impact some 20.5 km of shoreline in this season, and 35 km across all seasons. The probability of condensate reaching shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) is also very low for a pipe rupture (1.9% for the worst-case, and 0.75% across all seasons). The maximum condensate amount found on shore based on the worst-case scenario (deterministic simulation) is 0.5-1.3 tons. There is a 1% probability that the condensate may reach the Knysna Lagoon should a rupture occur in winter and spring. In winter and spring, worst-case model results indicate that there is a 1% probability that surface condensate >5 µm thick will overlap with the Tsitsikamma MPA (a maximum area of 162.9 km^2, or 54.7% of the MPA), and Robberg MPA (an area of 13.9 km^2, or 52.7% of the MPA).

Within the Priority Exploratory Area, model results show a 40-50% probability that a spill of crude oil from Discharge-1 will extend up to 460 km from the rupture point to the southwest entering international waters, depending on season, with a 90-100% probably that a surface slick will spread up to 340 km to the southwest across all seasons. There is a 37% probability that a spill of crude oil from Discharge-2 will extend up to 500 km from the rupture point to the southwest, entering international waters during the summer, and a 90-100% probably that the surface slick will spread 135-310 km from the rupture point to the southwest across all seasons. There is also a 90-100% probably that the surface slick will spread 138 km to the north/northeast in winter, a 70% probability of the spill moving north-east towards Gqeberha in summer, and an 80% probability of an autumn spill moving north/north-east towards the east coast of South Africa.

Offshore, surface crude oil (> 5 µm thick) is projected to intersect with several EBSAs and MPAs, including almost the entirety of the Southwest Indian Seamounts MPA and large portions of the Shackleton Seamount Complex EBSA and the Mallory Escarpment and Trough EBSA to the southwest. For Discharge-1, there is a >70% probability that the plume overlaps with 53% of the Southwest Indian Seamounts MPA, with an overlap of 44% in spring. In autumn, there is a 50-70% probability of the modelled plume overlapping with Port Elizabeth Corals, with this spill projected to cover 90% of the EBSA. For Discharge-2, there is a >70% probability that the plume overlaps with 47% of the Southwest Indian Seamounts MPA, with an overlap of 40% in spring. In autumn, there is a 10-30% chance of the modelled plume overlapping with Port Elizabeth Corals, with this spill projected to cover ~90% of the EBSA, and a 10-30% probability of the spill covering ~96% of the Agulhas Bank Complex MPA in spring.

Both the Discharge-l and Discharge-2 results indicate that the surface crude oil > 5 µm thick is also projected to overlap coastal MPAs in winter. For Discharge-1, there is a probability of 30-50% that the spill will overlap with the Addo Elephant National Park MPA (maximum area of 439.3 $km^{2,}$ representing 39.6% of the MPA), 58.6% of the Tsitsikamma MPA (maximum area of 170.8 km^2) and a 10-30% probability of overlapping 95% of the Goukamma MPA (maximum area of 30.5 km^2). For Discharge-2, there is a 50-70% probability of the surface spill overlapping 28.8% of the Addo Elephant National Park MPA (maximum of 319 km^2). There is also a 70-90% probability of overlap with the Tsitsikamma MPA (representing 84.61% of the MPA, with a maximum area of 246 km^2) and 40.47% of the Goukamma MPA (13.75 km^2).

The model results show that crude oil (>10 g/m²) is expected to reach shore for spills at both discharge points. For Discharge-1, oil is expected to reach the shore in 1-3 days (minimum) and 10-15 days average (winter is the worst case, with oil expected to come ashore in the Gqeberha area after approximately 1 day. The highest probability of oil-shoreline impact after a well blowout occurs in autumn (Season 2, April-Jun) and winter (Season 3, Jul-Sept), with a maximum shoreline impact probability of 87% in the Oyster Bay and St. Francis Bay areas, from Plettenberg Bay to Gqeberha. In spring (Season 4, Oct-Dec), there is a 42% probability of the oil reaching shore from Knysna to St. Francis Bay area. Model results for Discharge-2 indicate that shoreline oiling annual probability is 83%, with the highest probability of oil-shoreline impact after a well blowout occurring in autumn (Season 3, July-Sept) with a maximum shoreline impact probability of 100% from George to Gqeberha. In spring (Season 4, Oct-Dec), 63% of shoreline impacts are observed on the Tsitsikamma National Park coastline area, while in autumn (Season 2, Apr-Jun), 98% of impacts are modelled to occur between Knysna and Gqeberha. The period of the year identified as the worst in the event of a blowout (i.e., with maximum crude oil amount onshore coupled with the maximum probability) is again the third quarter (spill starting in August).

Impact assessment

Identified potential impacts that may be experienced during the construction, production and exploration phases, as well as across all project phases before and after mitigation are summarised in Table 1.

Under normal operations, four impacts were rated as of high significance, prior to mitigation. Six impacts were rated as medium, and 25 were rated as of low significance, and 13 were rated as of very low significance prior to mitigation. Twenty-three impacts were rated as of negligible significance, and no mitigation is therefore required 1. Of the activities that are anticipated to occur across all project phases, three were rated as of low significance prior to mitigation, with two impacts remining low and the other being reduced to very low significance after the implementation of mitigation. Impacts related to unplanned events (gas and condensate and crude spills) are all rated as high to very high before mitigation.

Decommissioning/closure procedure impacts are expected to be similar (if not less) to those assessed during the construction/exploration phase. Impacts predominately related to disturbance of the benthos linked to infrastructure removal and well decommissioning/plugging, as well as exclusion zones for fisheries due to abandoned infrastructure that presents a hazard to fishing activity.

Table 1.1. Summary of potential impacts before and after mitigation.

Phase	Impact	Before mitigation	With mitigation
Normal operations			
Construction	Impact 1a: Loss of benthic habitat and disturbance/mortality of infauna, relative to sensitivity.	**LOW**	**VERY LOW**
	Impact 1b: Loss of benthic habitat and disturbance/mortality of epifauna, relative to sensitivity.	**HIGH**	**MEDIUM** (no offset/compensation) **LOW** (offset/compensation)
	Impact 2: Biochemical and toxicity to the water column and benthic impacts associated with the discharge of drilling fluid and cuttings.		
	WBMs	**LOW**	**LOW**
	Cement	**LOW**	

Phase	Impact	Before mitigation	With mitigation
Normal operations			
Construction (cont.)	Impact 3a: Benthic impacts associated with the discharge of drilling muds and cuttings on infauna.	**LOW**	**LOW**
	Impact 3b: Impacts of elevated turbidity on pelagic marina biota.	**VERY LOW**	**VERY LOW**
	Impact 3c: Benthic impacts associated with the discharge of drilling muds and cuttings on epifauna.	**HIGH**	**MEDIUM** (no offset/compensation) **LOW** (offset/compensation)
	Impact 3d: Impacts of elevated turbidity on light penetration	**NEGLIGIBLE**	n/a
	Impact 4: Drilling noise impacts on marine megafauna, fish, turtles and avifauna.		
	24-hr exposure	**LOW**	**LOW**
	30-min exposure	**LOW**	
	Impact 5a: General construction noise impacts on marine megafauna and avifauna — helicopters.	**LOW**	**LOW**
	Impact 5b: General construction noise impacts on marine megafauna and avifauna — vessels.	**LOW**	**VERY LOW**
	Impact 6: Light and water pollution impacts of well (flow) testing/flaring		
	Flaring lighting	**LOW**	**VERY LOW**
	Hydrocarbon 'drop-out'	**LOW**	**VERY LOW**
	Produced water discharge	**VERY LOW**	**VERY LOW**
	Impact 7: Impacts of light pollution from construction activities on pelagic marine fauna.	**LOW**	**LOW**
	Impact 8: Impacts of the introduction of alien and invasive species	**HIGH**	**MEDIUM**
	Impact 9: Impacts on fisheries and mariculture as a result of construction related exclusion zones.		
	Deepsea trawl	**VERY LOW**	**VERY LOW**
	Hake longline	**NEGLIGIBLE**	n/a
	Mid-water trawl	**NEGLIGIBLE**	n/a
	Line fishery	**NEGLIGIBLE**	n/a
	Large pelagics	**LOW**	**LOW**
	Small pelagics	**NEGLIGIBLE**	n/a
	Rock lobster	**NEGLIGIBLE**	n/a
	Squid jig	**NEGLIGIBLE**	n/a
	Small-scale	**NEGLIGIBLE**	n/a
	Recreational	**NEGLIGIBLE**	n/a
	Rock Lobster	**NEGLIGIBLE**	n/a
	Mariculture	**NEGLIGIBLE**	n/a

Phase	Impact	Before mitigation	With mitigation
Normal operations			
Production	Impact 10: Impacts on water quality and marine systems resulting from routine operational discharges to the marine environment.	**MEDIUM**	**LOW**
	Impact 11a: Impacts on the local benthic environments from presence of subsea infrastructure— infrastructure not buried.	**VERY LOW**	**VERY LOW**
	Impact 11b: Impacts on the local benthic environments from presence of subsea infrastructure — infrastructure buried.	**NEGLIGIBLE**	n/a
	Impact 12: Impacts of physical presence of above water infrastructure (FA-platform etc.) on avifauna	**LOW**	**LOW**
	Impact 13: Impacts of operational artificial lighting on the marine environment.	**MEDIUM**	**LOW**
	Impact 14: Impacts on fisheries and mariculture as a result of production related exclusion zones.		
	Deepsea trawl	**VERY LOW**	**VERY LOW**
	Hake longline	**NEGLIGIBLE**	n/a
	Mid-water trawl	**NEGLIGIBLE**	n/a
	Line fishery	**NEGLIGIBLE**	n/a
	Large pelagics	**LOW**	**LOW**
	Small pelagics	**NEGLIGIBLE**	n/a
	Rock lobster	**NEGLIGIBLE**	n/a
	Squid jig	**NEGLIGIBLE**	n/a
	Small-scale	**NEGLIGIBLE**	n/a
	Recreational	**NEGLIGIBLE**	n/a
	Mariculture	**NEGLIGIBLE**	n/a
Exploration	Impact 15: Biochemical and toxicity impacts on water quality and benthic impacts related to exploratory drilling and cementing operations.		
	WBMs	**LOW**	**LOW**
	Cement	**LOW**	
	Impact 16a: Benthic impacts on infauna associated with exploratory drilling discharges.	**LOW**	**LOW**
	Impact 16b: Impacts of elevated turbidity on pelagic marina biota due to exploratory drilling discharges.	**VERY LOW**	**VERY LOW**
	Impact 16c: Benthic impacts on epifauna associated with exploratory drilling discharges.	**HIGH**	**MEDIUM** (no offset/compensation) **LOW** (offset/compensation)
	Impact 16d: Impacts of elevated turbidity on light penetration during exploration phase drilling.	**NEGLIGIBLE**	n/a
	Impact 17: Light and water pollution impacts of exploratory well testing and flaring.		

Phase	Impact	Before mitigation	With mitigation
Normal operations			
	Flaring lighting	LOW	VERY LOW
	Hydrocarbon 'drop-out'	LOW	VERY LOW
	Produced water discharge	VERY LOW	VERY LOW
	Impact 18: Exploratory drilling noise impacts on marine megafauna, fish, turtles and avifauna.		
	24-hr exposure	LOW	LOW
	30-min exposure	LOW	
	Impact 19: Noise pollution impacts for exploratory VSP activities on marine megafauna and avifauna.	LOW	LOW
	Impact 20a: General construction noise impacts on marine megafauna and avifauna — helicopters.	LOW	LOW
	Impact 20b: General construction noise impacts on marine megafauna and avifauna — vessels.	LOW	VERY LOW
	Impact 21: Impacts on fisheries and mariculture as a result of exploratory exclusion zones.		
	Deepsea trawl	LOW	VERY LOW
	Hake longline	VERY LOW	VERY LOW
	Mid-water trawl	VERY LOW	VERY LOW
	Line fishery	VERY LOW	VERY LOW
	Large pelagics	MEDIUM	MEDIUM
	Small pelagics	VERY LOW	VERY LOW
	Rock lobster	VERY LOW	VERY LOW
	Squid jig	MEDIUM	MEDIUM
	Small-scale	MEDIUM	MEDIUM
	Recreational	VERY LOW	VERY LOW
	Mariculture	NEGLIGIBLE	n/a

Phase	Impact	Before mitigation	With mitigation
Surveys activities and vessel traffic			
All project phases	Impact 22: Disturbance to sediments, seabed and benthic communities as result of exploratory marine surveys (ROV, metocean, sediment sampling).	LOW	VERY LOW
	Impact 23: Noise pollution impacts for sonar profiling activities.	LOW	LOW
	Impact 24: Impacts of increased vessel traffic on marine ecosystems and users	LOW	VERY LOW

Phase	Impact	Before mitigation	With mitigation
Unplanned events			
Unplanned events	Impact 25: Impacts of pollution generated through littering, fuel leaks, refuelling (bunkering), or collision during construction on the marine environment	MEDIUM	LOW
	Impact 26: Faunal strikes as a result of increased vessel traffic	LOW	VERY LOW
	Impact 27a: Impacts on marine ecological systems and communities as a result of a condensate oil spillage, including a blowout (Western sites)		
	Plankton	HIGH	MEDIUM
	Benthic fauna	HIGH	MEDIUM
	Fish	HIGH	MEDIUM
	Seabirds	VERY HIGH	HIGH
	Turtles	VERY HIGH	HIGH
	Marine mammals	VERY HIGH	HIGH
	Coastal environment	VERY HIGH	HIGH
	Impact 27b: Impacts on marine ecological systems and communities as a result of a crude spillage, including a blowout (Eastern sites)		
	Plankton	VERY HIGH	HIGH
	Benthic fauna	VERY HIGH	HIGH
	Fish	VERY HIGH	HIGH
	Seabirds	VERY HIGH	HIGH
	Turtles	VERY HIGH	HIGH
	Marine mammals	VERY HIGH	HIGH
	Coastal environment	VERY HIGH	HIGH
	Impact 28a: Impacts on commercial and recreational fishing as a result of a condensate oil spillage, including a blowout (Western sites)		
	Deepsea trawl	HIGH	MEDIUM
	Hake longline	HIGH	MEDIUM
	Mid-water trawl	HIGH	MEDIUM
	Line fishery	HIGH	MEDIUM
	Large pelagics	HIGH	MEDIUM
	Small pelagics	HIGH	MEDIUM
	Rock lobster	HIGH	MEDIUM
	Squid jig	HIGH	MEDIUM
	Small-scale	HIGH	MEDIUM
	Recreational	HIGH	MEDIUM
	Mariculture	HIGH	MEDIUM

Phase	Impact	Before mitigation	With mitigation
Unplanned events			
	Impact 28b: Impacts on commercial and recreational fishing and mariculture as a result of crude oil spillage, including a blowout (Eastern sites)		
	Deepsea trawl	VERY HIGH	HIGH
	Hake longline	VERY HIGH	HIGH
	Mid-water trawl	VERY HIGH	HIGH
	Line fishery	VERY HIGH	HIGH
	Large pelagics	VERY HIGH	HIGH
	Small pelagics	VERY HIGH	HIGH
	Rock lobster	VERY HIGH	HIGH
	Squid jig	VERY HIGH	HIGH
	Small-scale	VERY HIGH	HIGH
	Recreational	VERY HIGH	HIGH
	Mariculture	VERY HIGH	HIGH

The high impacts are reduced to either medium or low significance with the introduction of suitable mitigation measures, and while the significance of the very high impacts are reduced through the successful implementation of suitable mitigation, these impacts remain of high significance. Two construction phase impacts that were assessed as of high significance are only reduced to low with the implementation of suitable offsets, otherwise they remain as impacts of medium significance.

The primary impacts of concern under normal operating conditions are:

- The loss of benthic habitat and disturbance/mortality of epifauna within CBA Natural/ Biodiversity Conservation Areas as defined by the Draft Marine Biodiversity Sector Plan (2023). This impact is considered to be of high significance prior to mitigation (Table 1). Indeed, the development of the subsea pipelines associated with oil and gas processes are considered **non-compatible** within the CBA Natural areas (i.e., Biodiversity Conservation Areas). While the environmentally preferable option is to reroute the pipeline to avoid CBA areas, as complete avoidance mitigation is not possible, offsets and/or compensatory measures will need to be developed as part of a Biodiversity Action Plan.

- Benthic impacts associated with the discharge of drilling muds and cuttings on epifauna, for both proposed production and exploratory drilling. This impact is considered to be of high significance (Table 1). While environmental effects in the lower water column are expected to endure for a very short duration, up to 2.5 days maximum, benthic effects (i.e., impacts on the sediment) are modelled to endure for up to five years. There is evidence that, depending on the discharge location, a plume of significant impact can extend beyond the confines of the Application Area. In particular, there is intersection with the Southwest Indian Seamounts Marine Protected Area to the southwest of Block 11B/12B. The area where cumulative environmental risks are expected within the modelled plume covers ~2.5% of the bottom water area of the MPA. Should this impact plume (PEC/PNEC > 1) overlap with vulnerable communities on hard ground, there is potential for an impact of substantial consequence (given the high sensitivity of the receptors), and recovery would only be expected over the medium- to long-term (>10 years) due to their long generation times.

While the final position of the proposed wells has not been decided, these modelling studies focused on worst-case scenarios. However, should the drilling methodology change from what has been modelled in these studies, additional modelling will need to be conducted prior to the commencement drilling to assess whether the impact plume (PEC/PNEC > 1) in the bottom water column is expected to intersect with any sensitive species (VME indicators), areas (such as MPAs or EBSAs), habitats or structures.

- The introduction of alien invasive marine species has a high impact significance prior to mitigation (Table 1). However, the risk of this impact is considered to be very low to improbable, which serves to reduce the significance the impact further. This impact is also not unique to oil and gas exploration and production activities, but rather a threat which is common to the South African marine environment given the numerous vessels that pass through South African coastal waters on a daily basis.

The primary impacts of concern for unplanned events are related exclusively to the impacts of oil and condensate on marine systems and resources:

- While it is noted that the probability of a major spill happening via a well blowout or a pipe rupture is considered to be extremely small, the impacts on marine ecological systems and communities as a result of oil/fuel spillage, including a blowout and pipeline rupture, are assessed as high to very high (Table 1). Any release of liquid hydrocarbons has the potential for direct, indirect and cumulative effects on marine fauna (and associated habitats) with knock-on effects on ecosystem form and function in the offshore, nearshore and coastal environment. Impacts derive from toxic and/or smothering effects on organisms in the path of a spill (with estuaries being particularly vulnerable), physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton (particularly copepods), pelagic eggs and fish larvae, and habitat loss or contamination. Groups at particular risk include seabirds (because they are long-lived and impacted by surface oiling through their use of habitat and feeding) as well as turtles and cetaceans (as they are long lived, and breath at the surface).

  While model results for discharge points in the western Project Development Area (Discharge-4 and 5; condensate) indicate a very small probability (0.5-1%) that a pipeline rupture would result in condensate reaching the shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) entering the Knysna Estuary, the impacts of condensate entering this system would be of high intensity. Modelling results for Discharge-1 and 2 (crude oil, in the eastern Exploratory Priority Area) indicate a far higher probability of oil reaching the Knysna Estuary — there is a modelled worst-case, maximum, shoreline impact probability of 100% from George to Gqeberha in winter (July to September), and 98% between Knysna and Gqeberha in autumn (April to June) for a blowout at Discharge-2. Even for Discharge-1, there is a 42% probability of the oil reaching the shore from Knysna to St. Francis Bay area in spring (Oct-Dec). The highest probability of oil-shoreline impact after a well blowout occurring in from July to September for both Discharge-1 and Discharge-2. The Knysna Estuary is one of only three large, permanently open estuarine bays along the South African coastline. The estuary is considered to be the most ecologically significant estuary in South Africa, representing 42.8 % of all estuarine biodiversity, and is home to several critically endangered species, the most famous of which being the Knysna seahorse *Hippocampus capensis*.

  There is also a particular concern regarding model results presented for a blowout of wells in the eastern Exploratory Priority Area — worst-case model results indicate a 30-50% probability of a crude oil spill reaching Addo Elephant National Park MPA (Algoa Bay) if there is a blowout at Discharge-1 in winter, and 50-70% probability of an oil spill reaching the Addo MPA if there is a blowout at Discharge-

2. An oiling of the Addo MPA and Algoa Bay would be of very high consequence for seabirds, as the Bay is host to highly important breeding islands for the endangered Cape gannet and African penguin.

Modelled surface oil spills are projected to also reach coastal MPAs, particularly from Discharge-1 and Discharge-2 blowouts, with potentially negative impacts on the biota protected with these areas — for example, worst-case model results show that there is a 70-90% probability that a blowout at Discharge-2 (crude oil) will result in a surface oil slick (>5 µm thick) that covers 84.61% of the Tsitsikamma MPA. This MPA, along with the others along the South Coast that are also likely to be affected (such as the Addo Elephant National Park MPA and Goukamma MPA) are especially important for the protection of over exploited, endemic seabream fish species.

The direct effects and vulnerability of many shoreline species, harvested by small-scale and recreational fishers means impacts associated with an uncontrolled spill are higher for this sector. These sectors also have reduced flexibility in terms of redistribution of effort, considering the extent of coastline potentially impacts by an oil spill. The offshore small-scale scetor is also likely to be impacted signiicantly, with a spill of >50% probbality overlapping with some 23% of the total allocated small-scale TAC (across all species) for a well-blow out in the Project Development Area, and 52% for a well blow-out in the Exploratory Priority Area.

Therefore, while the risk of occurrence of a blowout at these exploratory wells is low, the implications of a crude oil spill of the magnitude modelled are catastrophic — the impacts across all aspects of the marine environment are rated as very high prior to mitigation, and high after mitigation.

Recommendations

Note that in this assessment, mitigation is separated out as Project Controls (i.e., measures that will be implemented/undertaken by TEEPSA as part of industry best practise, Best Available Techniques (BAT) or legislative requirements) and addition mitigation specific to the proposed activities in this specific environment with the specific identified receptors and sensitivities. Project Controls include compliance with MARPOL discharge and waste control requirements, and compliance with IMO ballast water management requirements. In addition to the Project Controls, key mitigation for impacts on loss of benthic habitat and disturbance/mortality of epifauna due to construction and drilling under normal operating conditions include, inter alia:

- Pre-installation site EBS ROV surveys must be undertaken to identify sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops) within the proposed are of interest. These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform construction plans with the aim to provide a one km radius buffer to any sensitive communities, habitats or structures.

- Ensure installation of pipelines and manifolds locations are not located within a one km radius of MPAs or EBSAs.

- Technical studies must be undertaken to inform the pipe laying method to inform if trenching will be required and if so, to minimise the amount of trenching required. This will minimise the unavoidable impacts of increased suspended sediment and sedimentation rates in the vicinity of pipelaying activities.

- Pipeline routing must be optimised to minimise the unavoidable impacts of increased suspended sediment and sedimentation rates in the vicinity of pipelaying activities.
- Cement spillage to the marine environment must be minimised.
- While the final position of the proposed wells has not been finalised, these modelling studies focused on worst-case scenarios. However, should the drilling methodology change from what has been modelled in these studies, additional modelling will need to be conducted prior to the commencement drilling to assess whether the impact plume (PEC/PNEC > 1) in the bottom water column is expected to intersect with any sensitive species (VME indicators), areas (such as MPAs or EBSAs), habitats or structures.
- Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected.
- All process areas on board operational vessels should be bunded to ensure drainage water flows into the closed drainage system.
- Ensure only low-toxicity, low bioaccumulation potential and partially biodegradable additives are used in drilling fluid and cement.
- The Project Controls specify that, should lower toxicity Water-Based Muds (WBMs) not be able to provide the necessary characteristics for effective drilling during the risered phase, a low toxicity NADF will be used. In this instance, a zero-discharge strategy will be implemented (i.e. cuttings with NADF will be shipped to shore for disposal). At this stage, however, it is anticipated that only WBMs will used in the drilling stages for the Project.
- Avoid excess cement usage by using a ROV to monitor discharges to the seafloor around the drill casing.
- Innovative technologies and operational procedures for drilling solids discharges should be considered to minimise the impacts when drilling tophole sections to limit the extent of dispersion.
- Low-toxicity biodegradable detergents should be used in the cleaning of deck spillages.
- If complete avoidance mitigation is not possible, an offset/compensatory mechanism needs to be developed as part of a Biodiversity Action Plan (BAP) is required.

In addition to Ballast Water Management processes specified as per the Project Controls (including compliance MARPOL 73/78 International Convention for the Prevention of Pollution from Ships, 1973 and International Maritime Organisation (IMO) guidelines (Guideline A.868(20) governing discharge of ballast waters at sea), mitigation for impacts of the introduction of alien invasive marine species under normal operating conditions include, inter alia:

- Infrastructure such as wellheads, blowout preventer (BOPs) and guide bases used in other locations must be thoroughly cleaned before deployment.

Other recommendations for normal operating conditions include training on how to care for downed seabirds as part of induction and ongoing awareness training. .

For VSP and sonar activities, a minimum of two dedicated Marine Mammal Observer (MMO), with a recognised MMO training course, must be on board for marine fauna observation (360 degrees around drilling unit), distance estimation and reporting. One MMO should also have Passive Acoustic Monitoring (PAM) training, should a risk assessment, undertaken ahead of the sonar operation, indicate that the PAM equipment can be safely deployed considering the metocean conditions (specifically current). While the impacts of drilling noise (both production exploratory drilling) of marine mammals, avifauna, turtles and fish is expected to be of low significance, an independent, suitably qualified MMO must accompany the pre-drilling survey to undertake validation of cetacean migration/distribution models. In the unlikely event of a cetacean sighting within the Permanent Threshold Shift (PTS) threshold distance for the most sensitive species (400 m) immediately prior to drilling commencement, drilling may not commence until an independent MMO confirms that no cetaceans are present within this PTS radius.

The priority first step is the prevention of unplanned events (in this case, crude and condensate spills). If preventative barriers fail or are not effective under certain conditions, then response/recovery capabilities (minimisation or restoration barriers) will be in place. A "multi-barrier" (i.e., mitigation) approach in dealing with risks (particularly the risk of oil spills) will be implemented. This approach involves defining multiple preventative barriers (or avoidance mitigation measures) to manage environmental risk and is integrated into the application of the Mitigation Hierarchy ('avoid', 'minimize', 'restore' and 'offset'). The first step and most important priority in applying the Mitigation Hierarchy to manage the risk of a catastrophic oil spill is avoidance (or prevention). If these preventative barriers fail or are not effective under certain conditions, then response/recovery capabilities (minimisation or restoration barriers) will be in place.

Specific Project Controls for avoidance on unplanned events include:

- Constructing wells to international specification in consultation with a well design engineer who would provide operating and integrity parameters.
- Ensure sufficient redundancy i.e., multiple well casings and BOP "stacks".
- Ensure the employment of competent, well-trained staff during all operations.
- Safety critical equipment must be subject to testing and certification to ensure that it meets design specifications.

In the case of this project, where there is no equivalent habitat available within the concession area allocated to TEEPSA that can be restored or protected, and there is limited knowledge regarding the distribution of such habitat elsewhere, we are forced to consider adopting an 'out-of-kind' offset (see details in Section 9.2.1 of this report) . Knowledge regarding the distribution of habitat affected by project actions, and more particularly, the species associated with these habitat types, in the environment remains poor. One of the primary reasons for this is the challenges associated with undertaking scientific research in these deep-water environments and the paucity of funds required to do this. We propose therefore that an out-of-kind offset be considered and that this take the form of research conducted directly by TEEPSA (over and above any monitoring work that may be required to assess efficacy of any avoidance or mitigation measures implemented in terms of the EMP) or a funding allocation by TEEPSA to an appropriate government, parastatal or non-government agency for research that can contribute towards a better understanding of the distribution of deep water habitats and associated fauna off South African coast. Such a proposal would need to be further unpacked in the Biodiversity Action Plan for this study and would need to consider very carefully how "line of sight" from such research can contribute directly towards the kinds of concrete biodiversity outcomes required by the IFC and others.

Cumulative impacts

Anthropogenic activities can result in numerous and complex effects on the natural environment. While many of these are direct and immediate, the environmental effects of individual activities or projects can interact with each other in time and space to cause incremental or aggregate effects. Impacts from unrelated activities may accumulate or interact to cause additional effects that may not be apparent when assessing the activities individually. Cumulative effects are defined as the total impact that a series of developments, either present, past or future, will have on the environment within a specific region over a particular period of time (DEAT IEM Guideline 7, 2004). By definition, cumulative marine environmental impacts emanating from the proposed project are related to the overlap with various other sources of anthropogenic disturbance in the vicinity of the impact proposed project activities, under normal operating conditions.

Potential cumulative impacts therefore include increases in anthropogenic noise, disturbance of the seabed through discharges of drilling material, loss of seabed habitat with the placement of subsea infrastructure (pipelines), and an increase in the number of vessels and aircraft in the vicinity of the project. Cumulative impacts are likely to be no more significant than the impacts assessed for the construction, production and exploration phases. Although cumulative impacts from other hydrocarbon ventures in the area may increase in future, the cumulative impacts of the proposed project activities within Block 11B/1B and the adjacent Agulhas Bank can be considered of low significance.

DECLARATION OF INDEPENDENCE

Anchor Environmental Consultants (Pty) Ltd is an independent consultancy and has no business, financial, personal or other interest in the activity, application or appeal in respect of which the company was appointed other than fair renumeration for work performed in connection with the activity, application or appeal. No circumstances arose during the course of the project that compromised the objectivity of the specialists that performed the work.

BACKGROUND AND QUALIFICATIONS OF SPECIALIST CONSULTANTS

The study was undertaken by Dr Barry Clark, Ms Amy Wright, Ms Lily Bovim, Dr Adam Rees and Mr Geordie Thewlis.

Dr Barry Clark has over 30 years' experience in marine biological research and consulting on coastal zone and marine issues. He has worked as a scientific researcher, lecturer and consultant and has experience in tropical, subtropical and temperate ecosystems. He is one of the founding partners at Anchor Environmental Consultants and a Research Associate at the University of Cape Town. As a consultant has been concerned primarily with conservation planning, monitoring and assessment of human impacts on estuarine, rocky shore, sandy beach, mangrove, and coral reef ecosystems as well as coastal and littoral zone processes, aquaculture and fisheries. Dr Clark is the author of 27 scientific publications in class A scientific journals as well as numerous scientific reports and popular articles in the free press. Geographically, his main area of expertise is southern Africa (South Africa, Lesotho, Namibia, Mozambique, Tanzania, Seychelles, Mauritius and Angola), but he also has working experience from elsewhere in Africa (Republic of Congo, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Nigeria), the Middle East (UAE) and Europe (Azerbaijan).

Amy Wright has an MSc degree in Biological Sciences and BSc. Hons. degrees in Marine Biology and Applied Biology from the University of Cape Town. She is currently a Senior Consultant for Marine Ecosystems & Resources at Anchor Environmental and a professionally registered Natural Scientist (SACNASP 131256). She is a marine ecologist with direct experience in two- and three-dimensional hydrodynamic modelling of marine and estuarine systems to inform impact assessments and regulatory compliance, as well as monitoring program design and implementation. She has dispersion modelling, impact assessment, permitting and environmental auditing experience across a range of diverse industries, including land- and sea-based mariculture, maritime and estuarine engineering, dredging and offshore mining operations, reverse osmosis operations, power and gas facility intake, discharge and cooling (including green hydrogen systems), offshore oil and gas operations, fisheries processing and discharge, and shipping (ballast, antifoulants, heavy metals). She has experience across South Africa, Namibia, Mozambique, Mauritius, Kenya and Tanzania, and is the author of four scientific publications in Class A scientific journals and over 80 technical reports.

Dr Adam Rees has experience in temperate marine ecology, benthic ecosystems research, marine protected areas, marine spatial planning and management, marine impact assessment, commercial and recreational fisheries in a range of countries include the UK, Maldives, central and southern Africa. He is well experienced in quantifying and assessing changes to benthic systems, affected by marine protected areas (MPAs), fisheries/offshore aquaculture, marine renewable energy installations and anthropogenic developments/modifications. His PhD assessed the effects of commercial potting on reef habitats and the associated commercially important fauna within an MPA. He has published in class A scientific journals as lead author. One of his papers is in the Top 100 downloaded papers in Ecology for 2021 from Scientific Reports (Nature portfolio publishing group) and is now influencing inshore fisheries management policy of the UK and Europe. He is proficient in ecological survey design and planning, underwater video sampling and analyses, multivariate analysis of large quantitative datasets (PERMANOVA, R), spatial data analyses (ArcGIS, QGIS), boat and lab fieldwork and data collection, technical reporting, project and budget management, stakeholder engagement, grant writing and public speaking. He has previously worked as a postdoctoral researcher with the University of Plymouth and the Blue Marine Foundation (international marine NGO) and is currently a Visiting Researcher with the University of Plymouth. He has practical experience in several commercial fishery sectors and has good understanding of commercial fishery assessments and management. Adam is a SACNASP registered Professional Natural Scientist in Aquatic Science and Environmental Science (Registration Number: 141530).

Lily Bovim has always had a strong interest in the marine environment, and this has been the focus of her career, starting with a BSc in Marine Biology and Oceanography. After completing a BSc Honours, she held various research and field assistant positions before undertaking an internship with the Freshwater Research Centre. Lily was awarded an Erasmus Mundus scholarship to pursue an International Master of Marine Biological Resources, specialising in Marine Resource Management, which included semesters at multiple European universities and an internship at the Thünen Institute of Baltic Sea Fisheries. Her MSc thesis focused on the depth and temperature preferences of satellite-tagged meagre *Argyrosomus regius* in the NE Atlantic. She graduated Magna Cum Laude from her MSc. Lily joined the Anchor Marine Ecosystems & Resources team in October 2022 and fulfils a consultant role, with tasks mainly involving specialist reporting and data analysis.

Mr Thewlis has an MSc degree in Civil Engineering from the University of Cape Town. His research, focused on water quality and hydrological modelling. He is proficient in hydraulic, hydrological and hydrodynamic modelling across a range of numerical modelling software. He has experience in GIS, PCSWMM, and CorMix. He has been involved with several inland water and estuarine research projects for various institutions including the Water Research Commission and the Future Water Institute at the University of Cape Town and is in the process of publishing his first scientific paper. As an Environmental Consultant his responsibilities include environmental research, develop hydrodynamic models using numerical modelling software and impact assessment and monitoring project development.

SIGNATURES OF LEAD SPECIALISTS

I, Barry Clark, declare that:

- I act as the independent specialist in this application;
- I have performed the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature

Date: 15 September 2023

I, Amy Wright, declare that:

- I act as the independent specialist in this application;
- I have performed the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature

Date: 15 September 2023

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GLOSSARY

24-hour SEL (SEL24h): Acoustic energy accumulated over a 24-hour period.

Alien species: Species that occur outside their natural range and dispersal potential. Alien species are spread by human activity, intended or unintended, to new areas. May or may not become 'invasive species'.

Anthropogenic: Relating to or resulting from the influence of human beings on nature.

Ballast Water Convention: The International Convention for the Control and Management of Ships' Ballast Water and Sediments is a 2004 international maritime treaty which requires signatory flag states to ensure that ships flagged by them comply with standards and procedures for the management and control of ships' ballast water and sediments.

Ballast water: Fresh or saltwater held in the ballast tanks and cargo holds of ships. It is used to provide stability and manoeuvrability during a voyage when ships are not carrying cargo, not carrying heavy enough cargo, or when more stability is required due to rough seas.

Barite: A mineral consisting of barium sulfate ($BaSO_4$). Barite is a common weighting material used to formulate high-density drilling fluids because of its high density (4.2–4.48 g/cm^3) and low environmental impact.

Benthic: The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers. Organisms living in this zone are collectively referred to as the "benthos", e.g., the benthic invertebrate community, including crustaceans and polychaetes.

Bentonite: A clay used in drilling well fluids. It is easily hydrated by water and acts as a viscosifier (i.e., a material which increase the lubricity or viscosity of oil, water and synthetic drilling fluids).

Biochemical oxygen demand (BOD): The amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.

Biodegradation: A process where microbial organisms metabolize petroleum, degrading the hydrocarbon content. The process can take more or less time depending on the amount of type and amount of bacteria, the reservoir or ecosystem in which the bacteria are found, and the amount of oxygen present.

Bioregion: A region defined by characteristics of the natural environment rather than by man-made.

Bioturbation: Bioturbation is defined as the reworking of soils and sediments by animals or plants. It includes burrowing, ingestion, and defecation of sediment grains. Bioturbating activities have a profound effect on the environment and are thought to be a primary driver of biodiversity.

Construction phase: The stage of project development comprising site preparation as well as all construction activities associated with the development.

Critical Biodiversity Area: An area in a natural condition that is required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure. The management objectives for these areas require that they are to remain in a natural or near-natural state, with no further loss of natural habitat.

Crustacea/n: A group of invertebrate animals within the Phylum Arthropoda. A diverse group that includes decapods (lobsters, crabs and shrimps), seed shrimp, branchiopods, fish lice, krill, isopods, barnacles, copepods, amphipods and mantis shrimp.

Cumulative impacts: Direct and indirect impacts that act together with current or future potential impacts of other activities or proposed activities in the area/region that affect the same resources and/or receptors.

Dermal: Of or relating to skin.

Deterministic (oil spill) simulations: Detailed pictures of the oil trajectory during the simulation periods.

Diversity: the number of different species present in an ecosystem and relative abundance of each of those species." Diversity is greatest when all the species present are equally abundant in the area.

Dropstones: Isolated fragments of rock found within finer-grained water-deposited sedimentary rocks or pyroclastic beds. They range in size from small pebbles to boulders.

Ecological Support Area: An area that is not essential for meeting biodiversity targets but does play an important role in supporting the functioning of Protected Areas or CBAs and are often vital for delivering ecosystem services.

Ecologically or Biologically Significant Marine Areas (EBSAs): Defined by the Convention on Biological Diversity (CBD) as "geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the [EBSA] criteria".

Ecosystem Threat Status: Developed by SANBI (2018) is an indicator of threatened ecosystems, specifically the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function, or composition (Harris *et al.* 2018).

Ecosystem: a biological community of interacting organisms and their physical environment – a complex network or interconnected system.

Ecozone: The 2011 National Biodiversity Assessment used the terms 'ecoregions' and 'ecozones' to replace the similar but revised 'bioregions' and 'biozones' used previously and to avoid confusion between the different map layers from previous assessments.

EIF: An indicator of environmental risk for the water volume or sea floor area where the risk for an effect on the most sensitive species exceeds 5% (more than 5% of the most sensitive species are at risk). 1 EIF equates to 100 x 100 x 10 m^3 in the water column (100 000 m^3), and 1 EIF equates to 100 x 100 m on the sea floor (10 000 m^2; i.e., 100 EIF = 1 km^2).

EIF_{DD}: An indicator of environmental risk from for drilling discharges.

EIF_{PW}: An indicator of environmental risk from produced water discharges.

Environment: The external circumstances, conditions and objects that affect the existence of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.

Environmental Authorisation: Permission granted by the competent authority for the applicant to undertake listed activities in terms of the NEMA EIA Regulations, 2014.

Environmental Impact Assessment: A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.

Epifauna: Benthic fauna living on the substrate (such as a hard sea floor) or on other organisms.

Estuarine Functional Zone: Delineated by a 5 m above mean sea level (MSL) contour as proxy indicator, the area in and around an estuary which includes the open water area, estuarine habitat (such as sand and mudflats, rock and plant communities) and the surrounding floodplain area.

Gas condensate: A mixture of low-boiling hydrocarbon liquids obtained by condensation of the vapours of these hydrocarbon constituents either in the well or as the gas stream emits from the well.

Heatmap: a method of representing data graphically where values are depicted by colour, making it easy to visualize complex data and understand it immediately.

High seas: All parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State.

High-frequency cetaceans: Cetaceans with hearing range of 150 Hz to 160 kHz. Includes dolphins, toothed whales, beaked whales, bottlenose whales e.g., common dolphin *Delphinus delphis*, killer whale *Orcinus orca*, Atlantic bottlenose dolphin *Tursiops truncatus*, short-finned pilot whale *Globicephala macrorhynchus*.

Impact: A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.

Impulsive noise: considered to have high peak sound pressure, short duration, fast rise-time and broad frequency content at source i.e., explosives, impact piling and seismic airguns.

Infauna: Benthic fauna living in the substrate and especially in a soft sea bottom.

International Finance Corporation's (IFC) Performance Standards: Guidelines on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in an environmentally and socially sustainable manner. Clients of the IFC are required to apply relevant performance standards during the assessment of the environmental and social impacts of planned developments.

International Finance Corporation (IFC) Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts.

International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.

Invasive species: Alien species capable of spreading beyond the initial introduction area and have the potential to cause significant harm to the environment, economy or society.

Invertebrate: An animal without a backbone (e.g., a starfish, crab, or worm).

Lagrangian approach: An approach to particle modelling in fluid dynamics that deals with individual particles and calculates the trajectory of each particle separately (as opposed to the Eulerian approach, which deals with the concentration of particles and calculates the overall diffusion and convection of a number of particles).

LC_{50}: Lethal concentration 50 (LC_{50}) is the amount of a substance required to kill 50% of test animals during a predetermined observation period. LC_{50} values are frequently used as a general indicator of a substance's acute toxicity.

Low-frequency cetaceans: Cetaceans with hearing range of 7 Hz to 35 kHz. Includes baleen whales e.g., southern right whale *Eubalaena australis*, humpback whale *Megaptera novaeangliae*, Bryde's whale *Balaenoptera edeni*.

Macrobenthos/macrofauna: Those animals retained by a 1.0-mm-mesh sieve. Macrobenthic invertebrates are defined as organisms that live on or inside the deposit at the bottom of a water body.

Manganese nodules: mineral concretions on the sea bottom formed of concentric layers of iron and manganese hydroxides around a core, forming dark, well-rounded pebbles. Also referred to as polymetallic nodules or nodules.

Marine Spatial Planning (MSP): The public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process.

No Observed Effect Concentration (NOEC): The highest tested concentration for which there are no statistically significant difference of effect ($p<0.05$) when compared to the control group in long-term ecotoxicity studies.

Non-impulsive noise: Categorised as "steady state" noise i.e., sonars, vibropiling, drilling, shipping and other relatively low-level continuous noises.

of appendages (antennules and antennae) in front of the mouth and paired appendages near the mouth that function as jaws.

Offshore: The area seaward of the nearshore environment boundary.

Otariid carnivores: Eared seals e.g., Cape fur seals *Arctocephalus pusillus* Hearing range of 60 Hz to 39 kHz in water.

Peak SPL (SPL_{peak}): Greatest absolute instantaneous sound pressure over a stated time interval.

Permanent threshold shift (PTS): A permanent loss of hearing sensitivity.

Phocid carnivores: Earless/true seals e.g., southern elephant seal *Mirounga leonina*, leopard seal *Hydrurga leptonyx*. Hearing range of 50 Hz to 86 kHz in water.

Photooxidation: The degradation of oil due to the combined action of light and oxygen. Photooxidation can change the composition of an oil. It occurs when the sun's action on an oil slick causes oxygen and carbons to combine and form new products that may be resins. The resins may be somewhat soluble and dissolve into the water, or they may cause water-in-oil emulsions to form.

Phytodetritus: The organic particulate matter resulting from phytoplankton and other organic material in surface waters falling to the seabed. This process takes place almost continuously as a "marine snow" of descending particles, falling at the rate of about 100 to 150 m per day.

Plankton: The diverse collection of organisms found in water that are unable to propel themselves against a current.

Planktonic: Living within the plankton

PNEC (Predicted No Effect Concentration): A measure in toxicity studies that represents the concentration of a chemical compound in either water or sediments below which no adverse effects of exposure in an ecosystem are measured. This PNEC is usually derived from results of laboratory toxicity tests and must be provided for each compound to be considered in the discharge.

Pore space: Defined by porosity of a material possessing free space between the mineral grains, expressed as percentage, and depends on size and sorting of the particles as a cubic or hexagonal package.

Pore water: Water contained in the interstices/pore space of aquatic sediments (see 'Pore space').

Predicted Environmental Concentration (PEC): The calculated concentration of a chemical in the environment (in this case, the water column) over time and space introduced into the environment via a discharge.

Root mean square SPL (SPL_{rms}): Average root mean square pressure level over a stated time interval.

Sound Exposure Level (SEL): Measured in dB re 1 μPa^2-s:

Sound Pressure Level (SPL): Measured in dB re 1 μPa.

Species: A category of biological classification ranking immediately below the genus, grouping related organisms. A species is identified by a two-part name; the name of the genus followed by a Latin or Latinised un-capitalised noun.

Stochastic (oil spill) simulations: Statistical calculations / analyses based on the results from ensemble modelling a wide range of weather and/or seasonal conditions,

Sub-lethal responses/ sublethal toxic effects: Effects which reduce the capacity of a population to retain an internal balance within its community. This loss of balance can take the form of reduced growth rates or fertility (alteration of gametes), or increased mortality in larvae and juvenile stages.

Taxon (plural – taxa): Refers to any unit used in the science of biological classification, or taxonomy.

Temporary threshold shift (TTS): A temporary loss of hearing sensitivity.

Upwelling: An oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water from deep water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water.

Very high-frequency cetaceans: Cetaceans with hearing range of 275 Hz to 160 kHz. Includes true porpoises, Heaviside's dolphin *Cephalorhynchus heavisidii*, pygmy sperm whale *Kogia breviceps* and dwarf sperm whale *K. sima*.

Vulnerable Marine Ecosystem: Groups of species, communities or habitats characterized by their structural functionality and their vulnerability to physical disturbance. The identification of VMEs includes (i) uniqueness or rarity; (ii) functional significance of the habitat; (iii) fragility; (iv) live-history traits of component species that make recovery difficult; and (iv) structural complexity. Includes seamounts, hydrothermal vents, cold water corals and sponge fields.

Vulnerable Marine Ecosystem Indicator species: Species that signal the occurrence of vulnerable marine ecosystems, and which meet the five criteria of Food and Agriculture Organization of the United Nations (FAO) Deep-seas Fisheries Guidelines. These guidelines were developed for the protection of VMEs in the high seas (outside of any specific county's Exclusive Economic Zone (EEZ). However, the principles apply to areas within the EEZ as well and have been adopted in Marine Spatial Planning (MSP) as a measure to conserve important ecosystems from anthropogenic activities.

LIST OF ABBREVIATIONS

ACAP	Agreement on the Conservation of Albatrosses and Petrels, (2004)
Anchor	Anchor Environmental Consultants
BAT	Best Available Techniques
BCC	Benguela Current Commission
BOCP	Blowout Contingency Plan
BOD	Biochemical Oxygen Demand
BOP	Blowout preventer
CBA	Critical Biodiversity Area
CBD	Convention on Biological Diversity
CGR	Condensate Gas Ratio
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CPUE	Catch Per Unit Effort
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DO	Dissolved Oxygen
DREAM	Dose-related Risk and Effects Assessment Model
EA	Environmental Authorisation
EBS	Environmental Baseline Study
EBSA	Ecologically or Biologically Significant Marine Area
EEZ	Exclusive Economic Zone
EFZ	Estuarine Functional Zone
EIF	Environmental Impact Factor
EIF_{DD}	Environmental Impact Factor for Drilling Discharges
EIF_{PW}	Environmental Impact Factor for Produced Water Discharges
EMP	Environmental Management Plan
ESA	Ecological Support Area
ESIA	Environmental and Social Impact Assessments
EU-TGD	European Commissions technical guidance document on environmental risk assessment
FAO	Food and Agriculture Organization
GIS	Geographic Information System
HF	High Frequency,
HYCOM	Hybrid Coordinate Ocean Model
ICCAT	International Convention for the Conservation of Atlantic Tunas
ICMA	National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008)
ICMA	National Environmental Management: Integrated Coastal Management Act 24 of 2008
IFC	International Finance Corporation
IMMA	Important Marine Mammal Areas
IMO	International Maritime Organisation
IPIECA	International Petroleum Industry Environmental Conservation Association
ISPPC	International Sewage Pollution Prevention Certificate
IUCN	International Union for Conservation of Nature

IWC	International Whaling Commission
LC_{50}	Lethal concentration 50
LF	Low Frequency.
LOC	Loss of Containment
MARISMA	Marine Spatial Management and Governance Programme
MARPOL	The International Convention for the Prevention of Pollution from Ships (1973)
MBES	Multi-beam echo-sounding
MEG	Methyl ethylene glycol
MLRA	Marine Living Resources Act 18 of 1998 (as amended)
MMOs	Marine Mammal Observers
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MPRDA	Mineral and Petroleum Resources Development Act (No. 28 of 2002),
MSP	Marine Spatial Planning
NADF	Non-Aqueous Drilling Fluids
NBA	National Biodiversity Assessment
NEM:BA	National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
NEM:PAA	National Environmental Management: Protected Areas Act (Act No. 57 of 2003)
NEMA	National Environmental Management Act No. 107 of 1998 (as amended)
NEMA	The National Environmental Management Act (No. 107 of 1998)
NOAA	National Oceanic and Atmospheric Administration
NOEC	No Observed Effect Concentration
NOROG	Norwegian Oil and Gas Authority
OCW	Other marine carnivores in water
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-Operation (1990)
OS	Oil Spill
OSCAR	Oil Spill Contingency and Response
OSCP	Oil Spill Contingency Plan
PAM	Passive Acoustic Monitoring
PASA	Petroleum Agency of South Africa
PEC	Predicted Environmental Concentration
PNEC	Predicted No Effect Concentration
PS	Performance Standards
PSU	Practical Salinity Unit
RAS	Recirculating Aquaculture System
ROV	Remotely Operated Video
SACFOR	Superabundant, Abundant, Common, Frequent, Occasional and Rare Abundance Scale
SAMSA	South African Maritime Safety Authority
SANBI	South African National Biodiversity Institute
SANCCOB	Southern African Foundation for the Conservation of Coastal Birds
SBES	Single-beam echo-sounding
SEL	Sound Exposure Level
SEL24h	24-hour SEL
SIMPER	Similarity Percentage Analysis
SOP	Standard Operating Procedure
SOPEP	A Shipboard Oil Pollution Emergency Plan

SPL	Sound Pressure Level
SPL_{peak}	Peak SPL
SPL_{rms}	Root mean square SPL
SPS	Subsea Production System
TEEPSA	TotalEnergies E&P South Africa
TL	Transmission Loss
UNCLOS	United Nations Convention on the Law of the Sea (1982)
VHF	Very High Frequency
VME	Vulnerable Marine Ecosystem
VMEI	Vulnerable Marine Ecosystem Indicator
VSP	Vertical Seismic Profiling
WBM	Water-Based Muds

1 INTRODUCTION

1.1 Background

Anchor Environmental Consultants (Pty) Ltd (Anchor) was appointed by WSP Group Africa (Pty) Ltd to undertake a Marine Ecological and Fisheries Impact Assessment specialist study for an Environmental and Social Impact Assessments (ESIA) submission on behalf of TotalEnergies E&P South Africa B.V. (TEEPSA). This ESIA is for an Environmental Authorisation application required in terms of the Production Right application submitted to TEEPSA for Block 11B/12B. The offshore Block 11B/12B Production Right Application Area (approximately 12 000 km^2) is found at 500-2 300 m depth, some 75 km offshore from Cape St. Francis to the east and 120 km offshore from Mossel Bay to the west (Figure 1-1). The Block (hereafter the Application Area) is divided into two areas of interest – a western Project Development Area, and the eastern Exploratory Priority Area (Figure 1-1).

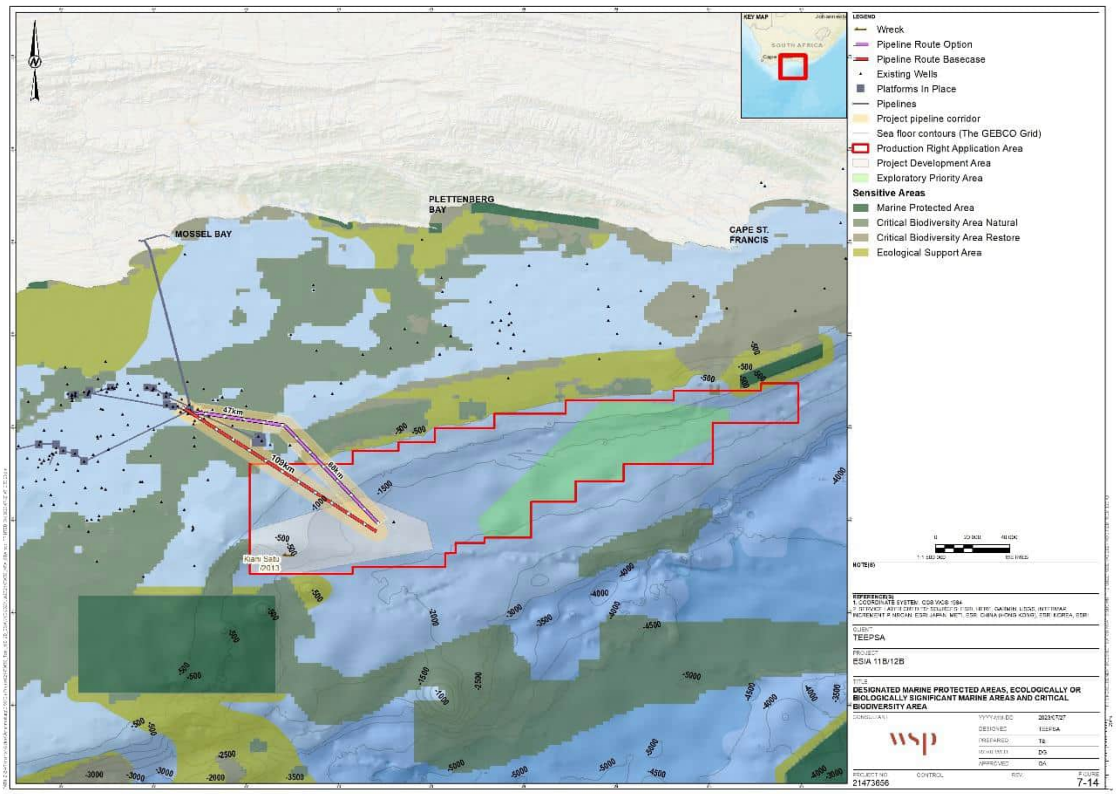


Figure 1-1. The Production Right Application Area (red) for Block 11B/12B and nearby designated Marine Protected Areas (MPAs) and Ecologically or Biologically Significant Marine Areas (EBSAs). The pipeline routing alternatives are indicated (WSP 2023a). The Project Development Area and Exploratory Priority Area are indicated.

1.2 PROJECT DESCRIPTION

1.2.1 DEVELOPMENT CONCEPT

The commercial viability of the hydrocarbon discovery in the Project Development Area was confirmed through technical and feasibility studies in 2019 and 2020. Both gas and condensate were identified as the potential hydrocarbon resources in the Production Development Area (WSP 2023a) (gas condensate is a mixture of low-boiling hydrocarbon liquids obtained by condensation of the vapours of these hydrocarbon constituents either in the well or as the gas stream emits from the well). The eastern and central area of the Block 11B/12B Production Right Application Area does not contain any wells; however, extensive 2D seismic surveys were acquired in 2020. It is also understood from these assessments that crude oil or gas and condensates are considered as the potential fluid type in these areas.

The development concept comprises the drilling of up to six development and appraisal wells in the Project Development Area, a subsea production system (SPS) to collect gas and condensate at the western sites, and a subsea pipeline to carry the gas and condensate to the existing F-A gas platform for further treatment and export (the western field is located approximately 109 km southeast of the existing F-A Platform) (Figure 1-2). Furthermore, up to four exploration wells will be drilled in the eastern Exploratory Priority Area (Figure 1-2).

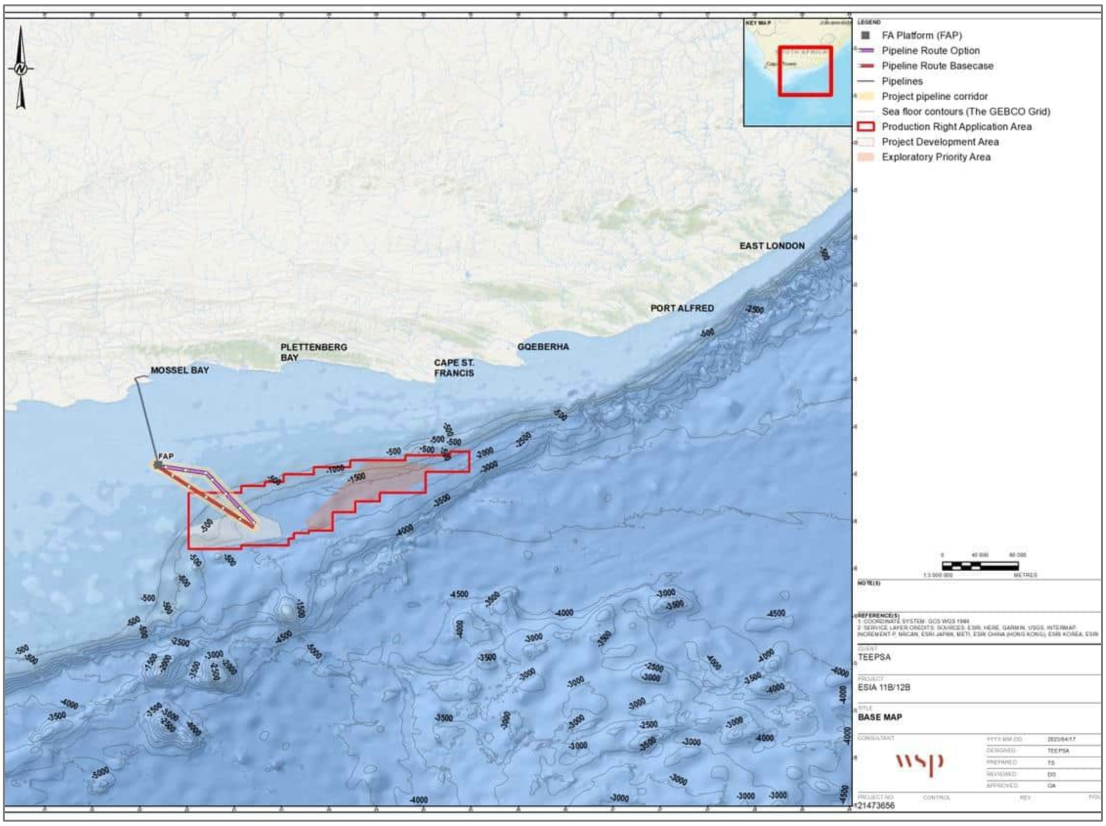


Figure 1-2. The Block 11B/12B Production Right Application Area (red) showing existing treatment and export facilities (WSP 2023a).

From the F-A Platform, gas and condensate will be conveyed via the existing PetroSA-operated gas and condensate pipelines onshore. The proposed development assumes no further production from the existing PetroSA fields, enabling the western production area development to exclusively use the offshore installation for the treatment and export of gas and condensate.

1.2.2 PROPOSED PROJECT ACTIVITIES

The proposed project activities are divided into Production and Exploration activities. The Production activities include the drilling of development wells and the installation of subsea infrastructure and the placement of production pipelines, while exploration activities include vertical seismic profiling (VSP), well logging and testing. Marine surveys (bathymetry and sonar surveys, seafloor sampling surveys and metocean surveys) will be undertaken at selected locations within Block 11B/12B, in support of the drilling activities.

DRILLING OF DEVELOPMENT WELLS

It is proposed that up to six development wells are drilled in the Project Development Area. Including mobilisation, the proposed time frame is to drill two development wells within Year 0 (120 days per well), one well in Year 1 (120 days per well), and two wells in Year 10 (120 days per well). These wells will ultimately be connected to F-A gas platform for further treatment and export i.e., the proposed development concept will connect up to six wells in the Project Development Area via a multiphase pipeline carrying both gas and associated condensates from the wells up to the F-A platform (DHI 2023). From there, it will be carried onshore for further treatment and exporting via the existing PetroSA-operated gas and condensate pipelines.

The current proposed approach is to have a combination of vertical wells and deviated wells connected with a manifold (WSP 2023a) (Figure 1-3). The preliminary well design is presented in Table 1.1. While there is currently no information available on the spatial extent of the gas field once all the infrastructure is installed and tied back to the production pipeline, the ESIA for Block 5/6/7 specified that the footprint of a single well cap equated to 27 m^2; the cumulative footprint of six development wells is expected to cover some 62 m^2.

Table 1.1. Preliminary well design. Note that the term "section" refers to individual portions of a single wellbore (WSP 2023a).

Section	Description
Conductor pipe	Drill 26" x 42" hole section and run 36" Conductor pipe. Drill [~90 meters below the mud line (BML)] and cement.
26" Hole section / 22" Surface Casing	Shallow hazard (SHAZ) assessment is performed to a depth of 1 000 m below mud line to avoid any gas bearing formations however the possibility of shallow water flow must be managed. Drill 26" hole 500-600 m below the mud line. The objective is to obtain good formation integrity test (FIT) at the 22" shoe, in order to safely circulated the kick without fracturing the shoe to be able to increase MW in the 14 ¾" hole section if necessary. Run and cement 22" casing up to seabed.
14 ¾" hole section / 10 ¾" casing	TD criteria: Geological (based on marker) Drill 14 ¾" hole section up to 50m above top of western Project Development Area reservoir (or as close as safely possible). Ensuring not entering the reservoir in this phase. Run 10 ¾" casing and cement 500m above the shoe. A contingency casing (13 5/8" or 14") will remain available to deploy in order to avoid any kind of uncertainties due to poor pressure and fracture gradient or potential open hole issues.

Section	Description
8 ½" open hole	Drill 8 ½" hole up to Max TD.

Drilling is proposed to be undertaken using a semi-submersible drilling unit[1], supported by one or two tugboats to keep it on location, and supply vessels. The final rig selection will be made depending upon availability and final design specifications. When at the well location, the pontoons are partially flooded (or ballasted) with seawater to submerge the pontoons to a pre-determined depth below the sea level where wave motion is minimised. This gives stability to the drilling vessel thereby facilitating drilling operations. Development wells will be drilled in the Project Development Area and exploration wells will be drilled in the Priority Exploration Area.

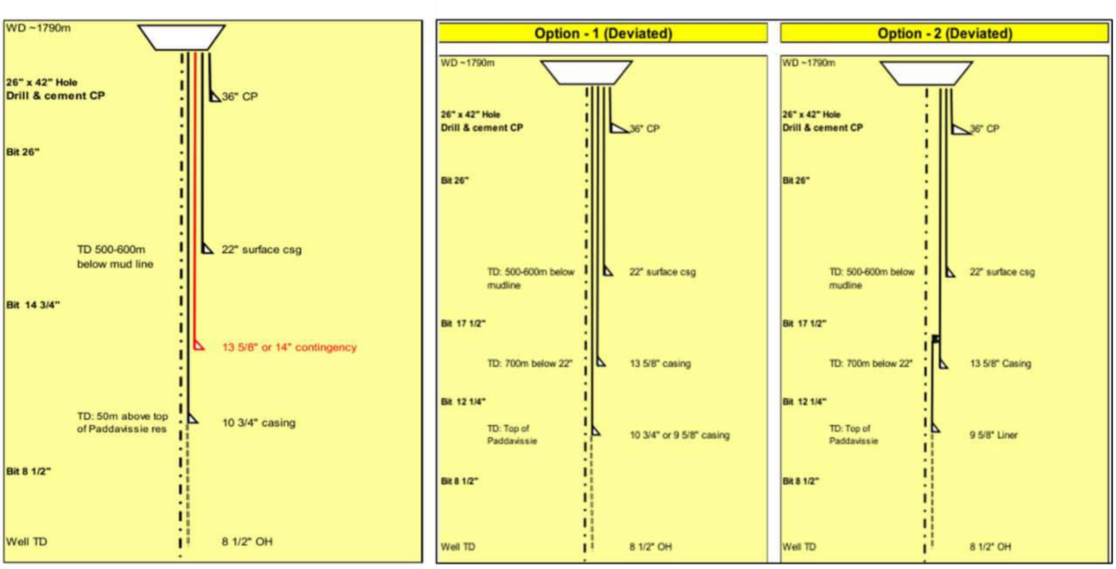


Figure 1-3. Vertical well design (left) and options for deviated wells (right) (WSP 2023a).

Drilling fluid is a mixture of fluids, chemicals and solids that are tailored to provide the correct chemical and physical characteristics that are required for safe drilling of a well (WSP 2023a). There are two types of drilling fluid: Water-Based Muds (WBM) and Non-Aqueous Drilling Fluids (NADF). WBM and NADF differ in terms of their chemical composition:

- The main ingredient of WBM is freshwater or seawater, making up to 85-90% of the total volume of the WBM. The remaining 10-15 % of the volume typically comprise of barite, potato or corn starch, cellulose-based polymers, xanthan gum, bentonite clay, soda ash, caustic soda and salts (these are usually either potassium chloride KCl or sodium chloride NaCl). Other minor additives may be used in special circumstances such as citric acid for pH control, or polyethylene glycol butyl ether for clay inhibition, amongst others (Aftab *et al.* 2016).
- NADF use a mineral oil derived base fluids with significantly reduced aromatics and extremely low polynuclear aromatic compounds. The main chemicals used in NADF consists of a base

[1] A semi-submersible drilling vessel is a drilling rig located on a floating structure of pontoons.

oil, brine, gelling products, lime and emulsifiers. NADFs base fluid and other chemicals have a higher toxicity than WBMs which may cause an increase in toxicity in the marine environment. The industry trend is moving towards the use of low toxicity NADF which is biodegradable (OGP 2003).

At this stage it is not anticipated that NADFs will be used in the drilling process for the Project. WBMs will be used in both the initial stages of well drilling (riserless stage) and in the riser stage of drilling. Preliminary well drilling fluid and cement details are provided in Table 1.2 and will be confirmed as detailed engineering progresses (WSP 2023a).

Table 1.2. Preliminary Drilling Fluid and cement detail (WSP 2023a)

Hole section	Casing type	Casing size	Type of drilling fluid	Cementing summary
26" x 42"	Conductor pipe	36"	Sea water/Hi-vis pills/ Pump and Dump (PAD) mud	Up to seabed
26"	Surface casing	22"	Sea water/Hi-vis pills/PAD mud	Up to seabed
14 3/4"	Production casing	10 3/4"	High performance Water	500m above the casing shoe
8 1/2"	Long round thread casing (LC)	7" liner	High performance Water based mud	To Be Confirmed (TBC)
-	UC	5 1/2" Tbg	Completion Brine (TBC)	NA

SUBSEA PRODUCTION SYSTEM (SPS)

A subsea system will connect the western Project Development Area wells to the F-A Platform (WSP 2023a). It is proposed to have a direct subsea tie-back to the F-A Platform via a new 18” riser. Subsea structures including Flow Line End Termination (FLET) and a production manifold at the end of the pipeline will allow the connection of the western wells (WSP 2023a). The weights and dimensions of subsea equipment that are planned (at this stage) to be deployed for the Project Development Area wells are presented in Table 1.3 below. From these dimensions, and the proposed number of units, the footprint of impact of subsea infrastructure (with 10% contingency) is calculated as 93 686 m^2 (Table 1.3). The inclusion of infrastructure to link the western Project Development Area sites has an additional footprint of 8 730 m^2 (4 995 t) (Groenewald E., Pers. Comm. 2023). The total area of impact of the proposed subsea infrastructure placement is therefore 1102 416 m^2 (54 478 t) (including a 10% contingency) (Table 1.3).

Table 1.3. Preliminary estimates of the area of impact derived from weights and dimensions of planned subsea equipment installation provided by TEEPSA for the western Project Development Area installations (Groenewald E., Pers. Comm. 2023)

Equipment	Number of units	Dimensions	Area of impact (m^2)	Weight (t)
Flowline (linear)	118 718 m	Diameter of 0.457 m	54 278	38 227
Umbilical (linear)	113 143 m	Diameter of 0.25 m	28 286	5 657
Flet	1 unit	2x2x2 m	8	40
Flextail	4 units			80
Manifold	2 units	6x6x3 m	2 376	500
Xtree + jumper + FL	3 units	4.5x4.5x3 m	182	300

Equipment	Number of units	Dimensions	Area of impact (m^2)	Weight (t)
Subsea pig launcher	1 unit	2.5x2.5x2.5 m	16	50
Spool	1 unit	2x2x2 m	8	30
Sdu	1 unit	2.5x2.5x2.5 m	16	50
Umbilical accessories	1 unit			50
Contingency (+10%)			**8 517**	**4498**
Installations connecting to western Project Development Area (+contingency)			**8 730**	**4 995**
TOTAL			**102 416**	**54 478**

The feasibility of installing pigging[2] facilities for the western Project Development Area pipelines is under study, and provision for temporary pigging facilities may be included.

The structure foundations for both the new manifolds and subsea structure are gravity based, but this is to be confirmed (WSP 2023a). The structures also house a subsea distribution unit, flowmeters, isolation valves and pressure and temperature monitoring instruments. Hydrate inhibitor methylethylene glycol (MEG) will be distributed to the wells via an umbilical[3]. Preliminary flow assurance studies place the MEG injection rates between 2 and 15 m^3/h (for ramp-up operations). MEG lines will be included in the umbilical, together with other chemicals as corrosion inhibitor.

PRODUCTION PIPELINES

A rigid 18" subsea pipeline/production line from western Project Development Area to the F-A Platform will form part of the project activities. Precise routing and the subsea locations will be informed by additional environmental baseline and subsea/ bathymetry surveys to avoid critical areas related to environmental sensitivities and soil stability. As such, there are two proposed pipeline routes: the first is ~109 km in length, and the second is 115 km in length. Due to the uncertainties, a corridor with a 10 km width for the proposed production pipeline route Basecase and pipeline route Option has been indicated in Figure 1-1.

FA PLATFORM MODIFICATION

The F-A Platform will require some modifications to connect the new 18" line arriving from western Project Development Area wells. Preliminary flow assurance studies were performed to determine the volume of slug in the line especially during the transient periods (WSP 2023a). Based on these studies, a new separator may be required to handle the cumulated liquid in the pipeline. A slug catcher

2 Pigging is a process in which highly viscous fluids are conveyed out of pipelines. The pig is a cleaning device that is pumped through the pipeline under pressure. Thus, contaminations are conveyed out of the piping.

3 An umbilical links sea floor and oil and gas equipment for controls, power and heat. They provide electric and fibre optic signals, electrical power and hydraulic and chemical injection fluids to the subsea unit.

then capable of handling around 300 m^3 of slug[4] is to be installed in the F-A Platform. Sizing and configuration of the slug catcher will be defined during conceptual studies. Considering the production profile and Condensate Gas Ratio (CGR) of the Project Development Area wells, an increase in the condensate treatment could also be envisaged. Additional pumps and coalescer vessel are foreseen to increase condensate capacity in the platform for treatment and export to Mossel Bay. Permitting requirements associated with the proposed F-A Platform modifications will be addressed by PetroSA as part of their production right and associated activities.

EXPLORATION ACTIVITIES

In addition to production phase, TEEPSA is considering additional exploration work in the eastern Exploratory Priority Area of Block 11B/12B (Figure 1-2) where potential for similar hydrocarbons exists (WSP 2023a).

Up to four exploration and appraisal wells are proposed in the eastern Exploratory Priority Area, with associated activities including vertical seismic profiling (VSP), well logging and testing. Final site selection for the wells will be based on further detailed analysis of the pre-drilling survey data and the geological target.

- Each well will be created by drilling a hole into the seafloor with a drill bit attached to a rotating drill, which crushes the rock into small particles, called “cuttings”. After the hole is drilled, casings of steel pipe (which provide structural integrity to the newly drilled wellbore), are placed in the hole and permanently cemented into place (WSP 2023a). The diameter of the well decreases with increasing depth.

- Once the target depth is reached, the well will be logged and tested. Well logging involves the evaluation of the physical and chemical properties of the rocks in the sub-surface, and their component minerals, including water, oil and gas to confirm the presence of hydrocarbons and the petrophysical characteristics of rocks. Vertical Seismic Profiling (VSP) is an evaluation tool that is used when the well reaches target depth to generate a high-resolution seismic image of the geology in the well’s immediate vicinity. The VSP images are used for correlation with surface seismic images and for forward planning of the drill bit during drilling. VSP uses a small airgun array, which is operated from the drilling unit. During VSP operations, receivers are positioned in a section of the borehole and the airgun array is discharged at intervals. This process is repeated for different stations in the well and may take up to 8-12 hours to complete (WSP 2023a).

- Well (flow) testing is undertaken to determine the economic potential of any discovery before the well is abandoned or suspended. One test would be undertaken per exploration well if a resource is discovered. Testing may take 3-4 days to complete and involves burning hydrocarbons at the well site (WSP 2023a). A high-efficiency flare is used to maximise combustion of the hydrocarbons. If produced water arises during well flow testing (typically in

[4] A slug is an uneven distribution of liquid and gas in a pipeline. Pipelines transport both gas and liquids in two-phase flow. Liquids tend to settle in the bottom of pipelines, while the gases occupy the top section. Under certain conditions, the liquids and gases may group together to form slugs.

small quantities), these would be treated on-board to separate the hydrocarbons from seawater. The treated water would be discharged to sea (WSP 2023a).

- Once drilling and logging have been completed, the exploration well(s) will be sealed with cement plugs, tested for integrity and abandoned according to international best practice. Wells will be left on the seafloor with an abandonment cap (approximately 5 x 5 m with a height of 4 m, designed to allow for overtrawling) (WSP 2023a). For wells where a hydrocarbon resource is confirmed, a monitoring gauge may be installed on the wellhead (under the cap) to monitor pressure and temperature.
- A final clearance survey of the seabed will be undertaken using an ROV. The drilling unit and supply vessels will demobilise from the offshore licence area and either mobilise to the next drilling location or relocate into port or a regional base for maintenance, repair or resupply (WSP 2023a).

FULL BLOCK SURVEYS AND DATA COLLECTION ACTIVITIES

At specific locations within the Application Area, TEEPSA is proposing to deploy metocean buoys to measure oceanographical, meteorological and possibly acoustic data, i.e., currents, waves, water temperature, ambient water noise levels, wind and air parameters. The metocean survey scope will be defined depending on the need for complementary parameters for the highly dynamic weather conditions expected in this area. The wave buoy would require a temporary safety zone of between 500 m and 2 km radius on the sea surface (depending on the water depth). All vessels would be excluded from entering this safety zone.

Sonar surveys will be used to investigate the structure of the seabed (bathymetry) across approximately 50 km^2 for the development area and along the pipe routing (WSP 2023). Sonar surveys will be conducted from a vessel and might use multi-beam echo-sounding (MBES), single-beam echo-sounding (SBES), and/or sub-bottom profiling. Such surveys entail transmitting frequency pulses down to the seafloor to produce a digital terrain model and identify any seafloor obstructions or hazards. It has been assumed that sonar surveys will be carried out using a Kongsberg EM 712 MBES system (or equivalent). Sonar surveys are expected to occur within the development area and along the pipeline route. These surveys are expected to last 15-30 days and will be conducted between 1 December-31 May (to avoid the presence of marine mammals) (WSP 2023a).

Seafloor sampling will possibly be undertaken to collect sea floor sediment samples for environmental baseline data collection and studies as well as for monitoring of the environment during/post operations. It can also be used to supplement geotechnical and geophysical studies.

1.3 DATA SOURCES

A description of the proposed project activities and the development concept is sourced from the WSP (2023a) Scoping Report for the proposed offshore production right and environmental authorisation applications for the Application Area undertaken as part of the Environmental and Social Impact Assessment (ESIA).

Much of the information on the receiving environment is sourced from previous specialist studies supporting various Environmental Authorisation (EA) applications for the Block 11B/12B Application Area, including Pulfrich (2021), Pisces (2014, 2018, 2019), Atkinson (2010), CCA Environmental (2010), and SLR (2021).

Data on benthic habitats and biodiversity are sourced from Sink *et al.* (2010), Atkinson (2010), Shipton & Atkinson (2010) and Quick & Sink (2005), and the Deep Secrets Offshore Research survey undertaken by the National Research Foundation and African Coelacanth Ecosystem Programme in 2016 (Sink *et al.* 2021). The preliminary benthic infaunal and epifaunal results of the 2022 in situ Environmental Baseline Survey of Block 11B/12B are also included in this assessment (BSL 2023). The most recent Marine Mammal Observer data is provided as part of this as part of this Environmental Baseline Survey (BSL & CapMarine 2023).

Considerable work has been undertaken in assessing and protecting South Africa's marine, coastal and estuarine systems. Marine Spatial Planning (MSP) is prioritized as an initiative to enhance South Africa's Economy and many of the reports and data produced to support MSP around South Africa's coast have contributed to this assessment. They include:

- The National Framework on Marine Spatial Planning in South Africa provides guidance on MSP on the national level. It specifies the objectives of MSP and outlines the process.
- The Marine Spatial Planning Act, 2018 (Act No. 16 of 2018) provides the legal basis for MSP in South Africa.
- The National Biodiversity Assessment (NBA) is the primary tool for monitoring and reporting on the state of biodiversity in South Africa. It is used to inform policies, strategies and actions for managing and conserving biodiversity more effectively.
- Chapter 12 of the National Biodiversity Assessment (Driver *et al.* 2012) provides a summary of provincial spatial biodiversity plans, which produce maps of Critical Biodiversity Areas and Ecological Support Areas.
- SANBI's Biodiversity GIS (BGIS) online portal, which is a mapping platform that allows users to visualise and download important biodiversity features, reports and spatial datasets.
- Marine Living Resources Act 18 of 1998 (as amended) (MLRA), the National Environmental Management: Protected Areas Act (Act No. 57 of 2003) (NEM: PAA), and the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM: BA). All of these acts provide explicit protection for living and non-living resources below the high-water mark only (viz. the MLRA) or above the high-water mark only (the rest).
- National Environmental Management: Protected Areas Act 2003.

The Department of Fisheries, Forestry, and the Environment (DFFE) has spatially referenced up-to-date data on catch and effort for most commercial fisheries in South Africa. This fisheries data was acquired through a PAIA (Promotion of Access to Information Act) submitted by Anchor. The Promotion of Access to Information Act, 2000, is a freedom of information law in South Africa. It gives the constitutional right of access to any information held by the State. A summary of the data accesses through this PAIA request is outlined in Table 1.4.

This spatially referenced catch and effort data were processed, cleaned (error checked) and normalised. Source data and an overview of data processing steps are outlined in Appendix 2. Data were mapped using spatial reference data provided with each record and fishing location, plus catch in kg, were both used as the unit of 'effort'. Effort data were summarised across the south coast area of

South Africa only (in the area between imaginary lines drawn due east from the mouth of the Great Kei River (32°40'6S, 028°23'1E), and due south from Cape Agulhas (020°E longitude)), as this corresponded with the locations of Block 11B/12B. Data were summarised using a 1 x 1km grid to produce an overall 'footprint' for each fishery. A 1 km grid was chosen to prioritise spatial resolution at a scale appropriate for the analysis, assessment of impacts and interpretation. 1 km grid cells were considered a balance between overall processing time and effort required based on high resolution and level of. Raw values (e.g. number of trips, CPUE) were normalised to deal with skewed distributions (especially where some extremely high values may mask the overall picture) and converted to a standardised range (0-100) (Sink *et al.* 2019). For some datasets, additional steps were taken to further normalise data. In some cases, pressures were split into ten quantiles. For each fishery, where applicable, gridded data were edited where spatial restrictions are currently in place (e.g., fishing effort inside restricted MPAs were removed from the footprint).

Table 1.4. Overview of commercial fisheries catch and effort data received through Promotion of Access to Information Act data request to DFFE (request submitted 24th February 2022, data received 30th August 2022).

Commercial fishery	Data type(s)	Date range	Spatial resolution
Hake inshore and offshore trawl	Catch and effort	2009-2019	Point data (decimal degrees)
	Observer data	2008-2010	n/a
Commercial line fishery	Catch and effort	2010-2020	National Marine Linefish System grid cells
Hake longline	Catch and effort	2010-2022	Point data (decimal degrees)
	Observer data	2010-2011	n/a
Mid-water trawl	Catch and effort	2009-2019	Point data (decimal degrees)
Squid fishery	Catch and effort	2012-2019	5' x 5' grid cell

For fisheries where up to date data were not supplied as part of the PAIA request the next best available spatial dataset was used. Fisheries Intensity Layers are data used in the NBA 2018 assessment (Sink *et al.* 2019). The most appropriate measure (i.e., units such as effort or catch in the case of fisheries) to represent each pressure in the context of ecosystem degradation were selected for these layers. Pressures were summarised across the seascape using the 30 x 30 m pixels to produce a national map of intensity for each pressure. These raw values were normalised to deal with skewed distributions (especially where some extremely high values may mask the overall picture) and converted to a standardised range (0-100). For some datasets, additional steps were taken to further normalise data (see Majiedt *et al.* 2019). Where PAIA data was not available or not requested (e.g., South Coast Rock Lobster) these Fisheries Intensities Layers were used.

Data on the impacts of noise generated by proposed project activities (and in particular, drill rig operations and sonar surveys) on various marine groups (marine mammals, fish, turtles, diving birds) was generated by an underwater noise modelling study undertaken by WSP (2023b).

Impacts of the discharge of drill cuttings and water-based muds resulting from the proposed drilling activities were modelled in the western Project Development Area by Ditlevsen (2023), and by HES (2020) for wells in the eastern Exploratory Priority Area. The studies assessed impacts on both sediment and water quality of the introduction of toxic compounds, decreased oxygen levels, deposition of particle matter on the sea floor and changes in sediment grain structure.

Spill modelling based on predetermined loss of containment (LOC) scenarios associated with gas well and subsea production system operations within the western Project Development Area was undertaken by DHI (2023). Two modelling scenarios were analysed: 1) a Block 11B/12B well blowout with condensate LOC at Discharge-5, and 2) full pipeline rupture of condensate in the middle of the Critical Biodiversity Area (as defined in Section 4).

For the eastern Exploratory Priority Area wells, a crude oil spill was modelled by H-Expertise Services S.A.S (HESHES 2020c, d). A crude oil spill was considered at two sites (Discharge-1 and Discharge-2) that represent worst-case scenarios with respect to depth (1 254 m and 690 m, respectively), distance from the coast (89 km and 98km from the nearest shore, respectively) and proximity to areas of ecological sensitivity and significance.

1.4 Assumptions and limitations

The study is based on details provided by the client as they pertain to planned infrastructures design, proposed activities and sites etc. Given the nature of the activities for the Project, certain aspects of the Project are unknown at the time of the preparation of the ESIA and will only be resolved at a detailed design stage or once the project commences.

- The timeframe for the exploration activities is currently not known and could occur at any time within the 15 to 20-year life of the Project.
- The exact location of the production and exploration wells is not known. The production wells will be located in the south-western portion of the block within the Project Development Area, while the exploration wells will be located within the east north-eastern portion of the block, in the Exploration Priority Area. For the purposes of the marine acoustics modelling, drill cuttings discharge modelling and oil spill modelling, locations have been selected based on a number of factors, such as proximity to sensitive receptors, so that the assessment is based on a worst-case scenario.
- The exact alignment of the proposed production pipeline is not known. A 10 km wide corridor along the length of the proposed production pipeline alignment is considered for assessment purposes. The final pipeline alignment will be confirmed pending the outcome of further bathymetry, geotechnical and benthic surveys within the corridor.
- The location of offshore survey and data collection sites are not yet known but will likely be conducted along the production pipeline corridor and the drilling sites in the Project Development Area and Exploration Priority Area.
- The ESIA considers the assessment of exploration activities in the east north-eastern section of the block but does not aim to identify or assess the impacts or benefits of possible future production activities or outcomes in this section of the block.
- The assessment of cumulative impacts is based on information for offshore and onshore activities that have been authorised or an application for environmental authorisation has been submitted (ESIA Chapter 11).
- The assessment of the significance of impacts of the Project on the affected environment are based on the assumption that the activities are limited to those described in Section 1.2. If any substantial changes are made to the project description, impacts may need to be reassessed.

The accuracy and confidence of this study is dependent on the data available for the marine and coastal environments of the south coast and the concession area itself.

- The assessment of the offshore infaunal benthic biodiversity on the Agulhas Bank is largely desktop based, with some new in situ data that was made available for this assessment. The general understanding of the invertebrate fauna of the South African at these depths is relatively poor, as is the conservation status of any of the invertebrate species in these habitats (Pisces 2018, 2019). Available data are over ten years old and are sourced from the Sink *et al.* (2010) survey, as well as from Shipton & Atkinson (2010) and Quick & Sink (2005). The latter two studies were compiled as part of the EIAs for the development of the F-O Gas Field and the South Coast Gas project respectively (Pisces 2019). The Sink *et al.* (2010) study included analysis of ROV footage taken in reef and unconsolidated habitats and on gas-field infrastructure, SAT diver collections, trap sampling and grab sampling as part of the dedicated PetroSA-WWF study, while Quick & Sink (2005) collated records from the South African Museum of species from the Agulhas Bank area. This included a wide variety of seapens, alcyonacean soft corals, gorgonians and ascidians, many of which are regarded as endemic to the bioregion (Quick & Sink 2005).

- The preliminary results of a benthic infaunal and epifaunal assessment of the Block 11B/12B Application Area undertaken aboard the Bourbon Evolution 807 (Bourbon – BE807) are included in this assessment (BSL 2023). TEEPSA contracted Benthic Solutions Limited (BSL) to undertake a regional Environmental Baseline Study in Blocks operated by TotalEnergies E&P Namibia (TEEPNA, Blocks 2913B and 2912) and South Africa (TEEPSA, Blocks DWOB, 5/6/7 and 11B/12B). Anchor was subcontracted for this work to provide local support and expertise, specifically with regards to benthic invertebrate identification. The third and final phase of the wider regional campaign, undertaken from mid-November to mid-December 2022, included surveys conducted in Block 11B/12B and a small portion of the adjacent Block 9, located off the south coast of South Africa (Dawson *et al.* 2022). The Environmental Baseline Study (BSL 2023) presents the findings of the habitat investigation, ground truthing and environmental baseline assessment conducted across Block 11B/12B, including the proposed pipeline corridors. The aim of the survey was to document any pre-existing pollution and existing anthropogenic impacts within the Block, identify sensitive habitats or species susceptible to disturbance from drilling related activities, as well as establish an understanding of the natural variation in environmental conditions against which the environmental impact of future oil and gas operations can be assessed (BSL 2023). It comprised the collection of environmental samples from the seabed and water column, along with seabed video and stills imagery. Marine megafauna and the presence of marine user groups (e.g., shipping, fishing, marine mining) was also opportunistically recorded (BSL & CapMarine 2023).

  The survey included characterisation of the seabed and water column physico-chemistry and biology, as well as monitoring of anthropogenic activity (i.e., vessel traffic) and opportunistic observations of marine megafauna by marine mammal observations (MMO) and passive acoustic monitoring (PAM), to provide an understanding of the baseline conditions prior to commencing any further drilling activities (BSL 2023, BSL & CapMarine 2023). The sampling effort was designed to account the following:

    - Priority areas identified for development and exploration activities (including drilling).
    - Existing subsea infrastructures, including areas of potential impacts from drilling operations.

   - Sensitive and potential biodiversity interest areas (e.g., canyons, mud volcanos etc.).
   - Bathymetry and sediment type variation.
   - Opportunistic records of marine fauna and user groups
   - Reference locations situated a sufficient distance from potential impacts.
- The assessment of impacts based on modelling results is dependent on the accuracy of those model results (DHI 2023).
   - The drill discharge modelling systems did not make provision for changes to the sediment due to resuspension and transport by currents. Therefore, results pertaining to the duration of impact on benthos and associated sediments are likely to be highly conservative, especially in the context of redistribution of sediments by the Agulhas Current.
   - The figures of drill discharge modelled sediment results presented by HES (2020a, b) are presented in different ways depending on whether or not the smoothing (contouring) post treatment option is activated. Smoothing is useful to better visualise contour concentrations, especially for a low-resolution run, when maps are highly pixelated, and to interpolate/average the concentration among a zone leading to a decrease in the absolute maximum value of all variables calculated. (HES 2020a, b).
   - The properties of the hydrocarbon in the model's database does not precisely match those expected for the exploration well (HES 2020c, d). The properties and behaviour of the hydrocarbon spilled in a dynamic marine environment may vary slightly to those outputs produced, as is intrinsic to all modelling (HES 2020c, d).
- The impacts of sedimentation processes in the fate of both condensate and crude oil in the marine environment as a result of spills was not included in the spill modelling assessment for either the western Project Development Area or the eastern Exploratory Priority Area (DHI 2023, HES 2020c, d). While literature suggests that sedimentation is often limited compared to other weathering processes (see for example Guo *et al.* 2022), and these processes are likely to be limited in the Agulhas where water column turbidity is low and is only likely to be significant in nearshore environment (DHI 2023), details pertaining to these have not been provided in these modelling studies. It is assumed therefore that the studies deems these processes to be an insignificant mechanism. Given the assumption above, assessment of the impacts, and in particular, the impacts of crude oil on the benthic environment, was undertaken with a medium level of confidence.

2 LEGISLATIVE CONTEXT

The key pieces of South African legislation that are applicable to the environmental impacts of the proposed production and exploratory activities are presented below. These acts and their related regulations govern the legal requirements, the application processes to be followed and stipulate where exploration activities may or may not occur.

2.1 NATIONAL LEGISLATION

In terms of Section 24 of the Constitution of South Africa, 1996 (No. 108 of 1996) "*everyone has the right:*

a) to an environment that is not harmful to their health or well-being; and

b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that;

i. Prevent pollution and ecological degradation;

ii. Promote conservation; and

iii. Secure ecologically sustainable development and use of natural; resources while promoting justifiable economic and social development".

2.1.1 NATIONAL ENVIRONMENTAL MANAGEMENT ACT (NO. 107 OF 1998)

The National Environmental Management Act (No. 107 of 1998) (NEMA) as amended, provides for the incorporation of environmental considerations in decision-making. Section 2 of NEMA sets out the National Environmental Management principles. Section 2(3) states that "*development must be socially, environmentally and economically sustainable*". Section 2(4) states that:

c) "Sustainable development requires the consideration of all relevant factors including the following:

i. That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;

ii. That pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied;

iii. That the disturbance of landscapes and sites that constitute the nation's cultural heritage is avoided, or where it cannot be altogether avoided, is minimised and remedied;

iv. That waste is avoided, or where it cannot be altogether avoided, minimised and re-used or recycled where possible and otherwise disposed of in a responsible manner;

v. That the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource;

vi. That the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised;

vii. *That a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and*

viii. *That negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied".*

and "*The costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment.*"

Chapter 5 of NEMA sets out a suite of environmental management tools designed to ensure the integrated environmental management of activities. In accordance with this chapter, activities that have the potential to impact on— (a) the environment; (b) socio-economic conditions: and (c) the cultural heritage, need to be identified and must be considered. investigated and assessed prior to their implementation and reported to the organ of state charged by law with authorizing. permitting, or otherwise allowing the implementation of such an activity. Activities that require authorisation are Listed in Listing Notices 1, 2 and 3 published in terms of the Environmental Impact regulations of 2014.

Section 30 of NEMA deals with the control of emergency incidents and is therefore relevant to oil spills. An emergency incident is defined as an unexpected sudden occurrence leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed. In the event of an emergency incident, the responsible person must, as soon as possible, take all reasonable measures to contain and minimize the effects of the incident, undertake clean up procedure, remedy the effects of the incident and assess the immediate and long-term effects of the incident on the environment and public health. The possible actions of a relevant authority are described, as well as what should happen should the responsible person for to comply with a directive.

Under Section 24J of NEMA, the DFFE published National Biodiversity Offset Guidelines 2023 (Government Gazette 48841) to fulfil Section 2(4)(a)(i) of NEMA, which provides that "*sustainable development requires the consideration of all relevant factors including the following: … that the disturbance of ecosystems and loss of biodiversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied*." Government gazette No. 46088 (25 March 2022) defines the term "remedy" to include the rehabilitation and/or restoration of areas disturbed by development as well as biodiversity offsetting. Biodiversity offsetting is required when a proposed activity would have a significant residual negative biodiversity impact after all efforts have been made to avoid and minimise negative impacts on biodiversity and to rehabilitate and/or restore areas disturbed by development. The Guidelines note that the measures for 'offsets' must be read in the context of the mitigation hierarchy provided for in section 2(4)(a)(i) of NEMA as well as the Overall Policy on Environmental Offsetting.

2.1.2 National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008)

The National Environmental Management: Integrated Coastal Management Act 24 of 2008 (ICMA) is the primary environmental legislation responsible for the integration and coordination of various coastal and marine management efforts. This integrated coastal management addresses the governance of human activities affecting the sustainable use of goods and services generated by coastal and marine ecosystems.

Chapter 8 of ICMA controls marine and coastal pollution. Section 58(1) of ICMA places the duty of care requirement, as prescribed in Section 28 of NEMA, explicitly on any person who produced or discharged a substance which caused, is causing or is likely to cause, an adverse effect on the coastal environment. Section 28 of NEMA provides that every person who causes, has caused, or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from continuing or in so far as such harm to the environment is authorized by law or cannot be reasonably avoided or stopped, to minimize and rectify such pollution or degradation of the environment. The steps in this section include the taking of measures to control pollution causes, prevention of the movement of pollutants, elimination of the pollution source and remedying the effects of the pollution.

2.1.3 The Marine Living Resources Act 18 of 1998 (as amended)

The objectives and principles of the Marine Living Resources Act (MLRA) deal with the management of marine living resources, the need to protect whole ecosystems, preserve marine biodiversity and minimize marine pollution, as well as to comply with international law and agreements. The Act was amended in 2014 (Marine Living Resources Amendment Act 5 of 2014, commencement date 8 March 2016) to define 'small scale fishers' (Section 1), and to include 'subsistence fishers' within the definition of 'small scale fishers'.

2.1.4 Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)

The Mineral and Petroleum Resources Development Act (MPRDA) (No. 28 of 2002), as amended, is the principal legislation governing prospecting and mining and the exploration and production of oil and natural gas. The MPRDA gives effect to Section 24 of the Constitution by ensuring that South Africa's mineral and petroleum resources are developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development.

The MPRDA Regulations (GN R527 of 2004) provide for the application for and issuing of Reconnaissance Permits, Prospecting Rights, Exploration Rights, Mining Rights and Production Rights. Since 8 December 2014, environmental regulation of prospecting, mining, exploration and production and related activities has been removed from the MPRDA and transferred to NEMA.

2.1.5 National Environmental Management: Protected Areas Act (Act 57 Of 2003)

The National Environmental Management: Protected Areas Act 57 of 2003 primarily provides for the protection and conservation of ecologically sensitive areas and those which are representative of the Republic's biological diversity.

Chapter 2 states that Marine Protected Areas declared as such in terms of Section 43 of the Marine Living Resources Act, 1998 (Act No. 18 of 1998), and which exists when the National Environmental Management: Protected Areas Amendment Act, 2014, takes effect, must be regarded as a marine protected area declared as such in terms of Section 22A.Chapter 3 of the Act empowers the Minister to declare an area to be a Marine Protected Area (MPA) where various activities are prohibited. According to Section 48:

"*Despite any other legislation, no person may in a marine protected area… discharge or deposit waste or any other polluting matter and in any manner which results in an adverse effect on the marine* *environment, disturb, alter or destroy the natural environment or disturb or alter the water quality or abstract sea water…*"

The act states that Marine Protected Areas declared align with the Governmental strategy on the establishment and management of buffer zones around national parks to better meet their objectives and this applied to the Marine Protected Areas.

2.1.6 NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT (ACT 10 OF 2004)

The National Environmental Management: Biodiversity Act 10 of 2004 (NEM: BA) provides for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 1998; the protection of species and ecosystems that warrant protection; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment and functions of a South African National Biodiversity Institute; and for matters connected therewith.

As per Section 43, "*Any person, organisation or organ of state desiring to contribute to biodiversity management may submit to the Minister for his or her approval a draft management plan for… (b) an indigenous species- (i) listed in terms of section 56; or (ii) which is not listed in terms of section 56 but which does warrant special conservation attention*"

The NEM: BA Alien and invasive species regulations (2014) restricts the spread of listed invasive species through: transfer, release, discharging or disposing in waterways or oceans, catch and release, introduction to offshore islands, release into a discrete catchment system. It requires that a risk assessment should be carried out for listed species so ascertain likelihood of naturalisation and vector pathways.

NEM: BA Threatened or Protected Species Regulations (2007) provide a national approach to sustainable use of species that were threatened with extinction, or in need of national protection, while ensuring the survival of the species in the wild, thus ensuring the conservation of the species. NEM: BA enables the Minister to prohibit activities that may impact on the survival of species in the wild, and to regulate activities to ensure sustainable use of indigenous biological resources.

2.1.7 BIODIVERSITY MANAGEMENT PLAN FOR THE AFRICAN PENGUIN (2013)

The Biodiversity Management Plan for the African Penguin was developed and gazetted in terms of section 43 of NEM: BA, as the African penguin is listed as "Protected" in terms of Section 56 of NEM: BA.

One of this plan's objectives is to *"[m]inimise and/or mitigate the impact of catastrophic events and other key pressures and risks on African penguins*". Another objective is to "*minimise the impact of pollution (oil, hazardous and noxious substances) on African penguins through preventing spills, ensuring adequate preparedness, appropriate response and monitoring success*." The plan provides for actions which should take place to achieve these objectives.

Currently, the Draft African Penguin Biodiversity Management Plan has been gazetted for comment (in 2022).

2.1.8 South African Maritime Safety Authority Act (Act 5 of 1998)

This Act provides for the establishment of the South African Maritime Safety Authority (SAMSA). The objectives of SAMSA are to ensure the safety of life and property at sea, prevention and combat of pollution of the marine environment by ships and the promote the Republic's maritime interests. This Act assigns the responsibility for matters relating to the combating of pollution mentioned in Marine Notice No. 2 of 1996 issued by the Department of Transport on 24 January 1996 to the Department of Environmental Affairs.

2.1.9 Maritime Zones Act (Act 15 of 1994)

Section 10 of the Maritime Zones Act 1994 (Act 15 of 1994) states that: "*notwithstanding this Act or any other law the Republic may, in any area of the sea or the airspace above the sea, take such measures as are necessary against any vessel or aircraft in order to protect the coastline of the Republic or related interests, including fishing, from pollution or any threat of pollution resulting from a maritime casualty or an act or omission relating to such a casualty and which may reasonably be expected to result in major harmful consequences*".

2.1.10 Marine Spatial Planning Act (Act 16 of 2018)

The Act is built on the National Framework for Marine Spatial Planning (MSP) in South Africa (2017), which provides guidance on MSP on the national level. It specifies the objectives of MSP and outlines the process. The objectives of the Marine Spatial Planning Act (Act 16 of 2018) include the development and implementation of a shared marine spatial planning system to manage a changing environment that can be accessed by all sectors and users of the ocean, the conservation of the ocean for present and future generation and the facilitation of responsible use of the ocean. Where there is a conflict between existing uses, developing uses or activities, maximum coexistence of uses or activities should be preferred wherever possible but where such coexistence is not possible, the principles in Section 5(1) must be applied to resolve such conflict i.e., a precautionary approach must be applied. This approach must account for, inter alia, the sustainable use, growth and management of the ocean and its resources (5.1.a), the identification of economic opportunities which contribute to the develop-ment of the ocean economy (5.1.b), the promotion of collaboration and responsible use of the ocean through consultation and cooperation (5.1.c), the advancement of an ecosystem and earth system approach to ocean management which focuses on maintaining ecosystem structure and functioning within a marine area (5.1.c), adaptive management (5.1.e) and the reliance on the best available scientific information (5.1.h).

Section 5 describes the principles and criteria for Marine Spatial Planning. The precautionary approach is advised when following the principles, which include the sustainable use, growth and management of the ocean and its resources, the advancement of an ecosystem and earth system approach to ocean management which focuses on maintaining ecosystem structure and functioning within a marine area, the promotion of equity between and transformation of sectors, and the principle of good administration coherent and holistic planning and management.

Building on the Marine Spatial Planning Act (Act No. 16 of 2018) and the National Framework for Marine Spatial Planning in South Africa, DFFE published the Proposed Approach to Spatial Development and Management for South Africa's Marine Planning Areas in 2019. The document translates the overarching vision and high-level directions for developing South Africa's ocean space into a spatial management system that applies to all Marine Planning

Areas[5]. This document specifically provides for a "zoning scheme" system, which defines categories of sea use that inform the Draft marine sector plans (currently out for public comment).

2.1.11 Marine Pollution (Control and Civil Liability) Act (Act 6 Of 1981)

This Act provides for the protection of the marine environment from pollution by oil and other harmful substances and provides for liability following a discharge which causes pollution of the sea (which includes oil spills).

This Act describes the powers of SAMSA to take steps for the prevention of pollution of the sea where a harmful substance is being or is likely to be discharged from a ship or tanker. This Act also provides for the liability and cost-bearing of any loss or damage caused by pollution resulting from the discharge or oil and the measures taken after a discharge has occurred or in its prevention.

2.2 International Treaties and Obligations

2.2.1 Marine Pollution

Relevant international conventions and treaties regarding the prevention or management of marine pollution which have been ratified by the South African Government and which have become law through promulgation of national legislation are listed in Table 2.1 below.

Table 2.1. Ratified international conventions and treaties for the prevention or management of marine pollution.

Title	Description
United Nations Convention on the Law of the Sea (1982)	The UNCLOS convention imposes a general obligation on states to protect and preserve the marine environment, with further provision that that states shall take all measures to prevent, reduce and control pollution of the marine from any source, using for this purpose the best practicable means at their disposal and in accordance with their capabilities. This convention requires states to establish international rules and standards for the prevention, reduction and control of pollution of the marine environment from vessels and to promote the adoption of systems for the minimisation of the threat of accidents which might cause pollution of the marine environment, including the coastline, and pollution damage to the related interests of coastal states. This convention applies to the entire marine environment and is a global and legally binding agreement that holds member states responsible for their role in protecting and conserving the marine environment. Of particular importance is Part XII. Protection and Preservation of the Marine Environment: • Section 5 deals specifically with international rules and national legislation to prevent, reduce and control pollution of the marine environment. Article 208 (Pollution from seabed activities subject to national jurisdiction) requires:

5 A "marine area plan" is defined by the Marine Spatial Planning Act (Act 16 of 2018) as "a plan developed within a marine area by analysing and allocating the spatial and temporal distribution of human activities in the South African waters to achieve ecological, economic and social objectives, taking into account all relevant principles and factors set out in this Act".

Title	Description
	i. *Coastal States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with seabed activities subject to their jurisdiction and from artificial islands, installations and structures under their jurisdiction, pursuant to articles 60 and 80.* ii. *States shall take other measures as may be necessary to prevent, reduce and control such pollution.* • Section 5, Article 209 (Pollution from activities in the Area) requires: ii. *Subject to the relevant provisions of this section, States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from activities in the Area undertaken by vessels, installations, structures and other devices flying their flag or of their registry or operating under their authority, as the case may be. The requirements of such laws and regulations shall be no less effective than the international rules, regulations and procedures…. States shall take other measures as may be necessary to prevent, reduce and control such pollution.*
The International Convention for the Prevention of Pollution from Ships (1973)	The MARPOL convention is the main international convention concerned with the prevention of pollution of the marine environment from ships by operational or accidental causes, to which South Africa is a signatory. The Convention includes regulations aimed at preventing and minimizing pollution from ships and contains six technical annexes which set out detailed rules and standards. MARPOL 73/78 was developed by the International Maritime Organisation (IMO) with an objective to minimise pollution of the oceans and seas, including dumping, oil and air pollution. All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail, and member nations are responsible for vessels registered on their national ship registry. Annexure I of MARPOL contains the regulations for the prevention of pollution by oil and is mandatory for state parties. The Annexure deals with control of discharge of oil by stipulating the conditions under which ships may discharge water/oil mixtures into the sea. The regulations also define the requirements for the operation, construction, and equipment of tankers larger than 150 GRT and other ships larger than 400 GRT. The Marine Pollution (Prevention of Pollution from Ships) Act 2 of 1986 incorporates the convention and annexure 1 into South African domestic law. The other MARPOL Annexes are divided by pollutants category, each of which deals with the regulation of a particular group of ship emissions. • Annex II: Control of pollution by noxious liquid substances in bulk. • Annex III: Prevention of pollution by harmful substances carried by sea in packaged form. • Annex IV: Pollution by sewage from ships. • Annex V: Pollution by garbage from ships. • Annex VI: Prevention of air pollution from ships.
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972) and the 1996 Protocol	The London Convention (1972) is an agreement to control pollution of the sea from dumping and to encourage regional agreements supplementary to the Convention. It covers the deliberate disposal at sea of wastes or other matter from vessels, aircraft and platforms. It does not cover discharges from land-based sources, such as pipes and outfalls, wastes generated incidental to normal operation of vessels, or placement of materials for purposes other than mere disposal, providing such disposal is not contrary to aims of the Convention.
International Convention Relating to Intervention on the High Seas in Case of Oil Pollution Casualties (1969) and Protocol on the Intervention on the High Seas in cases of Marine Pollution by Substances other than oil (1973)	This Convention is an international maritime convention affirming the right of a coastal State to "*take such measures on the high seas as may be necessary to prevent, mitigate or eliminate grave and imminent danger to their coastline or related interests from pollution or threat of pollution of the sea by oil, following upon a maritime casualty or acts related to such a casualty*".

Title	Description
International Convention for the Control and Management of Ships' Ballast Water and Sediments (2017)	This Convention aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments.
International Convention on Oil Pollution Preparedness, Response and Co-Operation (1990)	The OPRC Convention is an international maritime convention establishing measures for dealing with marine oil pollution incidents nationally and in co-operation with other countries
Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal (1989)	This Convention is an international treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. It does not, however, address the movement of radioactive waste.

2.2.2 MARINE BIODIVERSITY AND ECOSYSTEMS

Relevant international conventions and treaties regarding the management and protection of marine biota and ecosystems which have been ratified by the South African Government and which have become law through promulgation of national legislation are detailed in Table 2.2 below.

Table 2.2. Ratified international conventions and treaties for the management and protection of marine biota and ecosystems.

Title	Description
United Nations Convention on the Law of the Sea (1982)	Alien species are specifically referred to in Section 1, Article 196 where member states are required to control marine pollution which includes the introduction of alien species (accidental or otherwise). While the law of the sea does not specify eradication or rehabilitation methods, it does place an obligation on member states to assess potential risks, monitoring and immediate notice of damage to the marine environment (Articles 204, 206, 235).
The Convention on Biodiversity (1992)	The Convention on Biological Diversity (CBD) is an international treaty, of which South Africa is a member state, that aims to promote "*the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.*" Under the CBD, member states adopted of the Kunming-Montreal Global Biodiversity Framework (GBF) in 2022. The GBF aims to address biodiversity loss, restore ecosystems and protect indigenous rights. The plan includes concrete measures to halt and reverse nature loss, including putting 30 per cent of the planet and 30 per cent of degraded ecosystems under protection by 2030. Ecologically or Biologically Significant Marine Areas (EBSAs) are important for South Africa's future contributions to achieving this target.
Convention of Migratory Species (1983)	The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as the Bonn Convention, of which South Africa is a party, is an environmental treaty of the United Nations which aims to conserve migratory species throughout their range. Of relevance is Article III (4): *"Parties that are Range States of a migratory species listed in Appendix I shall endeavour:* • *To conserve and, where feasible and appropriate, restore those habitats of the species which are of importance in removing the species from danger of extinction;* • *To prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species; and* • *To the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger the species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species."*

Title	Description
	Listed in Appendix I are the relevant species the Southern right whale *Eubalaena australis* and the humpback whale *Megaptera novaeangliae*. Southern right whales are likely to occur in the Block 11B/12B Application Area during winter, and while Humpback whales are likely to be present during summer and winter, with higher probability of occurrence in summer.
The International Whaling Commission (1946)	South Africa is a signatory to a resolution passed at the 67th International Whaling Commission (IWC) (2018) for the management of underwater noise impacts on marine mammals considered under the IWC. As per Resolution 2018-4: • It is recommended that best practice guidelines are taken into account "*to ensure robust, comprehensive, and transparent assessment and to facilitate mitigation of adverse effects of anthropogenic underwater noise such as the IMO Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (circular MEPC.1/Circ.833) and the CMS guidelines for Environmental Impact Assessments for Marine Noise-generating Activities (CMS, 2017)*". • It is recommended that *"cetacean research and conservation management efforts include the protection of the acoustic habitat and the impacts of anthropogenic underwater noise on lower trophic levels, including fish, invertebrates and other marine mammal prey species."*
RAMSAR Convention on Wetlands of International Importance	The Ramsar Convention encourages the designation of sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity. Once designated, these sites are added to the Convention's List of Wetlands of International Importance and become known as Ramsar sites. As a signatory to the Ramsar Convention, South Africa is committed to working towards the wise use of all wetlands through effective land use planning and the development of appropriate policies and legislation, management actions, and public education to protect selected natural purifiers of water resources. Article 3 of the Convention states that "*the Contracting Parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory.*" There are a number of Ramsar sites along the South Coast adjacent to the 11B/12B Application Area, including De Hoop, De Mond and Wilderness Lakes.
The Nairobi Convention (1996)	Administered by the United Nations Environment Programme (UNEP), the Nairobi Convention provides a platform for governments, civil society, and the private sector to work together for the sustainable management and use of the marine and coastal environment. Under the Convention, the Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region (1996) requires Contracting Parties take all appropriate measures to ensure the strictest protection of listed endangered species (including species likely to be present in the Block 11B/12B Application Area, such as the Leatherback turtles, Humpback and Blue whales), prevent damage to, or destruction of, critical habitats, and take all appropriate measures to prohibit the intentional or accidental introduction of alien or new species which may cause significant harm.
Convention on the Conservation of Migratory Species of Wild Animals (1983)	The Bonn Convention aims to conserve terrestrial, marine and avian migratory species throughout their range.
Memorandum of Understanding (MoU) on the Conservation of Migratory Sharks (2010)	The MoU was founded under the auspices of the Bonn Convention and serves as an international instrument for the conservation of migratory shark species, including species occurring off the South Coast of South Africa.
The MoU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (2001)	The MoU is an intergovernmental agreement that aims to protect, conserve, replenish and recover sea turtles and their habitats in the Indian Ocean and South-East Asian region.

Title	Description
Agreement on the Conservation of Albatrosses and Petrels, (2004)	ACAP protects all the world's albatross species, seven southern hemisphere petrel and two shearwater species. A number of these occur off the South Coast of South Africa.
International Convention for the Conservation of Atlantic Tunas	The ICCAT Convention provides for the management and conservation of tuna and tuna-like species in the Atlantic Ocean and adjacent seas.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)	CITES is a multilateral treaty to protect endangered plants and animals.
Revised African Convention for the Conservation of Nature and Natural Resources (2017)	The objectives of this Convention are to enhance environmental protection, to foster the conservation and sustainable used of natural resources, and to harmonise and coordinate polices in these fields.

2.2.3 IFC Performance Standards

The International Finance Corporation's (IFC) Performance Standards (PS) provide international best-practise guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in an environmentally and socially sustainable manner. Whilst this is not an IFC project, this assessment was undertaken in line with IFC Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts) and IFC Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources) in line with international best practise.

A summary of requirements and implications thereof for the assessment are outlined in Table 2.3 and Table 2.4 respectively.

Table 2.3. Summary of requirements and implications thereof of Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts).

Performance Standard 1	Implications for the assessment
Performance Standard 1 outlines the best-practice procedures for establishing an appropriate environmental and social management system commensurate with the level of social and environmental risks and impacts associated with the proposed project.	This Impact Assessment will need to take into account the IFC standard requirements for environmental management systems which include: • identifying risks and impacts, • ensuring sufficient organisational capacity and competency for the project, • integrating emergency preparedness and response into plans, • stakeholder engagement, and • monitoring and review processes
Identification of mitigation measures in accordance with the mitigation hierarchy.	Emphasis will be placed on avoiding significant impacts where feasible via a mitigation hierarchy, which is widely regarded as a best practice approach to managing risks, is based on a hierarchy of decisions and measures.

Table 2.4. Summary of requirements and implications thereof of Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources).

Performance Standard 6	Implications for the assessment
Performance Standard 6 requirements are guided by the principles set out in the 'Convention on Biological Diversity' and addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project lifecycle.	This Impact Assessment will need to be guided by the principles set out in the 'Convention on Biological Diversity'. The assessment will need to address the sustainable management and mitigation of impacts on biodiversity and ecosystem services throughout the project lifecycle.
Avoidance of impacts should be the priority and thereafter mitigation and restoration measures should be considered.	The adoption of the principles of the 'mitigation hierarchy', will inform impact mitigation and management.
An adaptive management approach over the course of the project should be adopted to ensure mitigation and management measures are responsive to changing conditions and the results of monitoring.	Recommendations made as part of the mitigation hierarchy and monitoring plan as part of this Impact Assessment and a Biodiversity Action Plan will need to be formulated as a 'living document' that can be easily updated and informed by an 'adaptive management' approach to impact mitigation and management. This will ensure that the plans remain current and relevant in the face of potentially changing environmental conditions. Monitoring plans and programmes will need to be formulated specifically to provide recommendations that feed back towards the updating of the Plan.
Biodiversity offsets may only be considered if appropriate avoidance, minimization and restoration measures have been applied in accordance with the mitigation hierarchy.	The assessment will need to integrate the principles of the 'mitigation hierarchy', seeking first avoid impacts, then mitigate and rehabilitate and finally offset residual impacts only once all other measures have been exhausted.
At a minimum a no-net loss should be achieved during the implementation of offsets, and in the case of critical habitats a net gain is required, with the biodiversity offset adhering to a "like-for-like or better" principle with said offsets requiring a biodiversity action plan to achieve net gain	The assessment and recommendations thereof will need to be based on a 'no net loss policy' should offsets be considered or required, which is also in line with South African National Offset Policy.
In instances where the proposed development is located within a legally protected area or an internationally recognised area, in addition to the conditions stipulated above the client will need to obtain legal permission for the development, act in a manner consistent with any government recognised management plans for such areas and consult PA (Protected Area) managers, affected communities and other stakeholders involved in the proposed project as appropriate and implement additional programs as appropriate to promote and enhance conservation aims and effective management of the area.	This may have implications for infrastructure located within future approved biodiversity offset target areas owned by other parties, that are likely to be promulgated as formal conservation / protected areas in future. This will need to be addressed in the impact assessment.
Performance Standard 6 also stipulates that IAP (Invasive Alien Plant) control needs to be undertaken within the project area that the client has control over.	While IAP management is not applicable to this project, the risk and impacts of the introduction and spread of marine invasive species needs to be assessed, and management for the prevention and control of invasive species need to be accounted for.
Performance Standard 6 states that any ecosystem services that stand to be impacted upon will need to be reviewed by the client and affected communities through the stakeholder engagement process (if they stand to be affected by ecosystem service loss) to identify priority ecosystem services.	Where the proposed development may impact priority ecosystem services, the impact assessment will need to specifically consider the implementation of relevant avoidance and mitigation measures in accordance with the 'mitigation hierarchy' (where the client has management control or significant influence over these ecosystem services).

3 DESCRIPTION OF AFFECTED ENVIRONMENT

3.1 OCEANOGRAPHY

Given that the physical oceanography of an area, particularly water temperature, nutrient and oxygen levels, are the principal driving forces that shape the marine communities, it is worth considering the broader oceanography of the region. The oceanography of the Block 11B/12B Application Area is influenced by both the strong-flowing Agulhas current that moves down the east coast of South Africa as well as by localised oceanographic processes (Figure 3-1).

It is the interaction of the warm Agulhas current with cooler temperate waters is the principal reason for the diverse range of coastal and marine flora and fauna for which South Africa is famous. The Agulhas current forms part of the Indian Ocean Gyre, which brings warm water from the tropics to the east coast of South Africa and moves at a speed of approximately 2.6 m/s (Branch & Branch, 1981). The Agulhas current hugs the continental shelf, moving close to the shore edge when the shelf is narrow but is deflected away from the coast as the shelf widens (i.e., from Port Elizabeth westwards). The continental shelf becomes progressively wider from Port St John's in the Eastern Cape down to the Agulhas bank in the southern Cape (Heydorn & Tinley 1980) (Figure 3-1).

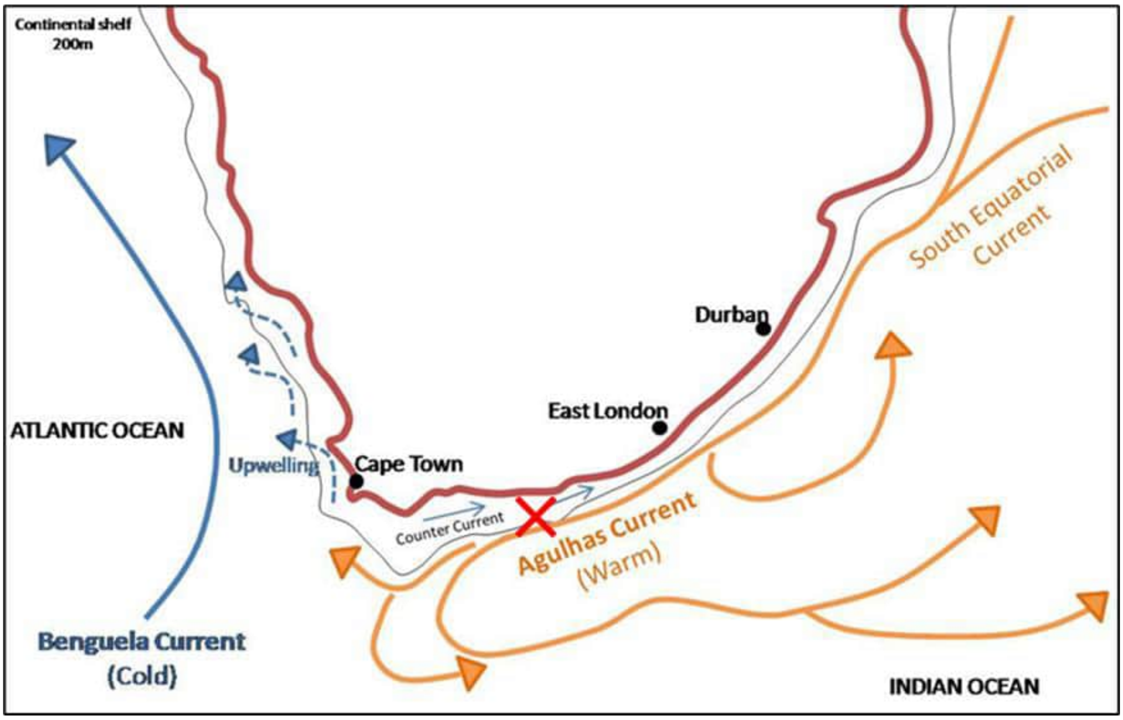


Figure 3-1. Major current streams around South Africa. The warm Agulhas Current (orange) flows down the east coast, and cold upwelling plumes (light blue) can be observed along the west coast (Source: Anchor, 2015). The area of the Block 11B/12B Production Right Application Area is indicated by the red cross.

The current produces large, complex meanders of approximately 130 km across the shelf, and eddies, which advect onto the Agulhas Bank (Swart & Largier 1987, Penven *et al.* 2001, Lutjeharms 2006, Pisces 2019) (Figure 3-2). After detaching from the shelf edge at 15°E, the Agulhas Current retroflects and lows eastwards (Schumann *et al.* 1998).

The thermal structure of Agulhas Bank is complex and is influenced by Agulhas current water intrusions at the surface and subsurface, upwelling and solar heating of surface waters (Pisces 2014a). The warm, tropical water carried by the Agulhas current cools as it moves southwards and supports a changing array of species. At the inner boundary of the Agulhas current, cold bottom water is advected onto the Agulhas Bank via shelf-edge upwelling (Schumann *et al.* 1982, 1998, 2005). This process is linked to bottom topography and is most intense at the eastern boundary of the South Coast (Hutchings 1994). Such shelf-edge upwelling largely defines the strong thermocline and halocline topography that typically develops between the cold bottom water and the sun warmed surface layer during spring, summer and autumn. Cool counter-currents also flow inshore of the Agulhas current in an easterly direction, providing important opportunities for northward and eastward migration of certain species such as the sardine *Sardinops sagax*. South of the continental shelf, the current turns back on itself (retroflects) and begins flowing eastwards and once again joins the Indian Ocean Gyre as the Agulhas Return Current (Figure 3-2).

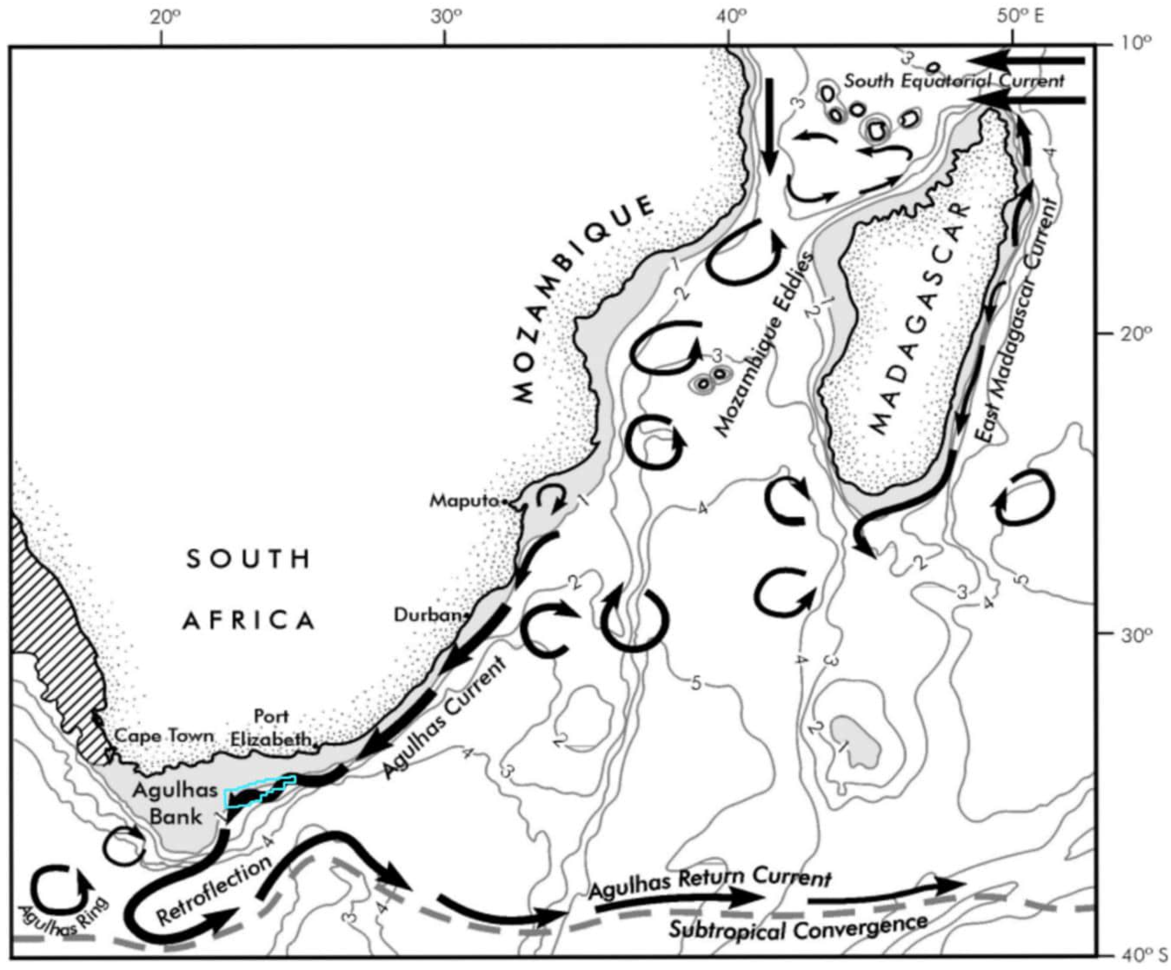


Figure 3-2. The major circulatory elements along the South Coast in relation to the Block 11B/12B Application Area (blue polygon) (adapted from Lutjeharms 2006 and Pisces 2014a).

3.2 Biogeography

Numerous attempts have been made to understand and map marine biogeographic patterns around the coast of South Africa, the most recent being Sink *et al.* (2012). Most of the studies recognised three coastal regions; a cool temperate west coast, a warm temperate south coast and a subtropical east coast region (Bustamante & Branch 1996, Branch *et al.* 2017). The Application Area falls within the warm temperate south coast, a region characterised by high diversity, with components of both the cool temperate and subtropical marine faunas, as well as high levels of endemism (species with distributions restricted to the bioregion). According to the most recent biogeographic divisions, the Application Area falls into within the Southwestern Indian Ecoregion and the Southwestern Indian upper and lower bathyal ecozones (Figure 3-3) (Sink *et al.* 2012). The more recent National Biodiversity Assessment (NBA) that was released in 2019 does not reclassify these biogeographic regions. Communities within this marine habitat are largely ubiquitous throughout the southern African South Coast region, being particular only to substrate type or depth zone. The biological communities occurring in the Application Area consist of many hundreds of species, often displaying considerable temporal and spatial variability (Pisces 2019).

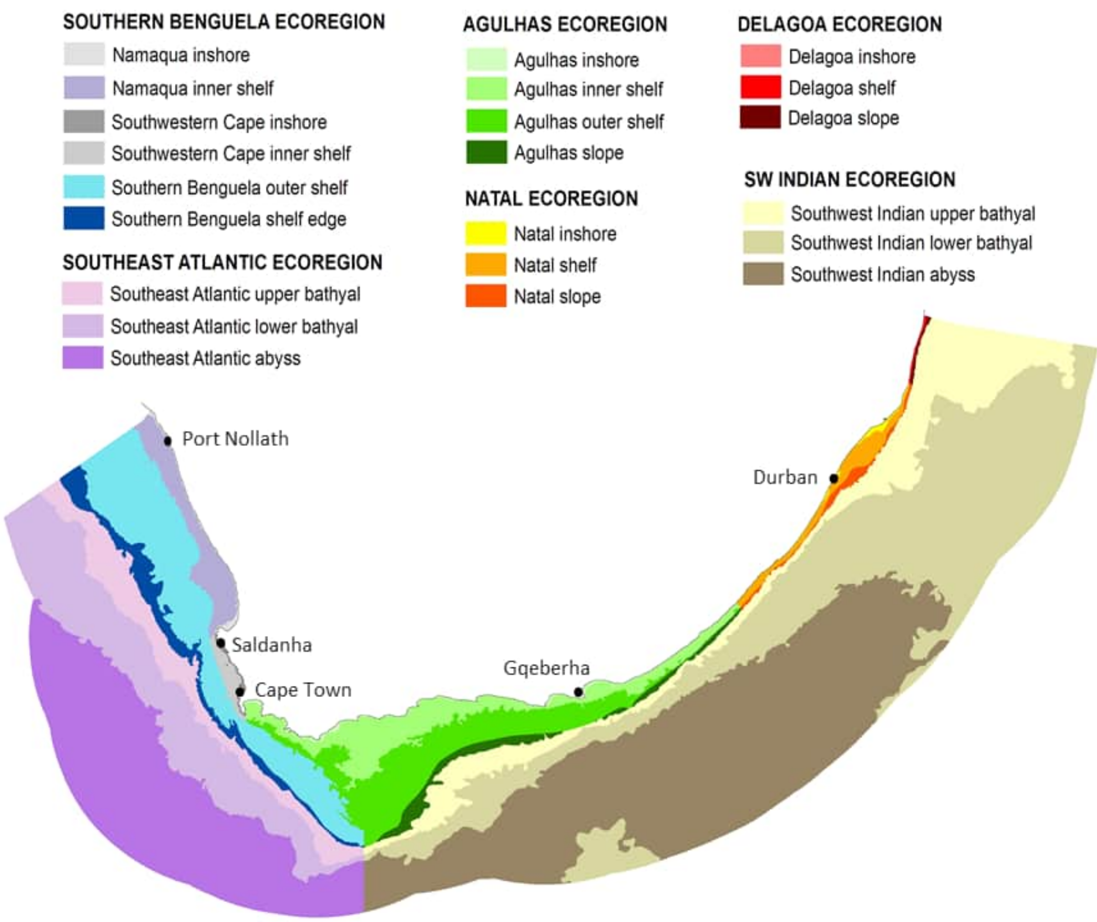


Figure 3-3. Inshore and offshore Ecoregions in South Africa as defined by Sink *et al.* (2012).

3.3 Ecology and Habitats

3.3.1 Benthic Habitats

The Application Area falls within the Outeniqua Basin, on the Agulhas Bank, southwards of the 200 m isobath and down to ~2 000 m depth (Figure 3-4). The diverse benthic habitats of Block 11B/12B therefore fall within the Agulhas sub-photic biozone (from 30 m depth to the shelf edge) and the continental slope biozone (beyond to the lower slope) (Pisces 2019). While the shelf edge is considered a distinct zone, benthic and pelagic components of the ecosystem interact closely in this steeper zone and it is therefore classified as part of the shelf (Karenyi *et al.* 2016, Sink *et al.* 2019). Within the shelf, four finer scale biomes are recognised, namely an inner, mid and outer shelf zone, and the shelf edge (Sink *et al.* 2019).

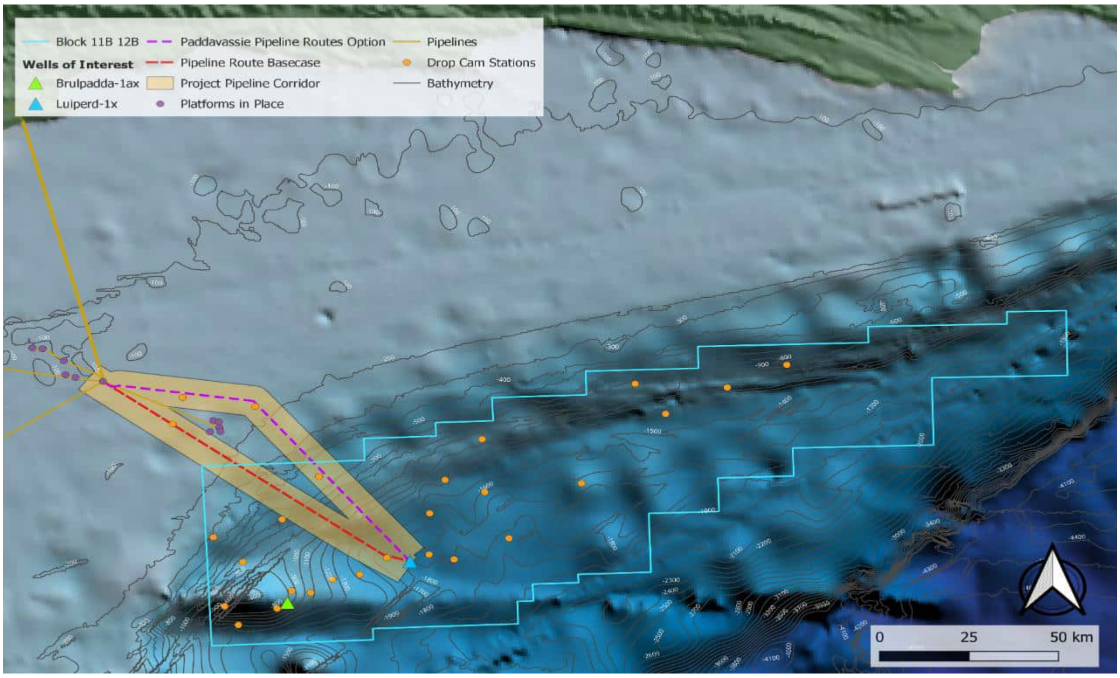


Figure 3-4. The bathymetry in the vicinity of the Block 11B/12B Production Right Application Area (indicated by the blue polygon) (SANBI 2018).

The 2018 National Biodiversity Assessment (NBA) delineation of offshore habitat types in the Application Area and surrounds is presented in Figure 3-5. The benthic habitat types in the area of interest include (moving from south to north) Southwest Indian Lower Slopes, Southwest Indian Mid Slope, Southwest Indian Upper Slope, with intersection with Agulhas Rocky Shelf Edge, Eastern Agulhas Outer Shelf Mosaic and Agulhas Blues in the vicinity of both pipeline routing options (Figure 3-5) (SANBI 2018). This means that most of the Application Area is a mosaic of both rocky reef and areas with sparse sediment cover, with the northern area characterised by hard sediment, meaning that a narrow layer of unconsolidated sand sits atop a denser clay layer (SANBI 2018, Pisces 2019). To the north-east, there are sandy outer shelf and shelf edge sediments, and hard shelf edge sediments to the west. The area beyond the 1 000 m depth comprises of unconsolidated sediments, and along the eastern half of the South Coast, the seabed is predominantly rocky reefs (Birch & Rogers 1973). Substrate types in the study area are presented in Figure 3-5 (SANBI 2018). The substrate that covers most of the Application Area is classified as "Southwest Indian Unclassified Slopes", rocky area in the north-western side of the Production Right Application Area ("Agulhas Rocky Shelf Edge") and along both proposed pipeline routing alternatives ("Agulhas Mosaic shelves") (Figure 3-5). Preliminary in situ validation of these habitat types was undertaken as part of the 2022 Bourbon Evolution 807 benthic epifaunal assessment of the Application Area (BSL 2023) (Figure 3-5).

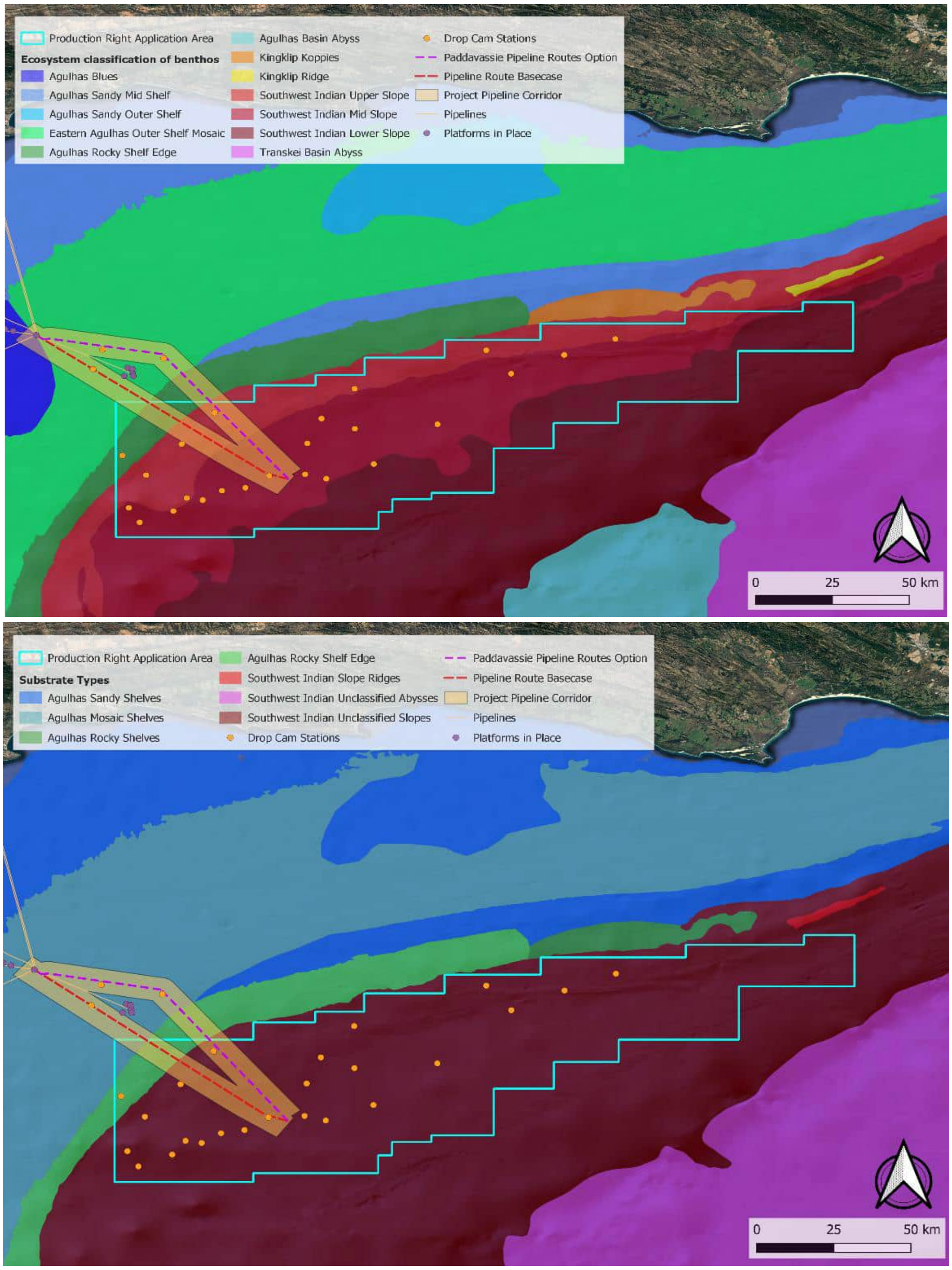


Figure 3-5. (Top) The ecosystem classification of benthos and (bottom) the substrate type in the vicinity of the Production Right Application Area (indicated by the blue polygon) (SANBI 2018).

EASTERN AGULHAS OUTER SHELF MOSAIC

Preliminary drop results from the 2022 Bourbon Evolution 807 campaign shows that stations surveyed in the Eastern Agulhas Outer Shelf Mosaic habitat type (i.e., in both proposed pipeline routing areas) were mostly soft sediment habitats, with mixed mud and sand soft bottom/sand seabed (Table 3.1, Figure 3-6) (BSL 2023). The ROV survey in this habitat showed that the habitat was mostly sandy substrate of variable coarseness, with limited hard substrate for epifaunal attachment (Table 3.1). Areas of greater heterogeneity tended to have higher levels of species diversity (Table 3.1).

Table 3.1. Preliminary habitat characterisation and epifaunal observations from drop camera sites and ROV transects from the 2022 Bourbon Evolution 807 environmental survey campaign of the Application Area and both pipeline routing options (BSL 2023).

Ecosystem classification of benthos as per SANBI (2018)	Summary habitat description
Eastern Agulhas Outer Shelf Mosaic	• Coarse sandy seabed areas covered in phytodetritus with occasional outcropping clay and a considerable amount of marine snow. The area was highly bioturbated and included thin trails, crater depressions, heart urchin tracks, and thick trails. Intermittent epifaunal species were observed. • Relatively barren areas of coarse sand and shell debris with heart urchin tracks as the only bioturbation. • Areas of gravelly sand, interspersed with short sections of cobble/boulder fields populated by corals, sponges, and bryozoans. Limited bioturbation evident. Vulnerable Marine Ecosystem (VME) indicator species were recorded. • Sandy seabed with crater depressions and a holothurian feeding scar, interspersed with areas of small cobble fields/hard substrate that are populated with soft and hard corals, sponges and Bryozoans. VME indicator species were recorded.
Agulhas Rocky Shelf Edge	• Coarse sandy seabed of mostly dead coral-like hydroid shards. Considered to be a healthy reef system with massive overhanging coral beds attached to large boulders, inhabited by several sessile and mobile species. High diversity of species. VME indicator species were recorded. • Coarse silty mud with pebbles (gravel), iron rich drop stones, manganese nodules (also referred to as polymetallic nodules) and occasionally shards of hard coral (coral-like hydroid). VME indicator species were recorded. • Gravelly sand with dropstones and manganese nodules. VME indicator species were recorded. • Coarse/rocky seabed with broken coral shards, rocks, dropstones, and boulders heavily covered in phytodetritus. Large boulders and ridges with Large overhanging lace Coral (Stylasteridae) and repeating epifaunal species in between areas of plain/flat coarse seabed with broken coral shards and small/medium rocks acting as attachment areas for sessile fauna. VME indicator species were recorded. • Coarse silty sand/mud with large boulders and rocks. A high number VME indicator species. • Sandy seabed with crater depressions and a holothurian feeding scar, interspersed with areas of small cobble fields/hard substrate that are populated with soft and hard corals, sponges and Bryozoans. High diversity of specie, including VME indicator species.
Southwest Indian Upper Slope	• Hard coral outcrops and a heterogenous environment, with seabed varying from coarse/rocky area (with manganese nodules and pebbles) to intermediate coarse and silty sand/mud (i.e., patches of coarse areas between silty sand) to a complete silty sand/mud seabed. In some instances, there were shards of hard coral pieces (coral-like hydroid) scattered on the seabed and sandstone-type rock and sandstone "plate-like" formations The habitat could be considered a sensitive environment and needs to be noted as a potential Marine Protected Area (MPA) area. VME indicator species. • Sandy with cobble stones and a few boulders, which then became predominantly gravelly-sand with a few interspersed boulders and ended

Ecosystem classification of benthos as per SANBI (2018)	Summary habitat description
	with sandy mud, which showed wide trails likely created by heart urchins. VME indicator species were recorded. • Hard substrate of predominately hard pavement/ concrete slabs or else short sections of pebble and cobble fields and very little sediment or fines. VME indicator species. • Part comprised of large boulders, pebbles (cobbles), rocks, and manganese nodules scattered across the seabed that acts as attachment areas for sessile species. Part coarse sand seabed with fewer pebbles, until it alternates between flat top/ wavy dunes in between sand ridges. VME indicator species were recorded. • Coarse sand with large, fossilized tree trunks across the entire area that acted as important attachment areas for sessile epifaunal species (at least 80-90% of the transect). Some areas with outcropping clay (eroded mud). The transect had a vast array of epifaunal species that repeated across the transect (i.e., same species recorded) including several soft corals, hard corals, and sponges. VME indicator species. • Medium to low profile reef with some steps, overhangs and drop-downs. The abundance and diversity of species was high, with many species occurring frequently and in close proximity to each other. Numerous species listed as potential indicators of VME throughout the transect, some in high abundance. • Started out on a complex three-dimensional coral reef rich with life. Later interspersed on flattened seabed with dense rubble of dead coral skeletons on top of unconsolidated silt/mud. In some areas, there were patches of outcropping mud. During mid transect, there were no more coral beds, only a seabed scattered dead coral and patches of outcropping mud. During the end, the there was a mixture of nodules, cobbles, pebbles, and boulders (some of which appeared to be fossils of wood/tree trunks). • Silty, gravelly sand with manganese nodules and underlaying clay terraces, "paving stones". At times these clay platforms or paving stones were exposed to form terraced pavements. VME indicator species were recorded.
Southwest Indian Mid Slope	• Coarse sand with outcropping clay, black dropstones, and scattered pebbles (i.e., cobbles). A boulder in the shape of a meteorite was observed that acted as an attachment area for sessile epifauna. Several fossilized whale bones were seen in the transect that also acted as attachment areas for sessile species. • Sandy/silty mud with small pebbles and dropstones acting as attachment areas for sessile epifaunal species. Some rocks also comprise manganese nodules and, in some areas, soundwaves were seen in the seabed. The area was mostly barren with mobile and sessile species intermittently recorded throughout the transect. • Hard pebble/cobble pavement with manganese nodules which is partially concreted in places, with a very minimal layer of overlying fine sediment. VME indicator species were recorded. • Coarse sand with pebbles with the transect at the end becoming more gravel-like (covered in pebbles). Large and small boulders and whale bones were seen throughout the transect that acted as attachment areas for sessile epifaunal species. • Large cobbles covered in phytodetritus on top of silty mud.

AGULHAS ROCKY SHELF EDGE

The one drop camera station within the Agulhas Rocky Shelf Edge habitat consisted of coral debris overlaying a hard clay seabed with a thin film of finer silty sediment (Table 3.1, Figure 3-6) (BSL 2023). The ROV transects show that this is a hugely diverse benthic habitat, ranging from a coarse sandy seabed to a rocky/silty sand/muddy seabed with broken coral shards, rocks, dropstones, and boulders (Table 3.1). The heterogeneity of the hard substrate results in high benthic epifaunal species diversity (Table 3.1).

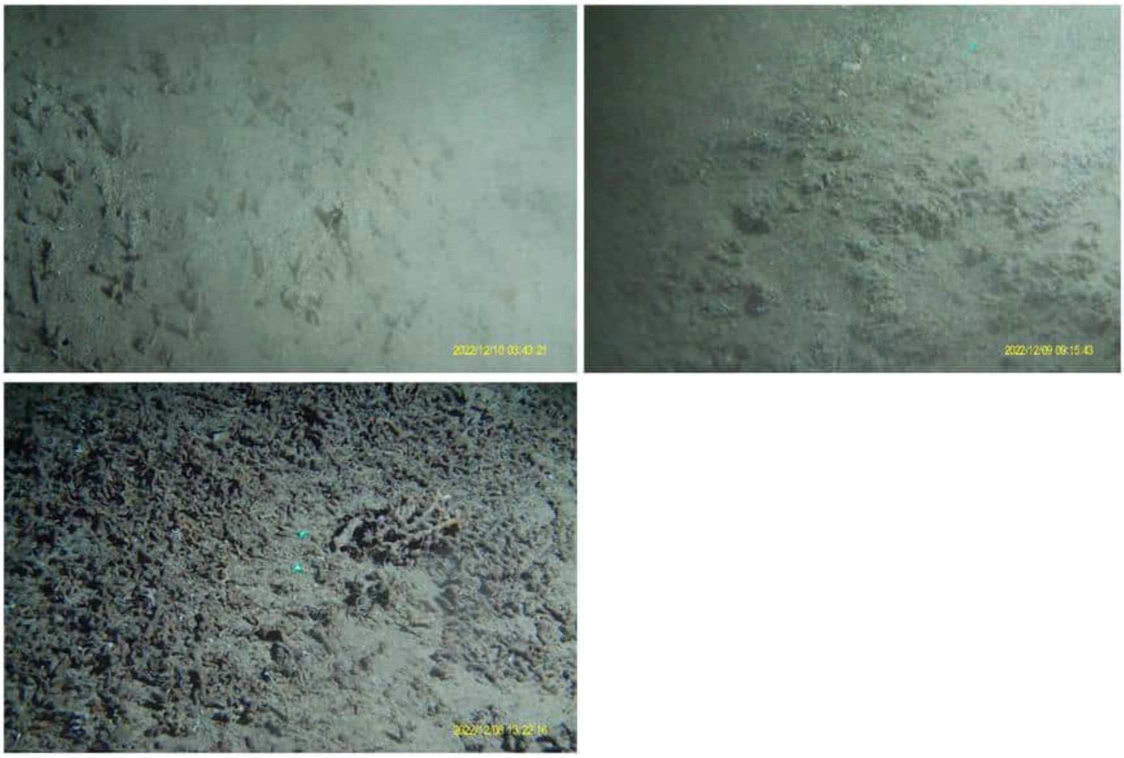


Figure 3-6. Preliminary data from drop camera shots for stations within the Eastern Agulhas Outer Shelf Mosaic habitat (top row), and the Agulhas Rocky Shelf Edge habitat (bottom left) (BSL 2023).

SOUTHWEST INDIAN UPPER SLOPE

Drop camera stations within the Southwest Indian Upper Slope habitat consisted of a mix of hard bottom (concreted clay bottom, sometimes with a slight veneer of mud) and soft bottom, with low density of pebbles, often with some phytodetritus and a high density of nodules (Table 3.1, Figure 3-7) (BSL 2023). The ROV transect results show that this benthic habitat type is also highly diverse, ranging from hard coral outcrops to a coarse/rocky area seabed (with manganese nodules and pebbles), to intermediate coarse and silty sand/mud (i.e., patches of coarse areas between silty sand), to a complete silty sand/mud seabed with bioturbation (Table 3.1). The heterogeneity of the hard substrate results in high benthic epifaunal species diversity (BSL 2023).

Benthic features from a transect conducted within this habitat type shows the diverse range of features that characterise the Southwest Indian Upper Slopes (Figure 3-8) (BSL 2023). The benthos included big rock boulders and/or large clay formations that create drop offs/steps on which coral outcrops are present. These drop offs host a number of different species such as spider crabs, eels, squid and molluscs.

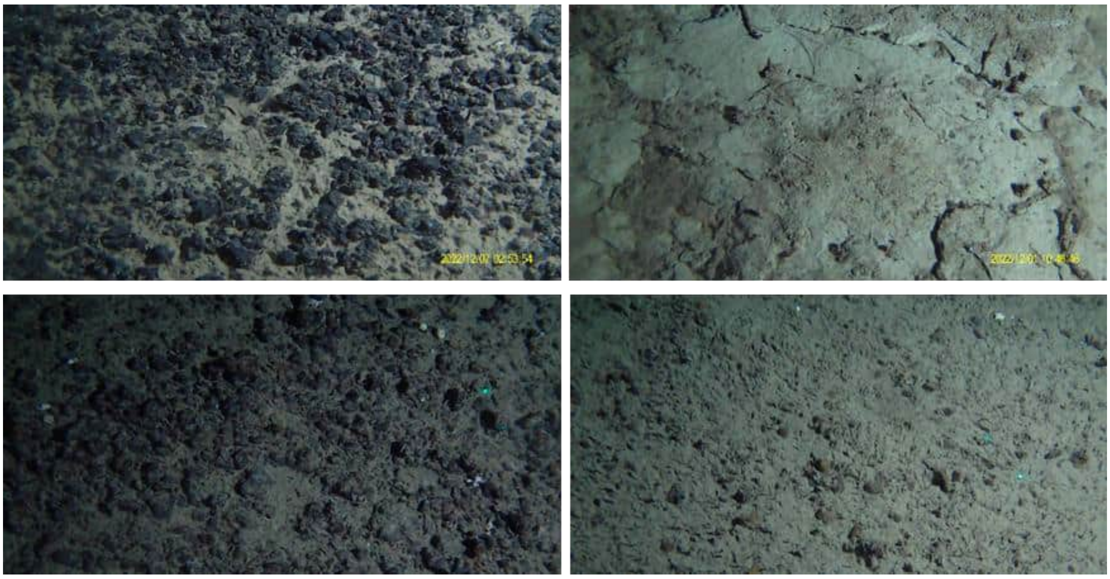


Figure 3-7. Preliminary data from drop camera shots for stations within the Southwest Indian Upper Slope habitat showing a mix of hard (top row, bottom left) and soft bottom substrata (bottom left), often with some phytodetritus and high density of nodules (BSL 2023).

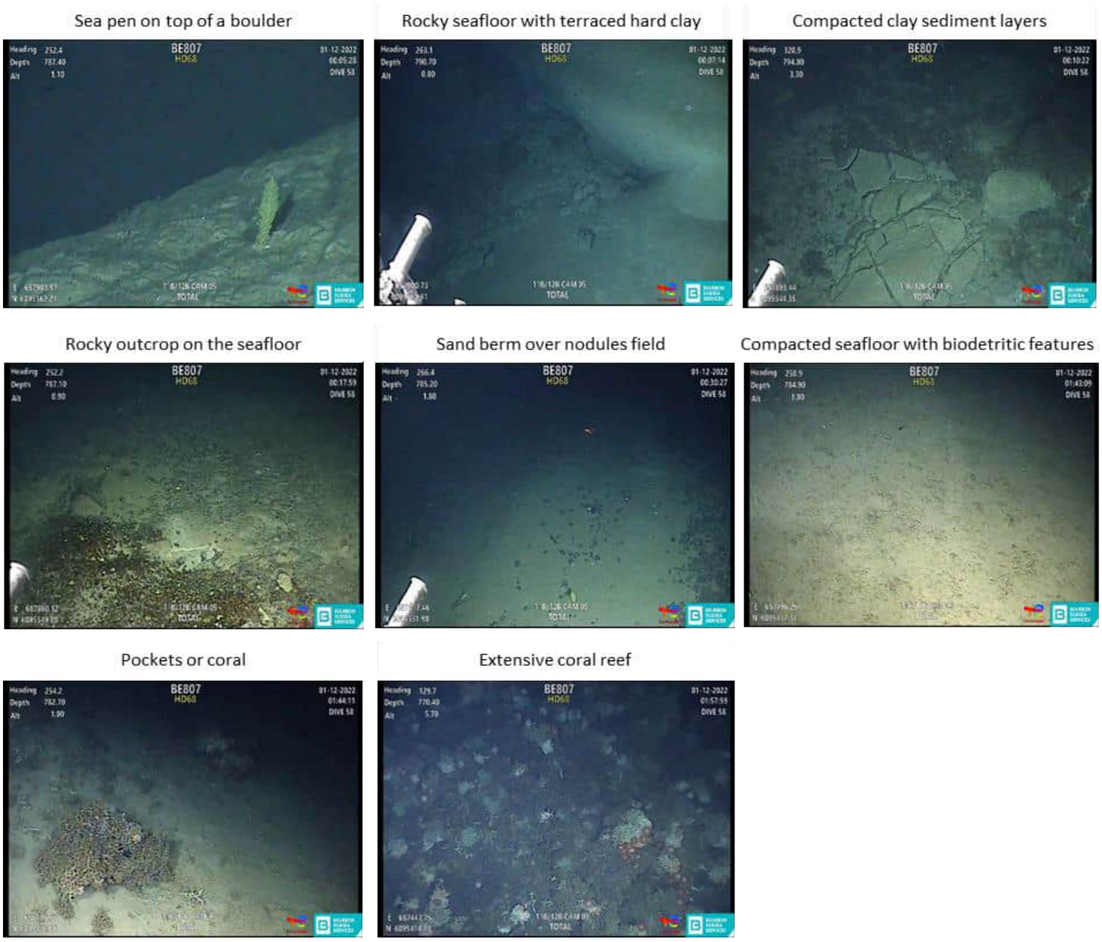


Figure 3-8. Preliminary data from an ROV transect within the Southwest Indian Upper Slope habitat showing a mix of hard substratum (top row), large cobbles/boulders with interspersed soft bottom (middle right), soft bottom partially covered with numerous nodules (middle left) and soft bottom (bottom row) benthos (BSL 2023).

Both rocky particulates on top of mud and corals were found on these features. Compacted clay sediment and rocky seabed features were also recorded, interspersed with aggregation of nodules (dark, well-rounded pebbles) separated by compact clay mounds or banks (Figure 3-8). Corals were also be found in the area, both in discrete patches and in large, reef-like fields (Figure 3-8).

SOUTHWEST INDIAN MID SLOPE

The majority of stations surveyed during the 2022 Bourbon Evolution 807 drop camera survey fell within the Southwest Indian Mid Slope zone (BSL 2023). Preliminary results how a diverse range of habitat types were observed in this zone, ranging from hard clay bottom with large boulders and dropstones, to large cobbles/boulders with interspersed soft bottom, to entirely soft bottom habitats with granules, heterogeneous pebbles and phytodetritus (Table 3.1, Figure 3-9). The ROV transect results show that this habitat type appears to be more homogeneous than the Southwest Indian Upper Slope and the Agulhas Rocky Shelf Edge habitats, with a benthic community characterised mostly by sandy/silty mud, coarse sand or small pebbles and dropstones (Table 3.1). Less hard rocky substrate and a more homogenous environment results in a lower epifaunal species diversity.

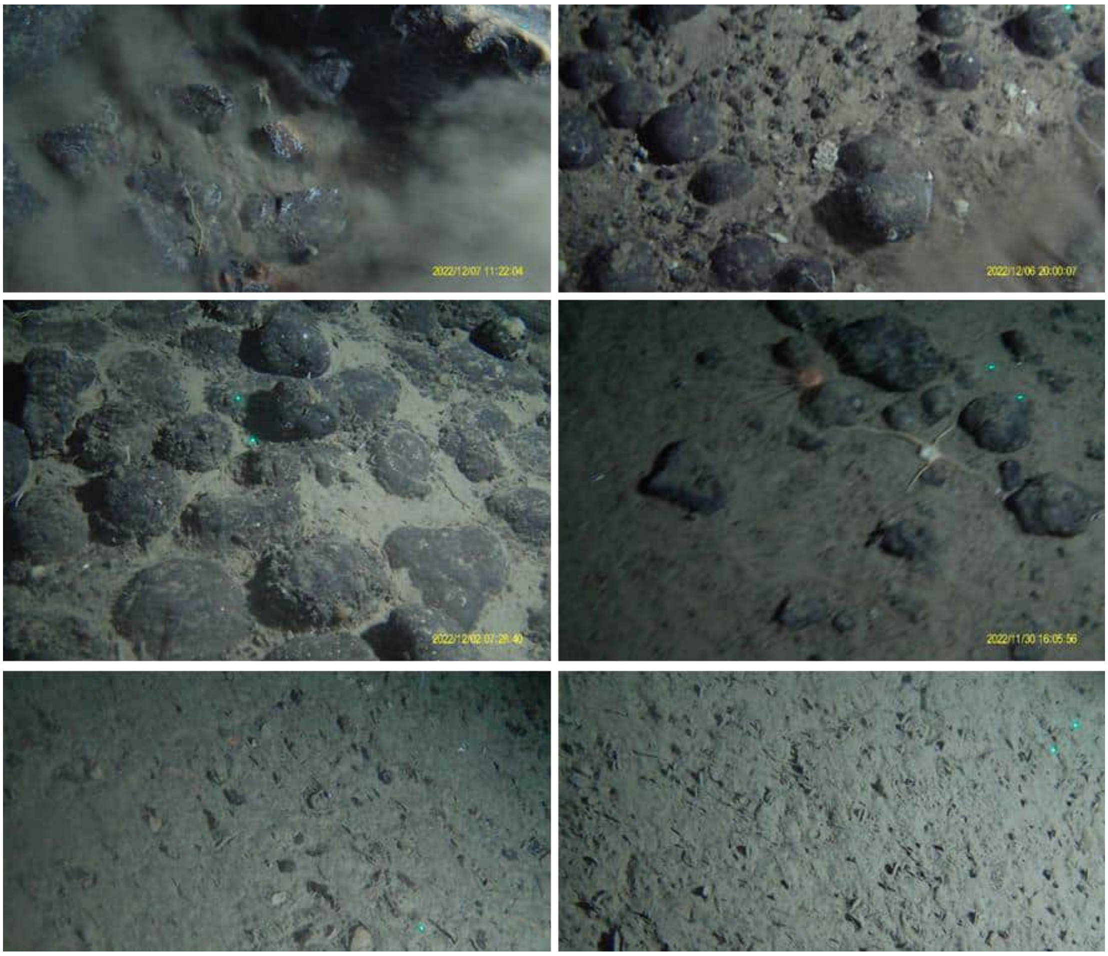


Figure 3-9. Preliminary data from drop camera shots for stations within the Southwest Indian Mid Slope habitat showing a mix of hard substratum (top row), large cobbles/boulders with interspersed soft bottom (middle right) soft bottom partially covered with numerous nodules (middle left) and soft bottom (bottom row) benthos (BSL 2023).

3.3.2 BENTHIC INVERTEBRATE COMMUNITIES

The benthic biota of offshore substrates constitutes invertebrates that live on (epifauna), or burrow within (infauna), the sediments, and are generally divided into megafauna (animals >10 mm), macrofauna (>1 mm) and meiofauna (<1 mm). The structure and composition of benthic invertebrate communities is primarily a function of abiotic factors such as water depth, current velocity and substratum (e.g., sediment grain size and organic content in unconsolidated sediments or reef structure/topography in areas of hard ground) (Snelgrove & Butman 1994, Flach & Thomsen 1998, Ellingsen 2002). Biotic factors that influence benthic community structure include predation, food availability, larval recruitment and reproductive success (Pisces 2019). Deep water habitats and communities are generally considered particularly sensitive to disturbance, as the fauna typically associated with them are frequently slow growing, slow to mature and long-lived.

Compared to nearshore habitats (<50 m depth), areas further offshore (>50 m depth) tend to be more stable, with little to no sediment disturbance driven by waves and current forcing (Fleming & Hay 1988). Therefore, deeper water communities inhabiting unconsolidated sediments tend to be more sensitive to substratum disturbance compared to their shallow water counterparts.

The diverse seabed habitats on the Agulhas Bank within the Application Area support diverse benthic invertebrate communities, with habitat type affecting community composition. The biodiversity of benthic macrofauna in the finer soft mud sediments of the Application Area typically polychaetes, nematodes, amphipods, isopods, molluscs and echinoderms) (Quick & Sink 2005, Sink *et al.* 2010, Shipton & Atkinson 2010). Alternatively, soft and relatively stable sandy habitats in the Application Area support diverse epifauna communities, including sea pens, molluscs, echinoderms (brittle stars and heart urchins), cerianthids (tube anemones), sponges, the deep-water rock lobster *Palinurus gilchristi* as well as a diverse infauna assemblage (polychaetes, amphipods, isopods, molluscs) (Quick & Sink 2005, Sink *et al.* 2010, Shipton & Atkinson 2010). Previous work has also documented low-profile rocky habitat (which is often sand inundated) with an epifaunal community comprising sponges, black corals, gorgonians and ascidians (Sink *et al.* 2006). Finally, there are also rock outcrops within the Block, which are highly structured reef habitats generally characterised by a diverse community of benthic and motile biota including sponges, various coral taxa, cerianthids, bryozoans, ascidians, basket stars and the rock lobster *P. gilchristi* (Quick & Sink 2005, Sink *et al.* 2010, Shipton & Atkinson 2010). Fauna occurring in the deeper reef areas and canyons have community assemblages distinctly different to those from shallower reefs (Sink *et al.* 2006).

INFAUNAL COMMUNITIES

Benthic infauna (animals that live in soft-bottom sediments) are frequently used to detect changes in the health of the marine environment resulting from anthropogenic impacts. These invertebrates are largely short-lived and, consequently, their community composition responds rapidly to environmental changes.

Preliminary results of the 2022 environmental survey campaign comprised of 412 taxa, with samples largely comprised of infauna (379 taxa, 92%) with the remainder constituting solitary epifauna (BSL 2023). Samples were dominated by annelids (segmented worms, 52.3%), arthropods (e.g., crustaceans, 32.2%), molluscs (6.7%) and echinoderms (3%) (Figure 3-10) (BSL 2023). All other groups (Cnidaria, Foraminifera, Hemichordata, Nematoda, Nemertea and Platyhelminthes) were represented by eight species, accounting for 3.8% of the specimens (BSL 2023).

Figure 3-10. Example infauna (macrofauna) from the 2022 Bourbon Evolution 807 environmental survey campaign of the Application Area and both associated pipeline routing options (BSL 2023).

Preliminary measures of abundance and species richness were highly variable across the surveyed sites, ranging from 14 to 1 081 specimens per 0.1 m², and from 12-90 species per site (BSL 2023). A higher number of species were recorded from sites in the upper shelf (<500 m) (mean 61.7±11.8 SD) compared to those that were deeper than 500 m (mean 46.6±18.8 SD) (BSL 2023). This pattern has been reported from other offshore areas of the South African south coast (BSL 2023). Preliminary mean Shannon-Wiener Diversity Index values indicate 'high' diversity and a slightly lower evenness at sites <500 m when compared to those >500 m (BSL 2023).

Macrofaunal community differences were driven by ecosystem type (as described by Sink *et al*. 2019) and depth, with a change in the benthic assemblage from the continental shelf to bathyal zone across the survey area (BSL 2023). These preliminary results demonstrate the importance of environmental conditions (including depth) in driving community structure and function and support the separation of South African benthic ecosystem types as delineated by Sink *et al*. (2019) (BSL 2023).

Preliminary results show that infaunal communities were significantly structured by sediment particle size (PSD) (ϱ=0.323, $p<0.05$) (BSL 2023). The majority of the Southwest Indian upper and lower bathyal sites comprised silts and clays, whereas the Agulhas shelf ecosystem type variants (outer shelf and shelf edge) were primarily characterised by coarse to medium sand (BSL 2023). Deep-water infaunal communities (>500 m) inhabiting the Southwest Indian Upper and Lower Bathyal ecosystems are similar, while those communities present in the Agulhas shelf have greater variability (Figure 3-11) (BSL 2023). The former were comprised of silt and clay, with annelids dominating (upper 54.9% and lower 63.3%), in contrast to the Agulhas shelf community (with the exception of the Sandy Shelf Edge, which ranged from 26.2-53.2%) (BSL 2023). The Agulhas shelf community (<500 m) was characterised by a variety of ecosystem types and a high abundance of crustaceans (Figure 3-11) (BSL 2023). In addition, there were more solitary epifauna in the bathyal ecosystem types (>2%), including ascidians (*Molgula*, Styelidae), lamp shells, a sea snail (*Puncturella noachina*) and a cnidarian (*Sphenotrochus*), all of which are associated with continental shelfs and the deep sea (Figure 3-11) (BSL 2023).

Annelida and Crustacea were the most abundant taxa across the six ecosystem types, with highest abundance in the Southwest Indian Lower Bathyal ecosystem (65.4%) and Sandy Outer Shelf ecosystem (40.2%), respectively (BSL 2023). The number of molluscs decrease in the ecosystem types with hard bottoms such as Hard Outer Shelf (6.3%) and Hard Shelf Edge (6.3%), compared to the Sandy Outer Shelf (10.7%) and the bathyal ecosystems (11.5-15.0%) (BSL 2023).

A Marine Biotic Index (AMBI) (Borja *et al*. 2000) based on these preliminary results, showed that 'disturbance sensitive species' were dominant in the Sandy Outer Shelf (59%), Hard Outer Shelf (54%), Hard Shelf Edge (46%) and Southwest Indian Lower Bathyal (37%) ecosystem types (BSL 2023). With the exception of the Sandy Shelf Edge, ecosystem types on the continental shelf and shelf edge had a higher proportion of disturbance sensitive species than bathyal ecosystems (BSL 2023). In contrast, the Sandy Shelf Edge was dominated by 'disturbance indifferent species' (62.60%), although this result is somewhat skewed by the very high abundance of the annelid *Diopatra papillosa* (BSL 2023).

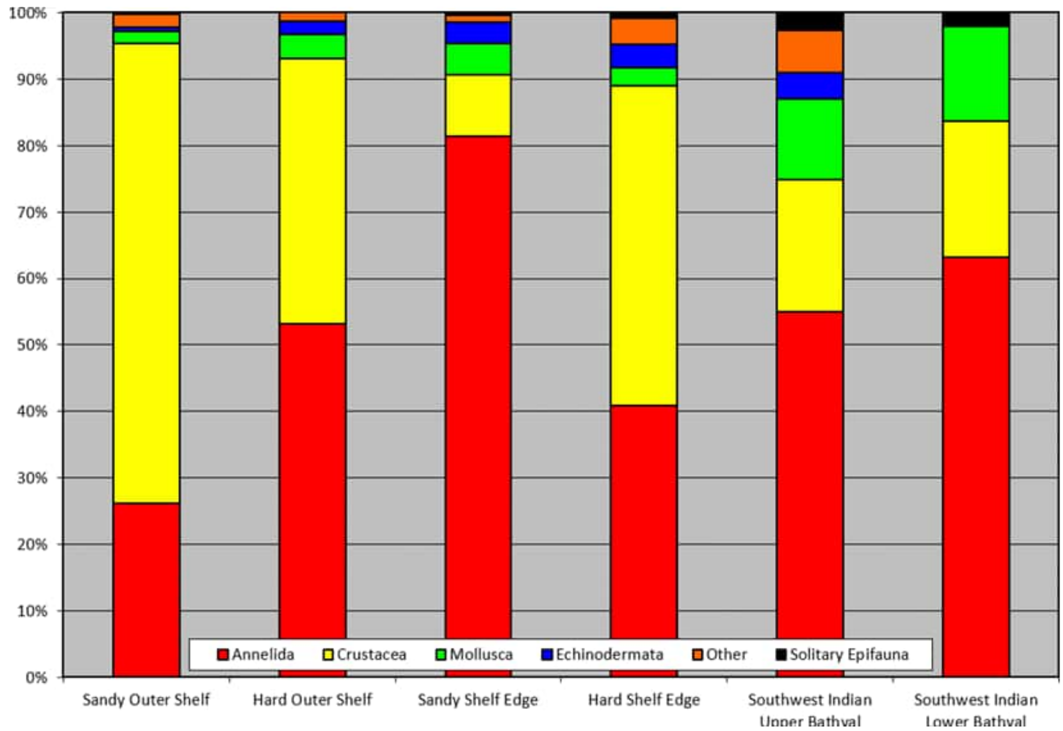


Figure 3-11. Preliminary average contribution of each group to total faunal abundance for each ecosystem type (BSL 2023).

EPIFAUNAL COMMUNITIES

As reported in previous studies, preliminary results from the 2022 Bourbon Evolution 807 campaign ROV survey revealed a high diversity of benthic epifaunal and mobile biota diversity across both Block 11B/12B and Block 9 (for both associated pipeline routing options), with 357 taxa from 11 phyla. The latter include Porifera (sponges), Cnidaria (anemones, corals, sea pens), Annelida (segmented worms), Arthropoda (crustaceans), Bryozoa (moss animals), Mollusca, Cephalopoda, (octopus, cuttlefish, squid), Echinodermata (sea stars, urchins, cucumbers), and Chordata (fish) (Figure 3-12 and Figure 3-13).

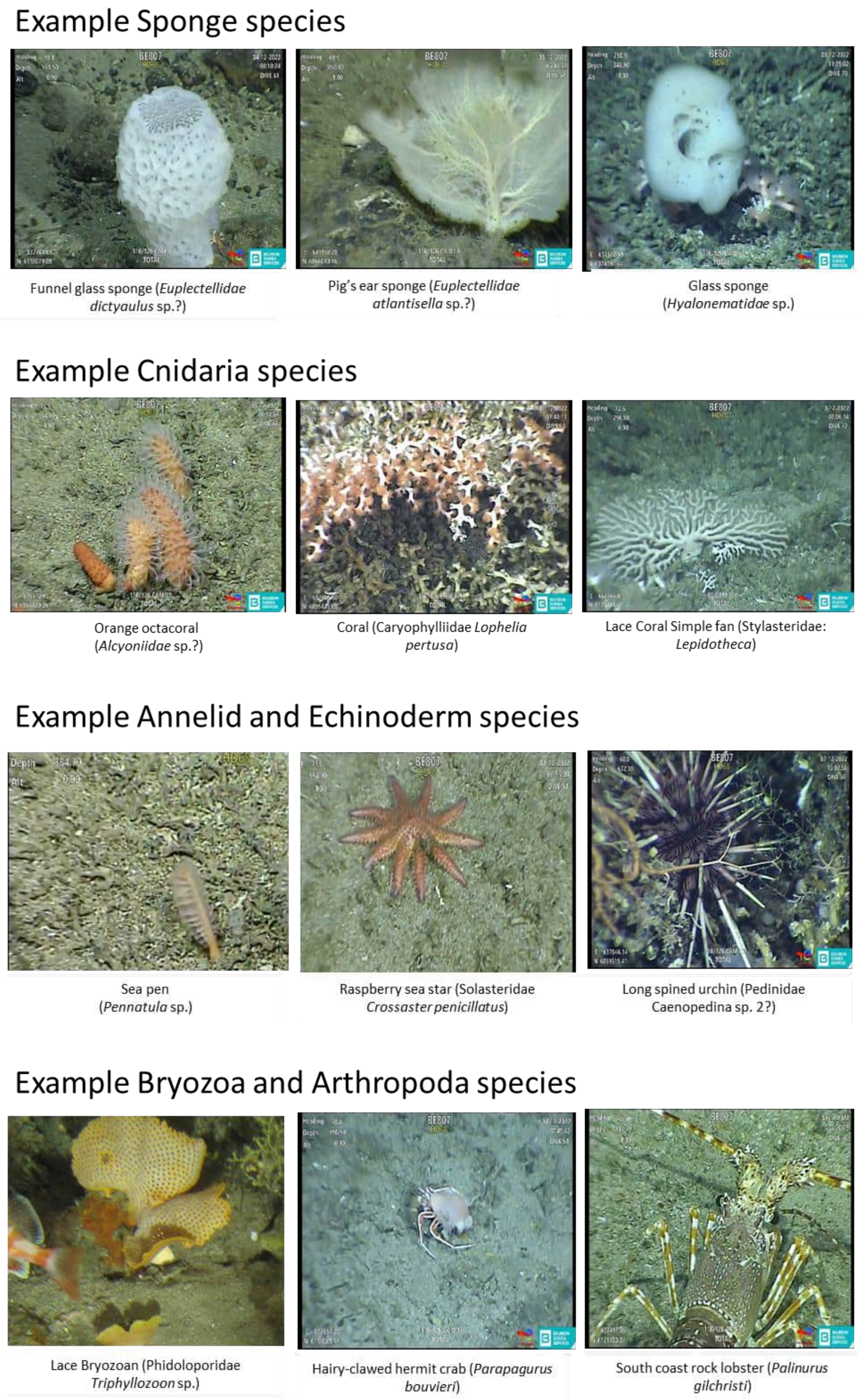


Figure 3-12. Examples of epifaunal species recorded in the Block 11B/12B Production Right Application Area and Bock 9 (both associated pipeline routing corridor options) by the 2022 Bourbon Evolution 807 environmental survey ROV campaign.

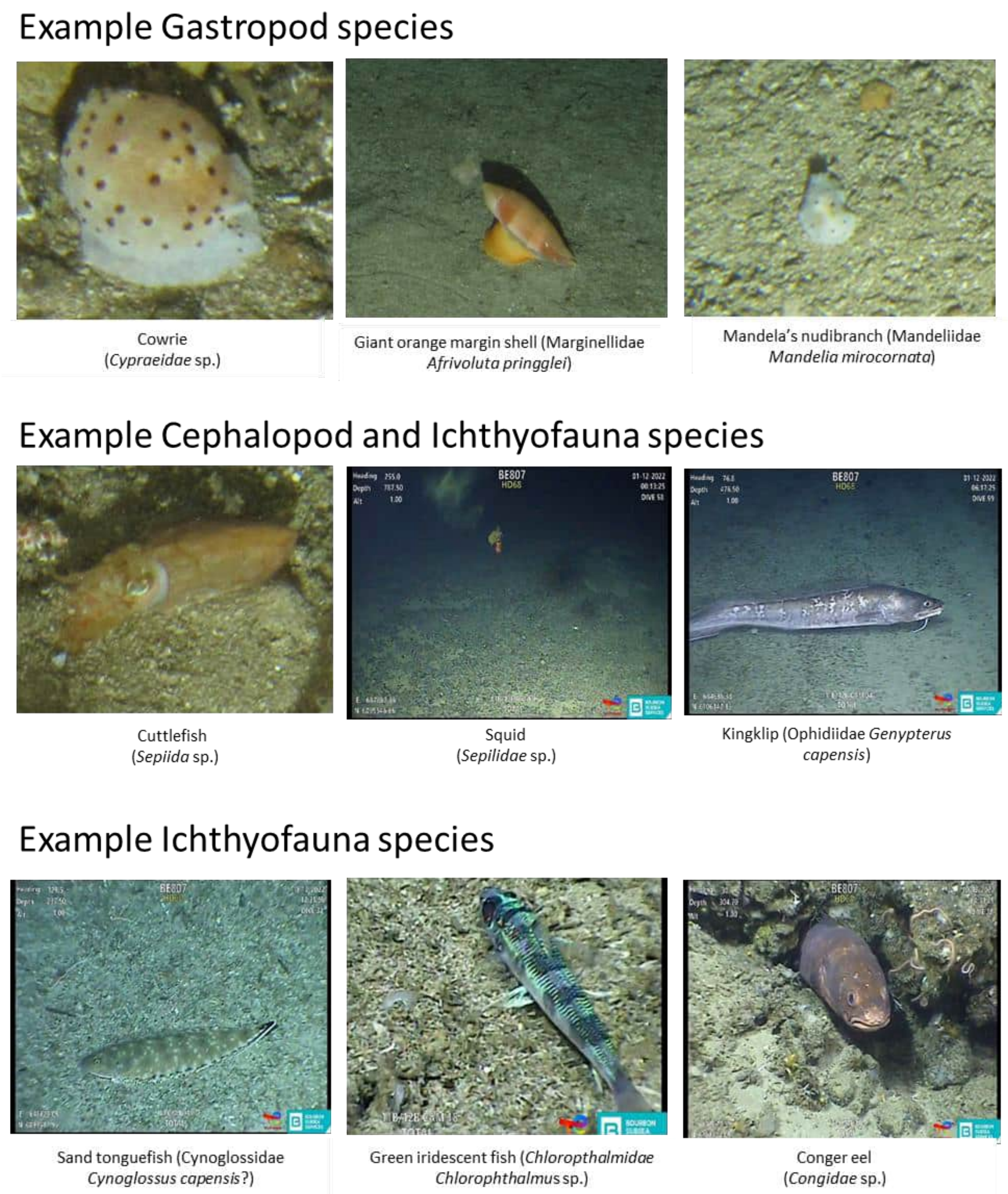


Figure 3-13. Examples of epifaunal and benthic species recorded in Block 11B/12B and Bock 9 (both associated pipeline routing corridor options) by the 2022 Bourbon Evolution 807 environmental survey campaign benthic ROV campaign (BSL 2023).

Community composition differed significantly according to depth (PERMANOVA, Pseudo-F = 4.554, p= 0.001) (Dawson *et al.* 2023, in BSL 2023), as previously reported by Griffiths *et al.* (2010) and Lange & Griffiths (2014) (BSL 2023). Taxa diversity in the Block can largely be attributed to the numerous substrate types (e.g., unconsolidated sediments, clay, cobbles, reefs, see Section 3.3.1) observed over depths ranging from relatively shallow waters on the continental shelf (lowest average depth 117 m) to deep waters off the shelf (maximum average depth ~1 800 m). The lack of unconsolidated soft sediments in the area (Table 3.1) resulted in a low occurrence of bioturbation.

Taxa diversity[6] was found to be highest in the western area of the Application Area, particularly the south-west corner, decreasing in the middle of the Block, and then increasing again (although not as high) to the east (Figure 3-14) (BSL 2023).

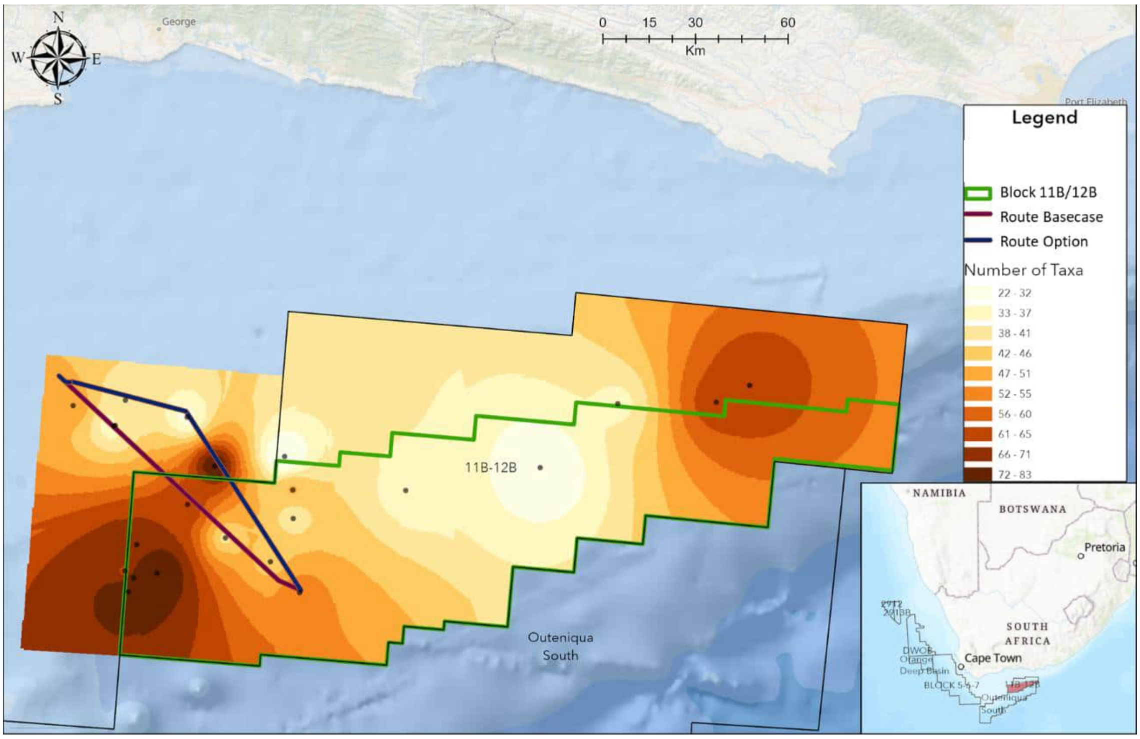


Figure 3-14. Number of taxa, according to phyla, based on preliminary data from the 2022 Bourbon Evolution 807 environmental survey ROV campaign (Dawson *et al.* 2023, in BSL 2023).

The substantial shelf area of the Agulhas Bank supports rich, deep-water communities of filter-feeding corals and sponges. Indeed, the 2022 environmental survey campaign undertaken in the Application Area and both proposed pipeline routing corridor options identified a number of potentially environmentally sensitive habitats, including coral gardens (soft coral), coral reefs (hard coral) and deep-sea sponge aggregations (BSL 2023):

- Soft corals such as bottlebrushes (Primnoidae, *Thouarella* sp.), *Anthomastus* and Malacalcyonacea species were observed along several transects across the Agulhas shelf.
- Hard corals create habitat for other species due to the rigidity of their calcium carbonate structures, and the shelter they provide from prevailing bottom currents (BSL 2023). The 2022 ROV campaign documented a number of large Stylasteridae 'overhangs', which provided habitat for other hard corals species (Dendrophyllidae), soft corals

[6] Diversity is a measure of not only the number of different species present in an ecosystem, but also the relative abundance of each of those species. Diversity is greatest when there are a large number of species present and all of them are equally abundant, with no one species dominating numerically over the others. Therefore, presence/absence data generated for each ROV transect provides a proxy for diversity within each transect, in respect of the number of taxa observed.

(Octocorallia), anemones (Actinaria), sponges (Hexactinellida) and brittlestars (Ophiuroidea).

- Deep-sea sponge communities are a VME in the southern Atlantic Ocean, and largely comprise Demospongiae and Hexactinellida species in areas of hard substrate (BSL 2023).

Of particular interest in this area are the extensive reef framework–forming cold-water corals that have been documented within the Southwest Indian Upper Bathyal, Agulhas Sandy Shelf Edge zones, and in association with deep reefs and submarine canyons on the Agulhas Inner Shelf and Shelf Edge zones, respectively (Sink & Samaai 2009, Sink *et al.* 2011, Pisces 2018). For example, a number of sites sampled by the 2016 Deep Secrets Offshore Research survey undertaken by the National Research Foundation and African Coelacanth Ecosystem Programme were characterised by highly sensitive benthic communities including reef-building Scleractinia corals and stylasterine lace corals (Sink 2016, cited in Sink *et al.* 2019). These cold-water corals are cnidarians encompassing stony corals (Scleractinia), soft corals (Octocorallia, including "precious" corals, gorgonian sea fans, and bamboo corals), black corals (Antipatharia), and hydrocorals (Stylasteridae) (Roberts *et al.* 2006). These corals are long-lived (hundreds of years old) and can form large reef frameworks that persist for millennia. In the Mediterranean Sea, off northwest Africa, and on the mid-Atlantic ridge beyond the southern limit of the ice sheets, Uranium–thorium dating suggests continuous cold-water coral growth over the last 50 000 years (Schröder-Ritzrau *et al.* 2005). These species are typically restricted to water temperatures of 4-12°C, and therefore tend to occur either in relatively shallow waters in the high latitudes, or at depths below warm surface water masses at low latitudes (200-4 000 m) (Freiwald & Roberts 2005, Roberts *et al.* 2006). Arguably the most three dimensionally complex habitats in the deep ocean, these reefs provide niches for many species, including commercially important fish species, with diversity that may be comparable to tropical reef systems (Roberts *et al.* 2006).

In recognition of these habitats, the 2018 NBA denotes the Kingklip Corals' Ecologically or Biologically Significant Marine Area (EBSA) to the north of the Concession Area as a Vulnerable Marine Ecosystem (VME), as defined by Atkinson & Sink (2018). This area was specifically highlighted for the high number of VME indicator species on rocky substrate at 150-800 m depth, including reef-forming Scleractinia corals, deep-water soft corals, Brisingida sea stars and the dominant octocoral Thouarella, with occurred with several associates (brittlestars, scale worms) as well as fish eggs and larvae (Sink *et al.* 2016,). The proposed alternative pipeline route passes through the southwestern corner of the Kingklip Corals EBSA**,** however, the base case route for the pipeline is located further away (Section 4.3). VMEs are "groups of species, communities or habitats characterized by their structural functionality and their vulnerability to physical disturbance" (FAO 2009, NBA 2018). Vulnerability relates to the likelihood that a population, community or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what time frame. The Identification of VMEs is based on five main criteria outlined in the 2006 Food and Agriculture Organization (FAO) guidelines for management of deep-sea Fisheries and includes (i) uniqueness or rarity; (ii) functional significance of the habitat; (iii) fragility; (iv) live-history traits of component species that make recovery difficult; and (iv) structural complexity (FAO 2009). Examples of indicator taxa of VMEs are also provided in the guidelines, and includes reef-building corals, sponge-dominated communities, endemic or rare communities and structural biogenic habitats (e.g., those composed of large bryozoans, protozoans or hydrozoans) (Auster *et al.* 2011). The 22 potential South African VME indicator taxa defined by Atkinson & Sink

(2018) include stony corals Scleractinia, bamboo coral Isidae, stylasterine lace corals *Errina*, *Errinopsis* and *Stylaster* spp., soft corals *Thouarella* spp. and seafans Melithaea genus as well as sea pens of the genus Antiopium, and habitat-forming sponges and bryozoa. All these taxa, with the exception of sea pens and Suberites sponges, are present in rocky habitat.

Species of importance observed in Block 11B/12B and Block 9, highlighted by Atkinson & Sink (2018) as potential indicators of VMEs, and recorded during the 2022 ROV campaign, include the reef-building cold water coral *Lophelia pertusa*, right angle corals Dendrophylliidae: *Cladopsammia* and *Eguchipsammia* sp., zigzag corals *Enallopsammia rostrata*, bottle brush sea fan Primnoidae, *Thouarella* sp., sabre bryozoan *Adeonella* sp., and the honeycomb false lace coral *Phidoloporidae* sp. (Figure 3-15) (BSL 2023).

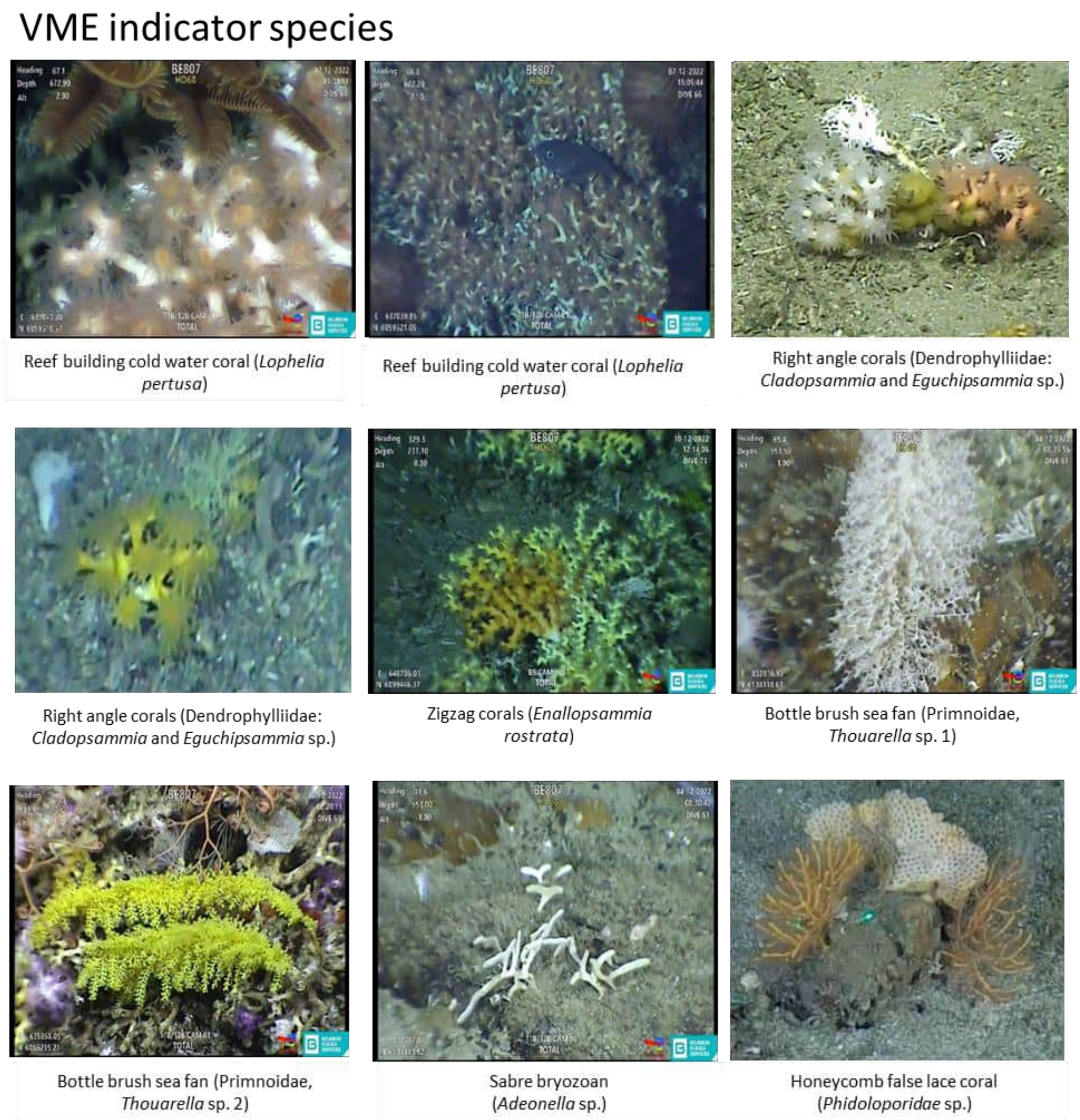


Figure 3-15. Examples of VME indicator epifaunal species recorded in the Block 11B/12B Production Right Application Area and Bock 9 (both associated pipeline routing corridor options) during the 2022 Bourbon Evolution 807 environmental survey ROV campaign (BSL 2023).

These VME indicator species were found across the Application Area and both associated pipeline routing corridor options (BSL 2023). VME indicator species were also found in two of the five ROV transects untaken within the Eastern Agulhas Outer Shelf Mosaic (all within the proposed pipeline routing corridor) (Table 3.2). Two of these sites fall within the Basecase proposed pipeline route (Figure 3-16). VME indicator species were recorded in all five of the ROV transects undertaken within the Agulhas Rocky Shelf Edge habitat type (Table 3.2). Again, VME indicator species were found at sites which fall within the pipeline corridor of both the Basecase and Option pipeline routes (see Figure 3-16) (Dawson *et al.* 2023, in BSL 2023).

VME indicator species were also found in all of the transects undertaken within the Southwest Indian Upper Slope habitat (Table 3.2). All of the sites surveyed within the eastern portion of the Concession Area (Figure 3-16) included VME indicator species (Table 3.2, Figure 3-16). Numerous fossils of wood/tree trunks were present on the seabed at various sites, providing unique and rare attachment areas for benthic epifaunal taxa. The second highest number of sponges (total of 19) was also recorded in this area. Due to a rich benthic faunal community and rare fossils discovered in this area, it is recommended that any disturbance activities (e.g., mining or dredging) that could result in the disappearance of these unique and well-preserved fossils and the associated biota be avoided (Dawson et al. 2023, in BSL 2023).

The area of proposed production drilling at the western Project Development Area discovery sites fall within the Southwest Indian Mid Slope benthic habitat (Figure 3-16). Of the five ROV transects undertaken in this habitat type, VME indicator species were observed in one of the transects, which falls outside both proposed pipeline route corridors (Table 3.2, Figure 3-16). No VME indicator species were observed in the transect undertaken closest to the western Project Development Area discovery site (Table 3.2, Figure 3-16) (Dawson et al. 2023, in BSL 2023).

BSL (2023) used the semi-quantitative SACFOR (Superabundant, Abundant, Common, Frequent, Occasional and Rare Abundance Scale) abundance scale to assess the presence/absence of soft and hard corals by transforming abundance data, size class and percentage cover, into seven categories (rare, occasional, frequent, common, abundant, and super-abundant) (BSL 2023, Coggan *et al*., 2007). A higher density of soft corals was classed at a SACFOR density of ‘Common’, or above, with higher levels of substrate heterogeneity (i.e., mosaic habitats like boulder/pavement and coral rubble) (BSL 2023). Most of these sites are located in the southwest of Block 11B/12B, and in the centre of both of the associated pipeline routing corridor options (BSL 2023). In contrast, soft corals were absent from the sandy habitat, and from areas where deep-sea manganese nodule fields were present (Table 3.2).

Deep-sea sponge communities were quantified by assessing sponge coverage per section of habitat as a running category following NOROG (Norwegian Oil and Gas Authority) (2019), with coverage classified into four categories: single individual or rare, scattered, common and high (BSL 2023). Results indicate a relatively low distribution of sponges across the survey area, with more than half (54%) of image stills reviewed showing no evidence of sponges, or sponge aggregations, and 33% showing a seabed coverage of <1% (of which 2.4% were single individuals) (BSL 2023).

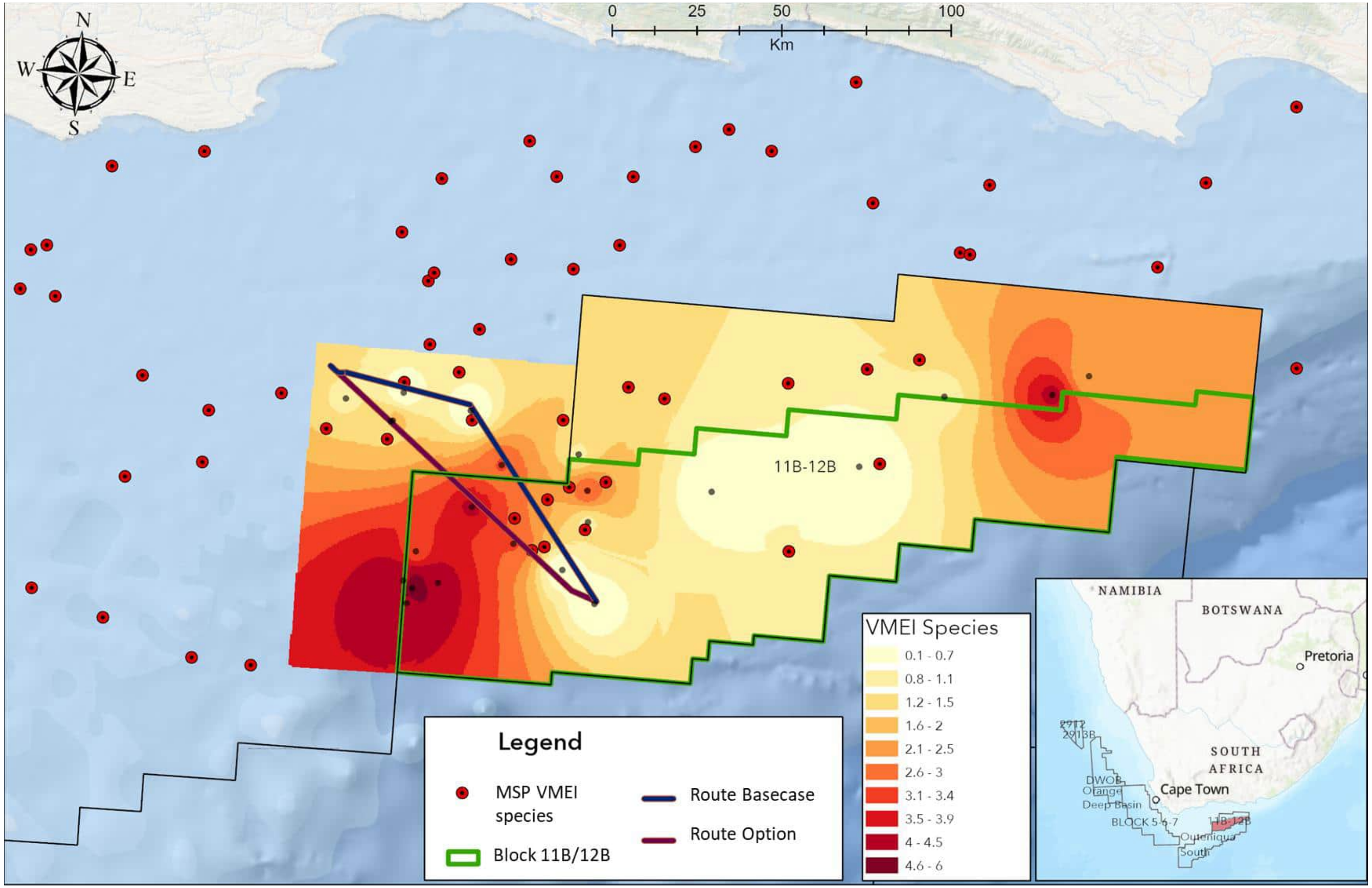


Figure 3-16. Spatial variation in preliminary VME indicator species richness according to ROV transects undertaken during the 2022 Bourbon Evolution 807 environmental survey ROV campaign. The locations of previously recorded VME indicator species (from DFFE 2023) are indicated by red points.

Table 3.2. Preliminary epifaunal VME indicator species observations from ROV transects undertaken during the 2022 Bourbon Evolution 807 campaign survey of the Application Area and both associated pipeline routing corridor options. The 'maximum' (i.e., worst-case) SACFOR abundance (estimation of density) is provided for soft and hard corals (BSL 2023).

Ecosystem classification of benthos as per SANBI (2018)	**Recorded VME indicator species**	**'Maximum' Density Estimation (BSL 2023)**	
		Soft Coral	**Hard Coral**
Eastern Agulhas Outer Shelf Mosaic	Honeycomb false lace coral (*Phidoloporidae* sp.) Cold water coral (*Lophelia pertusa*) Right angled corals (*Cladopsammia* and *Eguchipsammia* sp.) Sabre bryozoan (*Adeonella* sp.)		
Agulhas Rocky Shelf Edge	Bottlebrush sea fan (*Thouarella* spp.) Cold water coral (*Lophelia pertusa*) Overhanging lace Coral (*Stylasteridae* sp.) Right angled corals (*Cladopsammia* and *Eguchipsammia* sp.) Sabre bryozoan (*Adeonella* sp.) Zigzag coral (*Enallopsammia rostrata*)	Common	Common
Southwest Indian Upper Slope	Bamboo coral (*Isididae* sp.) Bottlebrush sea fan (*Thouarella* spp.) Branched sea whip (Isididea: *Keratoisidinae*) Cold water coral (*Lophelia pertusa*) Isididae sp. "nodal" Right angled corals (*Cladopsammia* and *Eguchipsammia* sp.) Sabre bryozoan (*Adeonella* sp.) Zigzag coral (*Enallopsammia rostrata*)	Common	Common
Southwest Indian Mid Slope	Bottlebrush sea fan (*Thouarella* spp.)		

These preliminary survey results indicate a hotspot of VME indicator species in the southwest area of the Block (Figure 3-16) (BSL 2023). To provide an indication of the overall sensitivity of the epifaunal community within the Application Area, Dawson *et al.* (2023) (in BSL 2023) presented an additional heat map that overlayed all three factors: total number of taxa, number of Vulnerable Marine Ecosystem Indicator (VMEI) taxa and occurrence/density of fossils. The importance/contribution of each factor to the overall sensitivity was weighted differently, with the most important being the number of VMEI taxa present in the ROV transect (50% contribution), the total number of taxa (35% contribution) and abundance of fossils (15%) (Figure 3-17). The sensitivity heat map shows that the western quadrant of the Block has a high to very high epifaunal sensitivity (Figure 3-17, Dawson *et al.* 2023) — these areas hosted the highest diversity of taxa (83 taxa), a number of potential VMEI species, and the second highest number of sponges (total of 19). This area was also host to numerous fossils of wood/tree trunks were observed on the seabed which form unique and rare attachment points for benthic epifaunal taxa (Figure 3-17, Dawson *et al.* 2023 in BSL 2023). Due to the high sensitivity, rich epifaunal community, and rare fossils discovered in the western area of the Block, a precautionary approach should be used for any development in this area (Dawson *et al.* 2023 in BSL 2023). Based on the sensitivity map (Figure 3-17), both pipeline routes go through an area of high sensitivity (Dawson *et al.* 2023 in BSL 2023).

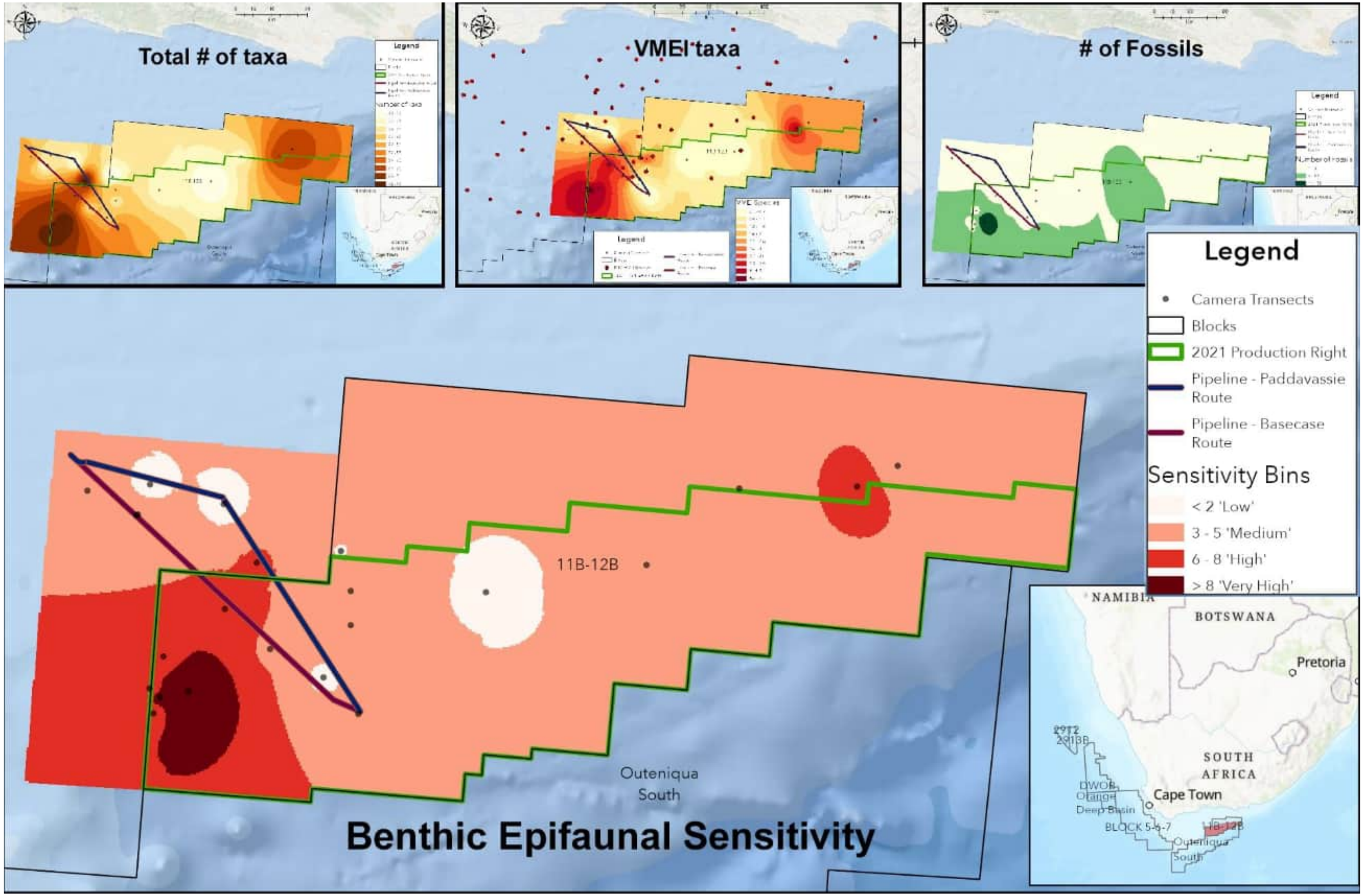


Figure 3-17. Spatial variation in epifaunal sensitivity within Block 11B/12B with weighted contributions from the total number of taxa (top left), number of VMEI taxa (centre) and number of fossils (top right) (Dawson *et al.* 2023, in BSL 2023).

3.3.3 PLANKTON

Phytoplankton biomass over the Agulhas Bank is strongly linked to environmental conditions: chlorophyll-a concentrations vary seasonally, being lowest in winter and summer (<1-2 mg/m^3) and peaking in spring and autumn (2-4 mg/m^3) (Brown 1992). Mean chlorophyll-a concentrations also vary with distance from shore, with higher concentrations inshore (<200 m depth) areas (1.46 mg/m^3 in the top 30 m of the water column) compared to areas further offshore (1.00 mg/m^3) (Brown *et al.* 1991, Brown 1992).

Low phytoplankton biomass in the surface waters of the Agulhas Bank is generally associated with periods of deep winter mixing, or when strong thermoclines are present, which results in low nutrient availability (Probyn *et al.* 1994, Pisces 2019). Under these conditions, surface water phytoplankton communities are generally dominated by large-celled diatoms and dinoflagellates, with an overall phytoplankton productivity of 200-800 mgC/m^2/hr, declining with depth to near zero in bottom waters (Pisces 2019).

While phytoplankton biomass tends to be restricted to a narrow range of surface water (the "chlorophyll maximum"), production can increase dramatically should the thermocline intercept this chlorophyll maximum, resulting in chlorophyll concentration of >10 mg/m^3 (Carter *et al.* 1987, Hutchings 1994). Increases in phytoplankton productivity are also linked to coastal upwelling (Probyn *et al.* 1994). Although seasonal diatom blooms do occur along the South Coast and on the Agulhas Bank, the red tide harmful algal blooms (HABs) characteristic of the Benguela upwelling system are seldom reported east of Cape Agulhas (Pitcher & Calder 2000).

South Coast zooplankton communities have comparatively high species diversity, ranging from 3-6 gC/m^2 (De Decker 1984). The South Coast mesozooplankton (>200 µm) is dominated by the calanoid copepod *Calanus agulhensis*, an important food source for pelagic fish stocks (Peterson *et al.* 1992). As with phytoplankton, mesozooplankton biomass increases from west (~0.51.0 g C/m^2) to east (~1.0-2.0 g C/m^2) and peaks on the central and eastern Agulhas Bank during summer in association with the subsurface ridge of cool upwelled water (Pisces 2019). Standing stocks are estimated to be 0.079 gC/m^2 between Cape Agulhas and Cape Recife (Verheye, unpublished data). Macrozooplankton (>1 600 µm) of the area include dense swarms of euphausiids, which are an important food source for pelagic fishes (Cornew *et al.* 1992, Verheye *et al.* 1994, Pisces 2019).

3.3.4 FISH AND SQUID

The South Coast ichthyofauna community comprises both temperate and tropical species because the region forms the transition zone between the warm south flowing Agulhas current and the cool upwelling Benguela Current System on the West Coast. This results in a productive system and diverse fish community which is supported by the species-rich benthic habitat present in the area (see Section 3.3.1).

The area of the Agulhas Bank east of Cape Agulhas between the shelf-edge upwelling and the cold-water ridge (where copepod availability is highest) is a spawning ground for many commercially important fish stocks, such as hake, kingklip, pelagic and squid (Figure 3-18) (Crawford 1980, Hutchings 1994, Roel & Armstrong 1991, Hutchings *et al.* 2002, Pisces 2019).

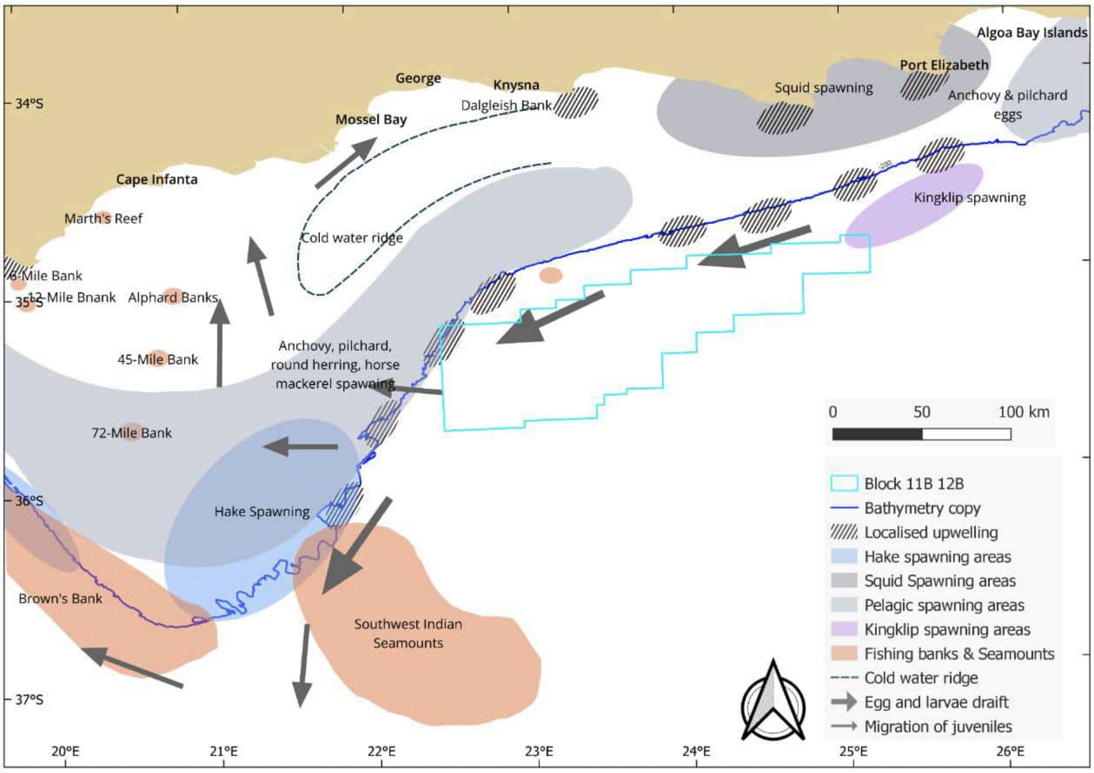


Figure 3-18. The Application Area (blue polygon) in relation to important seamounts, pelagic and demersal fish and squid spawning areas (adapted from Pisces (2019) after Anders 1975, Crawford *et al.* 1987, Hutchings 1994).

While most of the spawned eggs and larvae remain on the Bank, some are carried to the West Coast or out to sea via the Agulhas retroflection (Hutchings 1994, Duncombe Rae *et al.* 1992, Hutchings *et al.* 2002, Pisces 2019). Anchovy *Engraulis encrasicolus* spawn between October-January around the 200 m depth contour on the Agulhas Bank between Mossel Bay and Plettenberg Bay, after which the adults move inshore and eastwards. Sardine *Sardinops sagax* also spawn on the Agulhas Bank during spring and summer with adults moving eastwards and northwards after spawning, with recruits found inshore along the South Coast (Crawford 1980, Hutchings 1994, Pisces 2019, Teske *et al.* 2021, see Figure 3-18, Figure 3-19).

Winter (June-July) spawning of sardines on the central Agulhas Bank has also been reported in small areas characterised by high concentrations of phytoplankton (van der Lingen *et al.* 2006). Round herring are also reported to spawn along the South Coast, as do the demersal Cape hakes and kingklip (Roel & Armstrong 1991, Pisces 2019) (Figure 3-19). Spawning of the shallow-water hake *Merluccius capensis* occurs primarily over the shelf (<200 m) whereas that by the deep-water hake *M. paradoxus* occurs off the shelf (Pisces 2019). Kingklip spawn off the shelf edge to the south of St Francis and Algoa Bay, on the eastern edge of the Application Area (Hutchings 1994, Pisces 2019). Squid (*Loligo* spp.) spawn principally in the inshore waters (<50 m) between Knysna and Gqeberha, with larvae and juveniles spreading westwards.

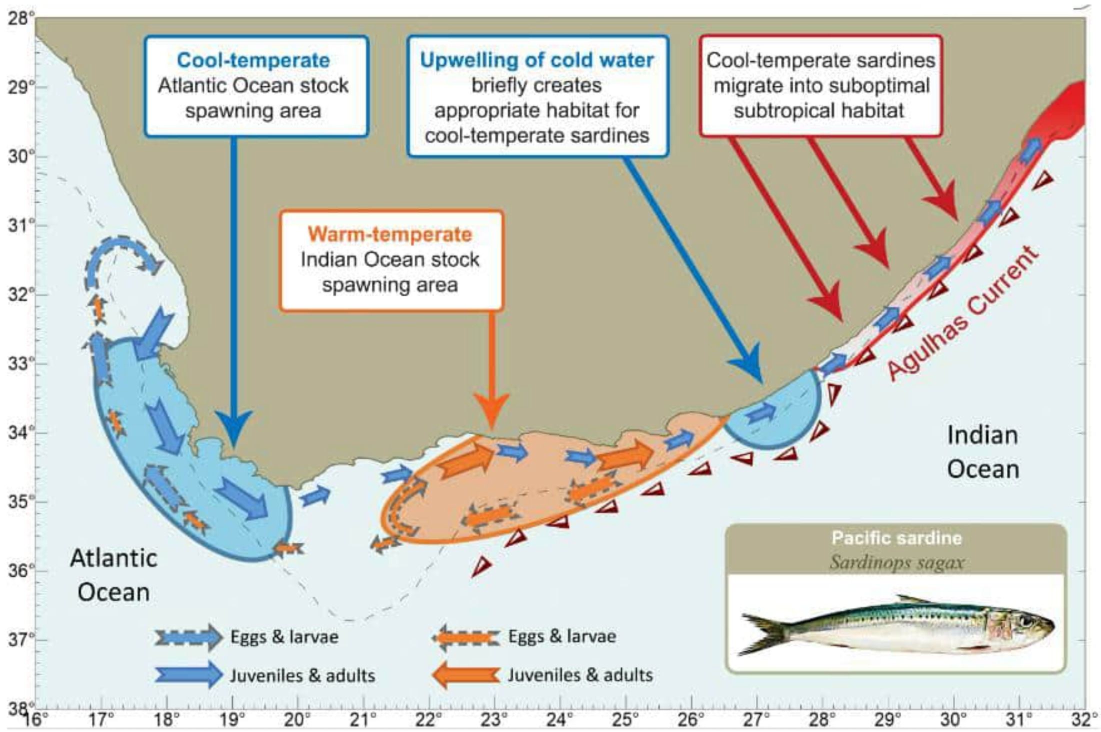


Figure 3-19. The spawning area in the Atlantic Ocean (blue, to the west) is numerically dominated by cool-temperate sardines, and the spawning area in the Indian Ocean (orange, to the east and south) is dominated by warm-temperate sardines. There is considerable exchange between these areas, with eggs and larvae from the Indian Ocean stock primarily moving westward and juveniles and adults of both stocks moving eastward. Upwelling on the southeast coast attracts cool-temperate sardines present on the south coast, which follow the cooler water as it is transported northward. When the upwelling ceases, these sardines eventually find themselves in an ecological trap of suboptimal subtropical habitat. Image: Teske *et al.* (2021).

Small pelagic species of the Agulhas Bank include anchovy *E. encrasicolus*, sardine *S. sagax*, round herring (or redeye) *Etrumeus whiteheadi*, chub mackerel *Scomber japonicas* and horse mackerel *Trachurus capensis* (Pisces 2019). Since 1996, there has been a population shift of the commercially important anchovy and sardine eastward from the west coast to the Eastern Agulhas Bank. Since 1996, 37% of the observed average adult anchovy biomass was in the area to the west of Cape Agulhas, compared to 64% of average prior to this date (DFFE 2020). While highly variable, the sardine biomass in the area to the west of Cape Agulhas has declined from 71% of the sardine biomass in 2016, to 32% in 2017 and 23% in 2019 (DFFE 2020). Anchovies are most abundant between the cool upwelling ridge and the Agulhas Current i.e., mostly on the inshore edge of the Application Area (Hutchings 1994, Pisces 2019). Horse mackerel are semi-pelagic shoaling fish that occur on the continental shelf off southern Africa and are currently more abundant off the South Coast than the West Coast (DFFE 2020). Round herring juveniles similarly occur inshore along the South Coast but move offshore with age (Roel *et al.* 1994, Hutchings 1994). Fisheries catch data and areas of operation relative to the Application Area are presented in Section 3.6.

In late summer and during winter, pockets of cool water are sporadically uplifted onto the shallow continental shelf inshore of the warm, southward-flowing Agulhas Current, expanding the suitable habitat available for *S. sagax* northward along the Eastern Cape coast (Teske *et al.* (2021). This results in the movement of large shoals that can reach 30-40 km in length northwards into southern KwaZulu-Natal following this cool water in what is known as the 'sardine run' (Van der Lingen *et al.* 2010, Pisces 2018). The shoals begin gathering in Algoa Bay in late February and move rapidly northwards in the cooler nearshore waters along the Eastern Cape coast, arriving in southern KwaZulu Natal coast in late May/early June before disappearing into the waters north of Durban (van der Lingen *et al.* 2010, Pisces 2018) (Figure 3-19). These large shoals are pursued by a variety of piscivorous predators, including great white sharks *Carcharodon carcharias*, copper sharks *Carcharhinus brachyurus*, common dolphins *Delphinus capensis* and cape gannets *Morus capensis* (O'Donoghue *et al.* 2010a).

Demersal fish on the wide Agulhas Bank continental shelf include demersal Cape hakes *Merluccius capensis* and *M. paradoxus* (see more details on the demersal fishery in Section 3.6) (Boyd *et al.* 1992, Hutchings 1994, DFFE 2020). The nursery grounds for these hake species are located off the west coast, and fish move southwards onto the Agulhas Bank as they grow, with juveniles of both species occupying shallower waters than the adults (Pisces 2018). Other important demersal species include kingklip *Genypterus capensis*, which inhabit deeper water across the whole southern coast, and are particularly associated with deep water rocky habitat (Japp *et al.* 1994, Pisces 2018). The species is thought to spawn beyond the 200 m isobaths between Cape St Francis and Gqeberha, in the north-eastern portion of the Block 11B/12B Production Right Application Area during spring, with juveniles occurring further inshore along the entire south coast (Figure 3-18). The Agulhas or East Coast sole *Austroglossus pectoralis* inhabits inshore muddy seabed (<125 m) on the shelf between Cape Agulhas and Algoa Bay (Boyd *et al.* 1992, Pisces 2018).

Commercially important **linefish species** that migrate and spawn along the South Coast include elf *Pomatomus saltatrix*, geelbek *Atractoscion aequidens*, yellowtail *Seriola lalandi*, kob *Argyrosomus* sp. seventy-four *Cymatoceps nasutus*, strepie *Sarpa salpa*, and Cape stumpnose *Rhabdosargus holubi* (Van der Elst 1988; summarised in Table 3.3). Indeed, the inshore region of the Agulhas Bank is an important nursery area for linefish species such as elf *P. saltatrix*, leervis or garrick *Lichia amia*, geelbek *A. aequidens* and carpenter *Argyrozona argyrozona* (Wallace *et al.* 1984, Smale *et al.* 1994, Pisces 2019). Adults undertake spawning migrations northwards along the South Coast between the cool water ridge and the shore, with eggs and larvae from the Kwa-Zulu Natal waters to the north dispersed southwards by the Agulhas Current, and juveniles occurring on the inshore Agulhas Bank (Garratt 1988, Beckley & van Ballegooyen 1992, Pisces 2019). Carpenter, for example, appear to have high reproductive output between the central Agulhas Bank and the Tsitsikamma Marine Protected Area (MPA) (Brouwer & Griffiths 2005, Pisces 2019). There are two separate nursery grounds for the species, one off the deep reefs off Cape Agulhas and another near Gqeberha, from whence older fish disperse to the west and east (van der Lingen *et al.* 2006, Pisces 2019).

Table 3.3. Important demersal and pelagic linefish species landed by commercial and recreational boat fishers and shore anglers along the South Coast (CCA & CMS 2001, Pisces 2018, DFFE unpublished data).

Common Name	Species	Common Name	Species
Demersal teleosts		Scotsman	*Polysteganus praeorbitalis*
Bank steenbras	*Chirodactylus grandis*	Seventyfour	*Polysteganus undulosus*
Belman	*Umbrina canariensis*	Silver Kob	*Argyrosomus inodorus*
Blacktail	*Diplodus sargus*	Slinger	*Chrysoblephus puniceus*
Blue hottentot	*Pachymetopon aeneum*	Snapper salmon	*Otolithes ruber*

Common Name	Species	Common Name	Species
Bronze bream	*Pachymetopon grande*	Spotted grunter	*Pomadasys commersonnii*
Cape stumpnose	*Rhabdosargus holubi*	Squaretail kob	*Argyrosomus thorpei*
Carpenter	*Argyrozona argyrozona*	Steentjie	*Spondyliosoma emarginatum*
Dusky Kob	*Argyrosomus japonicus*	Snoek	*Thyrsites atun*
Dageraad	*Chrysoblephus christiceps*	Strepie	*Sarpa salpa*
Englishman	*Chrysoblephus anglicus*	White steenbras	*Lithognathus lithognathus*
Fransmadam	*Boopsoidea inornata*	White stumpnose	*Rhabdosargus globiceps*
Galjoen	*Dichistius capensis*	Wreckfish	*Polyprion americanus*
Grey chub	*Kyphosus bigibbus*	Zebra	*Diplodus cervinus*
Kob	*Argyrosomus hololepidotus*		
Mini kob	*Johnius dussumieri*	Pelagic teleosts	
Musselcracker	*Sparodon durbanensis*	Elf	*Pomatomus saltatrix*
Natal stumpnose	*Rhabdosargus sarba*	Garrick/leerfish	*Lichia amia*
Poenskop	*Cymatoceps nasutus*	Geelbek	*Atractoscion aequidens*
Pompano	*Trachinotus africanus*	Green jobfish	*Aprion virescens*
Red roman	*Chrysoblephus laticeps*	King mackerel	*Scomberomorus cavalla*
Red steenbras	*Petrus rupestris*	Kingfish species	*Caranx* spp.
Red stumpnose	*Chrysoblephus gibbiceps*	Queenfish	*Scomberoides commersonnianus*
River bream	*Acanthopagrus berda*	Queen mackerel	*Scomberomorus plurilineatus*
Rockcod	*Epinephelus* spp.	Tenpounder	*Elops machnata*
Sand steenbras	*Lithognathus mormyrus*	Wahoo	*Acanthocybium solandri*
Santer	*Cheimerius nufar*	Yellowtail	*Seriola lalandi*

The **large migratory pelagic fish species** most likely to occur offshore, and in the Application Area include various tunas, billfish and sharks (Table 3.4). Many of these species are International Union for Conservation of Nature (IUCN) listed species. Populations of migratory pelagic species are facing declines on a global scale because their biology, behaviour and migratory nature make them particularly vulnerable to threats throughout their life history (Lascelles *et al.* 2014, Allan *et al.* 2021). These species are large consumers, and as such, declines in their populations have cascading effects on ecosystem structure and function (Allan *et al.* 2021).

Table 3.4. Important large migratory pelagic fish likely to occur in the offshore regions of the South Coast (IUCN 2022, adapted from Pisces 2018, 2019).

Common Name	Species	IUCN Conservation Status (IUCN 2023)
Tunas		
Southern Bluefin tuna	*Thunnus maccoyii*	Endangered
Bigeye tuna	*Thunnus obesus*	Vulnerable
Longfin tuna/albacore	*Thunnus alalunga*	Least concern
Yellowfin tuna	*Thunnus albacares*	Least concern
Frigate tuna	*Auxis thazard*	Least concern
Eastern little tuna/Kawakawa	*Euthynnus affinis*	Least concern

Common Name	Species	IUCN Conservation Status (IUCN 2023)
Skipjack tuna	*Katsuwonus pelamis*	Least concern
Atlantic bonito/ Katonkel	*Sarda sarda*	Least concern
Billfish		
Black marlin	*Istiompax indica*	Data deficient
Blue marlin	*Makaira nigricans*	Vulnerable
Striped marlin	*Kajikia audax*	Least concern
Sailfish	*Istiophorus platypterus*	Least concern
Swordfish	*Xiphias gladius*	Near Threatened
Pelagic Sharks		
Great Hammerhead shark	*Sphyrna mokarran*	Critically Endangered
Smooth Hammerhead shark	*Sphyrna zygaena*	Vulnerable
Pelagic Thresher shark	*Alopias pelagicus*	Endangered
Bigeye Thresher shark	*Alopias superciliosus*	Vulnerable
Common Thresher shark	*Alopias vulpinus*	Vulnerable
Dusky shark	*Carcharhinus obscurus*	Endangered
Great White shark	*Carcharodon carcharias*	Vulnerable
Shortfin Mako shark	*Isurus oxyrinchus*	Endangered
Longfin Mako shark	*Isurus paucus*	Endangered
Whale shark	*Rhincodon typus*	Endangered
Blue shark	*Prionace glauca*	Near Threatened
Oceanic whitetip shark	*Carcharhinus longimanus*	Critically Endangered
Bronze whaler shark	*Carcharhinus brachyurus*	Vulnerable

The coastal spawning grounds for **Chokka squid** *Loligo reynaudii* are mostly found between Plettenberg Bay and Algoa Bay in waters shallower than ~60 m (Jacobs *et al.* 2022a). This cephalopod species is the basis for an important commercial fishery that mostly targets the species on the spawning grounds or "nests" during the spawning season (spring-summer). The egg capsules of this species are deposited directly onto the seafloor and develop optimally at temperatures of 12-20°C and dissolved oxygen concentrations of >3 ml/l, which makes the Agulhas Bank an optimal area for spawning (Roberts 2005). The extent of the known inshore spawning grounds between Plettenberg Bay and Algoa Bay was estimated at approximately 90 km^2 (Sauer *et al.* 1992). Once they have spawned, surface currents transport some of the paralarvae towards the central Agulhas Bank, which offers rich feeding grounds (Huggett and Richardson, 2000, Roberts, 2005, Jacobs *et al.* 2022b). Both juvenile and adult chokka make use of the wider Agulhas Bank and the Benguela upwelling area (west coast of South Africa) to feed before returning east to spawn (Jacobs *et al.* 2022a).

Details regarding the fisheries dependent on these species, including participation (right holding and employment), fishing methods, fleet sizes, ports of operation and economic value are included in Section 3.6 below.

Coelacanths have been found in the waters off South Africa (Smith 1939, Fraser *et al.* 2020), Kenya (De Vos & Oyugi 2002), Tanzania (Benno *et al.* 2006), Mozambique (Bruton *et al.* 1992), Madagascar (Cooke *et al.* 2021), Comoros (Fricke *et al.* 2011) and Indonesia (Erdmann 1999). Along South Africa's east coast, coelacanths are known from four locations — Wright, Jesser and Diepgat canyons off Sodwana Bay, Chaka canyon off Cape Vidal, Umzumbe (90 km south of Durban), and off East London where the first coelacanth specimen was recorded. The most recent sighting of a live coelacanth was off the south coast of KwaZulu-Natal, some 325 km south of the iSimangaliso MPA where the main South African population is located. This suggests coelacanths are more widespread along the South African coast than previously thought (Fraser *et al.* 2020).

3.3.5 SEA TURTLES

The loggerhead turtle *Caretta caretta*, the leatherback turtle *Dermochelys coriacea* and the green turtle *Chelonia mydas* are the three species of turtle that breed in South African waters (Figure 3-20). In addition to these three species, the olive ridley turtle *Lepidochelys olivacia* and the Hawksbill turtle *Eretmochelys imbricata* have also been reported as rare visitors (https://www.marineprotectedareas.org.za/turtle).

Figure 3-20. Turtle species of the South Coast of South Africa: the loggerhead turtle *Caretta caretta* (top row), the leatherback turtle *Dermochelys coriacea* (bottom left) and the green turtle *Chelonia mydas* (bottom right). Image source: Wiki Commons (clockwise from top left) Hisgett 2015, Kanda 2006, Coalición Pro CEN 2005, Schulenburg 2012.

Green turtles are non-breeding residents often found feeding on inshore reefs. Leatherback turtles inhabit the deeper waters of the Atlantic Ocean and are considered a pelagic species that travel the ocean currents in search of their prey (primarily jellyfish) and may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al.* 2004, Lambardi *et al.* 2008). They come into coastal bays and estuaries to mate and lay their eggs on the adjacent beaches. Loggerheads tend to keep more inshore, hunting around reefs, bays and rocky estuaries along the African East Coast, where they feed on a variety of benthic fauna including crabs, shrimp, sponges, and fish. In the open sea their diet includes jellyfish, flying fish, and squid.

Green turtles nest mainly along the coast of Mozambique and on both Europa and Tromelin Islands (Lauret-Stepler *et al.* 2007). Loggerheads and leatherbacks nest along the sandy beaches of the northeast coast of KwaZulu-Natal, South Africa, as well as southern Mozambique during summer months. These loggerhead and leatherback nesting populations are the southern-most in the world (Nel *et al.* 2013). Even though these populations are smaller (in nesting numbers) than most other populations, they are genetically unique and thus globally important populations in terms of conservation of these species (Dutton *et al.* 1999, Shamblin *et al.* 2014).

The mean hatching success for loggerheads (73%) and leatherbacks (76%) on the South African nesting beaches is higher than reported at other nesting sites globally (de Wet 2013). Loggerheads reach sexual maturity at about 36 years of age whereas leatherbacks reach maturity sooner, at ~15 years (Pisces 2019). It has been estimated that only 1-5 hatchlings survive to adulthood (de Wet 2013). These hatchlings are poor swimmers for their first years of life: should they survive predation on their route from their beach nests to the sea, they are swept offshore by coastal rip currents to the Agulhas Current, and drift southwards (Hughes 1974a, b, c). After about ten years, the juvenile loggerheads return to coastal areas to feed on crustaceans, fish and molluscs, and subsequently remain in these neritic habitats, while leatherbacks remain in pelagic waters until they become sexually mature and return to coastal regions to breed (Hughes 1974 a, b, c).

Between breeding events (which occur every 2-3 years), loggerhead and leatherback turtles migrate to foraging grounds throughout the Southwestern Indian Ocean as well as in the eastern Atlantic Ocean. Loggerheads tend to stay inshore and travel north to foraging grounds along the southern Mozambican coastline or cross the Mozambique Channel to forage in the waters off Madagascar **(**Figure 3-21).

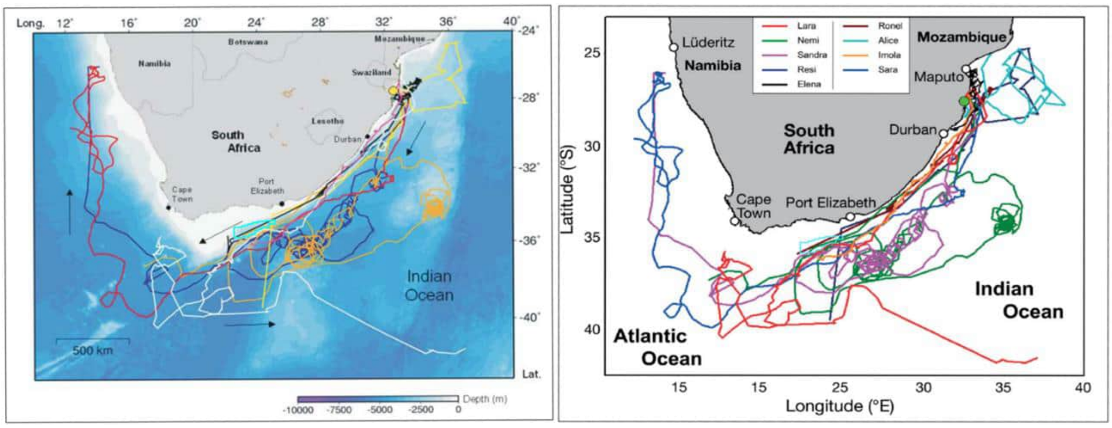


Figure 3-21. Spatial distribution of satellite tagged loggerhead turtles in relation to the Application Area (blue polygon). (Left) Post-nesting journeys of six leatherbacks tracked by satellite in years 1996–2003, showing movements towards the oceanic areas south and west of the continent; nesting beaches are indicated by yellow dots (Luschi *et al.* 2006). (Right) Reconstructed routes of 9 leatherback turtles around the southernmost part of the African continent (Lambardi *et al.* 2008).

Leatherbacks tend to move south with the Agulhas Current to forage in deeper waters offshore, with some individuals following the Benguela Current along the west coast of South Africa, as far north as central Angola (Figure 3-21) (de Wet 2013). Both loggerhead and leatherback turtles are likely to be encountered the Application Area.

Block 11B/12B MMO surveys from December 2019 to March 2020 (1 175.83 hours of visual observations) showed one sighting of a loggerhead turtle (*Caretta caretta*) during the survey (CapMarine 2020a). There were no observations of sea turtles in Block 11B/12B during the 2022 survey, although it is noted that turtles are difficult to locate in swells of above 2 m, and therefore, turtles would not have been seen in choppy or rough seas (BSL & CapMarine 2023).

3.3.6 BIRDS

Approximately 60 seabird species have been recorded or are considered likely to occur on the south coast of South Africa. These include resident species that breed along the coast (including the African penguin *Spheniscus demersus* (Box 1) and Cape gannet *Morus capensis* (both of which are listed as Endangered by the IUCN), migratory species that visit the coast to overwinter, breed and feed (like Damara tern *Sternula balaenarum*), as well as rare vagrants, which are species that stray outside their expected breeding, wintering or migrating range (Liversidge & Le Gras 1981, Ryan & Rose 1989).

Fifteen species breed within the South Coast region (Table 3.5). These include the African penguin *S. demersus* and Cape gannet *M. capensis*, a number of cormorant species including the Endangered Cape cormorant *Phalacrocorax capensis* and white-breasted cormorant *P. lucidus*, a number of tern species (the roseate tern *Sterna dougallii*, Damara tern *S. balaenarum*, swift tern *Thalasseus bergii*) as well as the kelp gull *Larus dominicanus vetula*. These species all breed on the coast or islands — Damara terns breed inshore between Cape Agulhas and Cape Infanta, a breeding colony of Cape cormorant is established on Robberg Peninsula, while kelp gulls breed in high numbers on the Keurbooms River estuary spit (Marnewick *et al.* 2015, Witteveen 2015). There are African penguin colonies along the South Coast at Dyer Island, east of Cape Agulhas, Cape Recife, and on the islands in Algoa Bay (St Croix Island, Jaheel Island, Bird Island, Seal Island, Stag Island and Brenton Rocks), with a new colony established in the De Hoop Reserve east of Cape Agulhas (van der Lingen *et al.* 2006, Pisces 2019, SANCCOB 2023). Several species breed on the beaches between Plettenberg Bay and the eastern boundary of the Tsitsikamma Section of the Garden Route National Park, such as the Caspian tern *Hydroprogne caspia*, African black oystercatcher *Haematopus moquini* and white-fronted plover *Charadrius marginatus* (Pisces 2019).

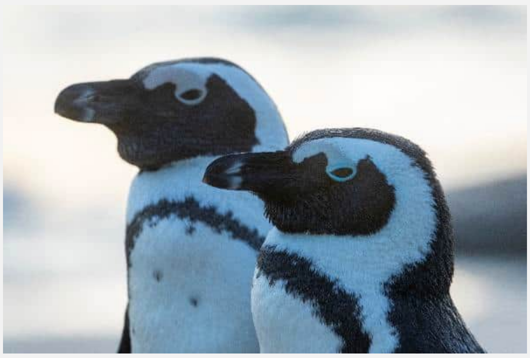
Table 3.5. Breeding resident seabirds present along the South Coast and their conservation status.

Common Name	Species	Global IUCN Conservation Status (2023)
African Penguin	*Spheniscus demersus*	Endangered
African Black Oystercatcher	*Haematopus moquini*	Least Concern
White-breasted Cormorant	*Phalacrocorax carbo*	Least Concern
Cape Cormorant	*Phalacrocorax capensis*	Endangered
Bank Cormorant	*Phalacrocorax neglectus*	Endangered
Crowned Cormorant	*Phalacrocorax coronatus*	Least Concern
White Pelican	*Pelecanus onocrotalus*	Least Concern

Common Name	Species	Global IUCN Conservation Status (2023)
Cape Gannet	*Morus capensis*	Endangered
Kelp Gull	*Larus dominicanus*	Least Concern
Greyheaded Gull	*Larus cirrocephalus*	Least Concern
Hartlaub's Gull	*Larus hartlaubii*	Least Concern
Caspian Tern	*Hydroprogne caspia*	Least Concern
Swift Tern	*Sterna bergii*	Least Concern
Roseate Tern	*Sterna dougallii*	Least Concern
Damara Tern	*Sterna balaenarum*	Least Concern

The seabird colonies, as well as the migratory and vagrant seabird visitors, are mostly supported by an abundance of small pelagic fish species (see Section 3.3.4) within the productive waters of the Agulhas Bank. Most of the breeding resident seabird species feed on fish (with the exception of the gulls, which scavenge, and feed on molluscs and crustaceans). Feeding strategies include surface plunging (gannets and terns), pursuit diving (cormorants and penguins), and scavenging and surface seizing (gulls) (Pisces 2019). All these species feed relatively close inshore, although gannets and kelp gulls may feed further offshore (Pisces 2019). For example, the majority of Algoa Bay penguins forage to the south of Cape Recife mostly within 20 km of the coast (although they have been recorded as far as 60 km offshore), following pelagic shoaling fish species such as anchovy, round herring, horse mackerel and pilchard which occur inside of the 200 m isobath (i.e., <200 m depth) (Pichegru *et al.* 2017, Pisces 2019). This distribution patterns are similar for most of the other foraging seabirds, which prey on the same small pelagic fish species (up to 40 km from the coast), although Cape gannets regularly feed as far offshore as 100 km and Cape cormorants have been reported up to 80 km from their colonies (Pisces 2019).

Box 1. History and status of the African penguin population in Southern Africa (from Clark *et al.* 2022)



The African penguin *Spheniscus demersus* is endemic to southern Africa, and breeds in three regions: central to southern Namibia, Western Cape and Eastern Cape in South Africa (Whittington *et al.* 2005a). The species has recently been up-listed to Endangered, under IUCN's 'red data list' due to data revealing rapid population declines as a result of numerous factors including pollution (from oil spills), changes in the abundance and distribution of small pelagic fish populations, competition with commercial fisheries and seals for food and predation pressure from kelp gulls and Cape fur seals, as well as potential exposure to conservation-significant pathogens (David *et al.* 2003, Pichegru *et al.* 2009, Crawford 2009, Crawford *et al.* 2011, 2014, Weller *et al.* 2014, 2016, De Moor & Butterworth 2015, Gremillet *et al.* 2016, Parsons *et al.* 2016, Sherley *et al.* 2020). The Namibian population collapsed in tandem with the collapse of its main prey species, the sardine *Sardinops sagax* (Ludynia *et al.* 2010). In South Africa, penguins breed mainly on offshore islands in the Western and Eastern Cape with strongly downward trends evident at all major colonies (Whittington *et al.* 2005b).

The global population of African penguins (including birds breeding on four Namibian Islands) hit a historical low of ~17 700 breeding pairs in 2019 with a high probability of having declined by almost 65% since 1989 (Sherley *et al.* 2020). Throughout South Africa, the African penguin population declined from an average of 48 000 pairs over the period 1979-2004 to 17 000 pairs in 2013, 13 600 pairs in 2019 and a record low of just 10 400 pairs in 2021 (Crawford *et al.* 2014, Boersma *et al.* 2020, Sherley *et al.* 2020). The number of African penguins breeding in the Western Cape decreased in a similar fashion from some 92 000 pairs in 1956, to 18 000 pairs in 1996. There was a significant recovery to a maximum of 38 000 pairs in 2004, before another dramatic collapse to 11 000 pairs in 2009, equating to a total decline of 60.5% in 28 years (Crawford *et al.* 2008a, b). West Coast penguin colonies (north of Cape Town) have fared the worst in South Africa, with an unsustainable average annual decline of 10% over the last 20 years (Sherley *et al.* 2020). This thought to be linked to a distribution shift of their main prey species (sardines and anchovies), with the Eastern Cape penguin colonies now holding ~41% of the national breeding population, up from ~27% in 1979 (Sherley *et al.* 2020). This overall downward trend strongly reinforces the argument that immediate conservation action is required to prevent further losses of these birds. In light of the ongoing decline in African penguin numbers nationally, a Biodiversity Management Plan for the African Penguin was gazetted in 2013, with aims: "*To halt the decline of the African penguin population in South Africa within two years of the implementation of the management plan and thereafter achieve a population growth which will result in a downlisting of the species in terms of its status in the IUCN Red List of Threatened Species*". Despite the successful implementation of many of the actions listed in the plan, these aims were not attained, and African Penguins in South Africa have continued to decline. This has led to several revisions of the Biodiversity Management Plan (Government Gazette No. 42775 18 October 2019, Government Gazette No. 47061 22 July 2022). This latest plan attributes population declines mostly to a scarcity of prey and recommends pelagic fishery exclusion zones around colonies, seasonal closures at penguin feeding grounds before and post moult, oil spill risk management and colony specific management such as predator control.

Penguin survival and breeding success has been linked to the availability of pelagic sardines *S. sagax* and anchovies *Engraulis encrasicolus* within 20-30 km of their breeding sites (Pichegru *et al.* 2009). Diet samples taken from penguins at Marcus and Jutten Islands showed that the diet of African penguins in the Southern Benguela from 1984 to 1993 was dominated by anchovy (Laugksch & Adams 1993). During periods when anchovies are abundant, food is more consistently available to penguins on the western Agulhas Bank than at other times (older anchovy remain there throughout the year and sardines are available in the region in the early part of the year). The reduced abundance of anchovy in the 1980s may partly explain the decrease in the African penguin population evident from 1987 to 1993. Subsequently the penguin population increased in tandem with a "boom" period for the South African sardine stock that increased from less than 250 000 tonnes in 1990 to over four million tons in 2002 (Clark *et al.* 2022 presenting data from Department of Environment, Forestry and Fisheries (DFFE) 2022). Anchovy biomass also increased from the late 1990s, peaked at over 7 million tonnes in 2001, remained relatively high (compared to the 1980s and 1990s) at between 2-4 million tonnes in most years until 2014 (DFFE 2022 data presented in Clark *et al.* 2022). Although both anchovy and sardine were still abundant along the west coast during the "boom" period around the turn of the century, much of the growth in biomass in these small pelagic stocks occurred to the east of Cape Agulhas benefiting seabirds at colonies along the south and east coast. Subsequently, the sardine stock crashed over the period 2004-2007 and the proportion of the sardine stock along the west coast declined dramatically at this time. The numbers of African penguins followed, despite anchovy remaining abundant off the West Coast and an increase in the proportion of the sardine stock west of Cape Agulhas up until 2013 (DFFE 2022 data in Clark *et al.* 2022). In the last seven years though, the estimated sardine biomass along the west coast has declined dramatically, with almost none detected in the 2018-2020 acoustic surveys (DFFE 2022 data in Clark *et al.* 2022). Anchovy biomass too declined from nearly 4 million tonnes in 2013 to about 800 000 tonnes in 2019, the second lowest estimate in the last two decades and the estimated biomass on the west coast was at its fourth lowest level since the turn of the century (DFFE 2022 data in Clark *et al.* 2022). A recovery in anchovy stocks was, however, documented during the 2020 acoustic survey with a total biomass estimate of around 2.5 million tonnes and about 60% of this west of Cape Agulhas. Despite this recent recovery in anchovy biomass, small pelagic fish availability (especially sardines) remains relatively low for penguins breeding along the west coast.

Several studies have identified additional drivers of African penguin populations at the colony level; these include oiling and predation by seals and kelp gulls, with the importance fishing and food availability decreasing at small colony size (<3 500 breeding pairs) (Ludynia *et al.* 2014, Weller *et al.* 2014, 2016). There is considerable uncertainty around the causes of African penguin population decreases which is a result of multiple pressures, some operating throughout the species range and others operating at different intensities at different colonies. One of the measures currently being employed to curb these declines is the use of no-take zones for purse-seine fishing. This strategy, recently tested at St Croix Island in the Eastern Cape, was effective in decreasing breeding penguins' foraging efforts by 30% within three months of closing a 20 km zone to purse-seine fisheries (Pichegru *et al.* 2010). In this case, the use of small no-take zones presented immediate benefits for the African penguin population dependent on pelagic prey, with minimum cost to the fishing industry, while protecting ecosystems within these habitats and important species. However, experimental fishing closures at Dassen and Robben Islands have not delivered such positive results, resulting in published rebuttals labelling the findings of Pichegru *et al.* (2010) premature. More recent revisions of the Biodiversity Management Plan for the African penguin do still consider a decline of food availability as a major driver of the African Penguin population decline and recommend fishery closures around colonies (Government Gazette No. 42775 18 October 2019, Government Gazette No. 47061 22 July 2022). On the 16 September 2022 the DFFE announced closures for small pelagic fishing around the major penguin breeding colonies of Dassen Island, Robben Island, Stony Point, Dyer Island, St Croix Island and Bird Island (www.gov.za/speeches/forestry-fisheries-and-environment).

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Southern Benguela and Agulhas Bank. Of the 49 species of seabirds that occur in the Benguela region, 14 are defined as resident, 10 are visitors from the northern hemisphere and 25 are migrants from the Southern Ocean. The 24 species classified as being common in the southern Benguela are listed in Table 3.6; those reported by Marine Mammal Observers (MMOs) for the Block 11B/12B Production Right Application Area are shaded (CCA Environmental 2005, CapMarine 2020a, 2020b, BSL & CapMarine 2023). Most of the species in the region reach highest densities offshore of the shelf break (200-500 m depth), with highest population levels during their non-breeding season (winter). Pintado petrels and *Prion* spp. show the most marked variation here. During MMO surveys within Block 11B/12B from 28 November 2022 to 9 December 2022, a total of 14 bird species (1 384 seabird individuals) were counted. The most abundant of which included Cory's shearwater *Caloneactris borealis*, the Cape gannet *M. capensis*, the white-chinned petrel *Procellaria aequinoctialis* and the great-winged petrel *Pterodroma macroptera* (BSL & CapMarine 2023).

Additional mid-water trawl vessel observer bird counts from an April 2005 campaign in the region of the Application Area were made available by PA Whittington (Pers. Comm. 2023). These data, while expected to vary seasonally, provide insight as to which species utilise the area and some approximation of numbers of species in the area (Table 3.6). The most abundant species were the vulnerable white-chinned Petrel *P. aequinoctialis* (which is a night surface feeding and surface diving species) with 1 209 individuals counted over 16 days (Table 3.6). Also abundant were the endangered plunge-diving Cape gannet *M. capensis* (792 individuals) and Indian yellow-nosed Albatross *Thalassarche carteri* (280 individuals), the near threatened shy albatross *Diomedia cauta* (195 individuals) and Wilson's storm petrel *Oceanites oceanicus* (109 individuals) (Table 3.6).

Table 3.6. Pelagic seabirds common off southern Africa and likely to occur in the Block 11B/12B Production Right Application Area, their mode of feeding (diving, plunging, surface feeders, occasional submerged feeders) with their conservation status as per the IUCN Red List (Crawford *et al.* 1991, IUCN 2022). Seabirds recorded by MMOs in the Block 11B/12B Production Right Application Area are

indicated by a * (BSL & CapMarine 2023, PA Whittington Pers. Comm. 2023). Counts made in April 2005 by PA Whittington (Pers. Comm. 2023) are also included.

Common Name	Species	Mode of feeding (Hockey *et al.* 2005)	Global IUCN Conservation Status (2022)	Count (total birds, April 2005)
Shy albatross *	*Thalassarche cauta*	Surface feeding, regular surface diving	Near Threatened	195
Black browed albatross*	*Thalassarche melanophrys*	Surface feeding, surface diving, occasional surface plunging	Least concern	15
Indian yellow-nosed albatross *	*Thalassarche carteri*	Surface feeding, surface diving, occasional surface plunging	Endangered	280
Atlantic yellow-nosed albatross *	*Thalassarche chlororhynchos*	Surface feeding, shallow diving, occasional surface plunging	Endangered	
Cape gannet *	*Morus capensis*	Pursuit-diving, pursuit-plunging	Endangered	792
Northern giant petrel *	*Macronectes halli*	Surface feeding, occasional surface diving, occasional surface plunging	Least concern	1
Southern giant petrel *	*Macronectes giganteus*	Surface feeding, occasional surface diving, occasional surface plunging	Least concern	2
Giant petrel sp. *	*Macronectes sp.*	Surface feeding, occasional surface diving, occasional surface plunging	-	3
Pintado petrel	*Daption capense*	Surface feeding, surface diving, occasional surface plunging (Night feeder)	Least concern	
Great-winged petrel *	*Pterodroma macroptera*	Surface feeding (Night feeder)	Least concern	3
Soft plumaged petrel *	*Pterodroma mollis*	Surface feeding, surface diving, occasional surface plunging	Least concern	
White-chinned petrel *	*Procellaria aequinoctialis*	Surface feeding, surface diving, rarely surface plunging (Night feeder)	Vulnerable	1 029
Spectacled petrel *	*Procellaria conspicillata*	Surface feeding, surface diving	Vulnerable	
Storm petrel sp.	-	-	-	25
Wilson's storm petrel *	*Oceanites oceanicus*	Surface feeding, occasional shallow surface diving (mostly head and neck, rarely entirely submerged)	Least concern	109
European storm petrel	*Hydrobates pelagicus*	Surface feeding, occasional surface diving	Least concern	25
Leach's storm petrel	*Oceanodroma leucorhoa*	Surface feeding (Night feeder)	Vulnerable	
Black-bellied storm petrel	*Fregetta tropica*	Surface feeding, occasional shallow surface diving (mostly head and neck, rarely entirely submerged)	Least concern	
Antarctic prion	*Pachyptila desolata*	Surface feeding, occasional surface diving	Least concern	
Salvin's prion	*Pachyptila salvini*	Surface feeding	Least concern	
Broad-billed prion	*Pachyptila vittata*	Surface feeding	Least concern	

Common Name	Species	Mode of feeding (Hockey *et al.* 2005)	Global IUCN Conservation Status (2022)	Count (total birds, April 2005)
Cory's shearwater *	*Calonectris diomedea*	Surface feeding, pursuit-diving, pursuit-plunging	Least concern	24
Great shearwater *	*Puffinus gravis*	Surface feeding, pursuit-diving, pursuit-plunging	Least concern	46
Sooty shearwater *	*Puffinus griseus*	Surface feeding, surface diving, pursuit-diving, surface plunging	Near Threatened	15
Flesh-footed Shearwater *	*Puffinus carneipes*	Surface feeding, surface diving, pursuit-diving, surface plunging	Near Threatened	72
Manx Shearwater *	*Puffinus puffinus*	Surface feeding, surface diving, pursuit-diving	Least concern	1
Subantarctic Skua *	*Catharacta antarctica*	Surface feeding, shallow surface diving (mostly head and neck, rarely entirely submerged)	Least concern	34
Sabine's gull *	*Larus sabini*	Surface feeding, up-ending	Least concern	
Tern sp. *	*Sterna sp.*	-	-	
Arctic tern *	*Sterna paradisaea*	Surface feeding, shallow plunge diving	Least concern	
Antarctic tern	*Sterna vittata*	Surface feeding, shallow/surface plunge diving (Occasional night feeder)	Least concern	
Common tern *	*Sterna hirundo*	Shallow plunge diving, up-ending	Least concern	11
Pomarine jaeger *	*Stercorarius pomarinus*	Surface feeding	Least concern	
Cormorant sp. *	*Phalacrocorax* sp.	Pursuit-diving, pursuit-plunging	-	
Franklin's Gull *	*Larus pipixcan*	Surface feeding	Least concern	1

3.3.7 MARINE MAMMALS

Based on historic sightings or strandings records, as well as habitat projections of known species parameters, an estimated 35 species of cetaceans (whales and dolphins) are thought to occur (or are likely to occur) in the waters of the South Coast (Findlay *et al.* 1992, Best 2007, Weir 2011, unpublished records held by Sea Search, Pisces 2014, Pisces 2019) (Table 3.8). One resident species of coastal pinniped is present (the Cape fur seal *Arctocephalus pusillus pusillus*), while vagrant records include southern elephant seal *Mirounga leoninas*, subantarctic fur seal *A. tropicalis*, crabeater seal *Lobodon carcinophagus* and leopard seal *Hydrurga leptonyx* (David 1989). The position of the Application Area in relation to Important Marine Mammal Areas (IMMA) is presented in more detail in Section 4.6.1 below.

Marine mammals can be grouped by their hearing range, with the whales generally split along taxonomic lines (Table 3.7). Mysticetes, or the baleen whales, fall within the so-called "low frequency cetacean" group, with a generalised hearing range of 7 Hz to 35 kHz, while most toothed whales (Odontocetes) are "high hearing range cetaceans", with a generalised hearing range of 150 Hz to 160 kHz (Table 3.7). Hearing frequency groups for all cetacean species likely to occur off the South Coast, classified in accordance with hearing ranges presented in Table 3.7, are listed in Table 3.8 below.

Table 3.7. Marine mammal hearing groups (from Southall *et al.* 2019) with some South African species examples.

Hearing group	Generalised hearing range	Example species
Low-frequency cetaceans	7 Hz to 35 kHz	Baleen whales e.g., southern right whale *Eubalaena australis*, humpback whale *Megaptera novaeangliae*, Bryde's whale *Balaenoptera edeni*
High-frequency cetaceans	150 Hz to 160 kHz	Dolphins, toothed whales, beaked whales, bottlenose whales e.g., common dolphin *Delphinus delphis*, killer whale *Orcinus orca*, Atlantic bottlenose dolphin *Tursiops truncatus*, short-finned pilot whale *Globicephala macrorhynchus*
Very high-frequency cetaceans	275 Hz to 160 kHz	True porpoises, Heaviside's dolphin *Cephalorhynchus heavisidii*, pygmy sperm whale *Kogia breviceps*, dwarf sperm whale *K. sima*
Phocid carnivores in water	50 Hz to 86 kHz	True seals e.g., southern elephant seal *Mirounga leonina*, leopard seal *Hydrurga leptonyx*
Otariid and other carnivores in water	60 Hz to 39 kHz	Cape fur seals *Arctocephalus pusillus*, Cape clawless otter *Aonyx capensis*

The distribution of cetaceans can largely be split into those associated with the continental shelf and those that occur in deep, oceanic water. Importantly, species from both environments may be found on the continental slope (200-2 000 m), making this a very species rich area for cetaceans (Table 3.8). Cetacean density on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging covering 1 000s of kilometres. The most common species within the Application Area (in terms of likely encounter rate, not total population sizes) are the long-finned pilot whale and humpback whale. Southern right whales (as the most abundant baleen whales off the coast of South Africa), Bryde's whales, common bottlenose dolphins, common dolphins and sperm whales are also likely to occur in the Application Area (CapMarine 2020a, 2020b, Purdon *et al.* 2020a). Sei whales (Endangered) and killer whales are also likely to occur in low densities (CapMarine 2020a, 2020b, Purdon *et al.* 2020a, IUCN 2023). Blue (Critically Endangered), fin (Vulnerable), Antarctic minke (Near Threatened), dwarf or common minke and pygmy right whales may also occur in the region as they all show some degree of migration to, or through, the licence Block region between their feeding and breeding grounds (CapMarine 2020a, 2020b, Purdon *et al.* 2020a IUCN 2023).

Table 3.8. Cetacean occurrence off the South Coast of South Africa, their distribution, seasonality, hearing frequency, and IUCN Red List conservation status (Southall *et al.* 2019, IUCN 2022, *Penry *et al.* 2016, **Barendse & Carvalho 2016). Hearing frequency abbreviations: HF = High Frequency, VHF = Very High Frequency, LF = Low Frequency.

Common name	Species name	Hearing Frequency	Distribution		Seasonality (presence in the area)	Global IUCN (2022) Conservation Status
			Shelf (<200 m)	Offshore (>200 m)		
Delphinids (Odontocetes)						
Dusky dolphin	*Lagenorhynchus obscurus*	HF	Yes (0-800 m)	No	Year round	Least Concern
Heaviside's dolphin	*Cephalorhynchus heavisidii*	VHF	Yes (0-200 m)	No	Year round	Near Threatened
Common bottlenose dolphin	*Tursiops truncatus*	HF	Yes	Yes	Year round	Least Concern
Common dolphin	*Delphinus delphis*	HF	Yes	Yes	Year round	Least Concern
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	HF	Yes	No	Year round	Near Threatened
Southern right whale dolphin	*Lissodelphis peronii*	HF	Yes	Yes	Year round	Least Concern
Striped dolphin	*Stenella coeruleoalba*	HF	No	Data deficient		Least Concern
Indian Ocean humpback dolphin	*Sousa plumbea*	HF	Yes	No	Year round	Endangered
Pantropical spotted dolphin	*Stenella attenuata*	HF	Yes (edge)	Yes	Year round	Least Concern
Risso's dolphin	*Grampus griseus*	HF	Yes (edge)	Yes	Data deficient	Least Concern
Long-finned pilot whale	*Globicephala melas*	HF	Yes (edge)	Yes	Year round	Least Concern
Short-finned pilot whale	*Globicephala macrorhynchus*	HF	Data deficient			Least Concern
Rough-toothed dolphin	*Steno bredanensis*	HF	Data deficient			Least Concern
Killer whale	*Orcinus orca*	HF	Yes (occasional)	Yes	Year round	Data deficient
False killer whale	*Pseudorca crassidens*	HF	Yes (occasional)	Yes	Year round	Near Threatened
Pygmy killer whale	*Feresa attenuata*	HF	Data deficient			Least Concern
Sperm whales (Odontocetes)						
Pygmy sperm whale	*Kogia breviceps*	VHF	Yes (edge)	Yes	Year round	Least Concern
Dwarf sperm whale	*Kogia sima*	VHF	Yes (edge)	Data deficient		Least Concern
Sperm whale	*Physeter macrocephalus*	HF	Yes (edge)	Yes	Year round	Vulnerable
Beaked whales (Odontocetes)						
Cuvier's beaked whale	*Ziphius cavirostris*	VHF	No	Yes	Year round	Least Concern
Baird's beaked Whale	*Berardius bairdii*	HF	No	Yes	Year round	Least Concern
Southern bottlenose beaked whale	*Hyperoodon planifrons*	HF	No	Yes	Year round	Least Concern
Hector's beaked whale	*Mesoplodon hectori*	HF	No	Yes	Year round	Data Deficient
Strap-toothed Whale	*Mesoplodon layardii*	HF	No	Yes	Year round	Least Concern

Common name	Species name	Hearing Frequency	Distribution Shelf (<200 m)	Distribution Offshore (>200 m)	Seasonality (presence in the area)	Global IUCN (2022) Conservation Status
True's beaked whale	*Mesoplodon mirus*	HF	No	Yes	Year round	Least Concern
Gray's beaked whale	*Mesoplodon grayi*	HF	No	Yes	Year round	Least Concern
Blainville's beaked whale	*Mesoplodon densirostris*	HF	No	Yes	Year round	Least Concern
Baleen whales (Mysticetes)						
Antarctic minke whale	*Balaenoptera bonaerensis*	LF	Yes	Yes	>Winter	Near Threatened
Common minke whale	*Balaenoptera acutorostrata*	LF	Yes	Yes	Year round	Least Concern
Fin whale	*Balaenoptera physalus*	LF	Yes	Yes	MJJ & ON	Vulnerable
Blue whale (Antarctic)	*Balaenoptera musculus ssp. intermedia*	LF	No	Yes	Winter peak	Critically Endangered
Sei whale	*Balaenoptera borealis*	LF	Yes	Yes	MJ & ASO	Endangered
Bryde's whale (inshore subspp.)	*Balaenoptera brydei* (previously *B. edeni*)	LF	Yes	Yes	Year round	Vulnerable*
Pygmy right whale	*Caperea marginata*	LF	Yes	Data deficient	Year round	Least Concern
Humpback sp.	*Megaptera novaeangliae*	LF	Yes	Yes	Year round, SONDJF	Least Concern
Humpback B2 population	*Megaptera novaeangliae*	LF	Yes	Yes	Summer peak ONDJF	Vulnerable**
Southern right whale	*Eubalaena australis*	LF	Yes	No	Year round, SONDJF	Least Concern

The following is the most up to date description for common cetacean species distribution and behaviour in South African waters, with particular focus on the probability on presence within the Application Area.

Southern right whale: Southern right whales migrate to the lower latitudes of southern Africa to breed and calve and arrive between June and November each year. They exhibit an exclusively coastal distribution mainly in sheltered bays (90% <2 km from shore, see Best 1990, Elwen & Best 2004). The most significant concentration of these whales currently occurs on the South Coast between Cape Town and Gqeberha (Pisces 2019). However, the southern African population historically extended from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres) (Roux *et al.* 2011). As the southern right population recovers from commercial whaling activities, their range is expanding from its contracted distribution on the south coast of South Africa back to these historic grounds (Banks *et al.* 2011, Roux *et al.* 2001).

Winter concentrations have been recorded all along the southern and eastern coasts of South Africa as far north as Maputo Bay, with the most significant concentration currently on the South Coast between Cape Town and Gqeberha. Southern right whales are likely to occur in the Application Area during winter (Figure 3-22; Purdon *et al.* 2020a). They typically arrive in coastal waters off the South Coast between June and November each year, although animals may be sighted as early as April and as late as January. While in local waters, southern right whales are found in groups of 1-10 individuals, with cow-calf pairs predominating in inshore nursery areas. From July to October, animals aggregate and become involved in surface-active groups, which can persist for several hours (Pisces 2018, 2019).

Many southern right whales remain in the Southern Benguela during summer to feed off Cape Columbine and St Helena Bay on the South African West Coast (Mate *et al.* 2011). Although there are no recent data available on the numbers of right whales feeding in the St Helena Bay area, mark-recapture data from 2003-2007 estimated roughly one third of the South African right whale population at that time were using St Helena Bay for feeding (Peters *et al.* 2005). Given this high proportion of the population known to feed in the southern Benguela, and the historical records, it is highly likely that several hundreds of right whales can be expected to pass directly through the Application Area between May and June and then again November to January (Pisces 2018, 2019).

Bryde's whale: Two genetically and morphologically distinct populations of Bryde's whales are present off the coast of southern Africa (Best 2001, Penry 2010, Penry *et al.* 2016, Penry *et al.* 2018). The larger offshore form has recently been described as *Balaenoptera brydei*, while the taxonomic status of the smaller inshore form is uncertain but may be considered a subspecies of *B. brydei* (Best 2007, Penry *et al.* 2016, Penry *et al.* 2018). The offshore form is unlikely to be encountered off the South Coast (Steiner *et al.* 2008). The "inshore population" is unique amongst the southern African baleen whales in that it is resident year-round on the continental shelf and Agulhas Bank, occasionally undertaking small seasonal trips up the east coast during the annual sardine migration (Caputo *et al.* 2017). The inshore form has a small population of approximately 600 individuals, possibly declining in numbers. The most recent South African National Red Data list assessment classified this inshore population as Vulnerable (Penry *et al.* 2016). The current distribution of this population implies that it is highly likely to be present in the Application Area throughout the year, with peak encounter rates in late summer and autumn (Figure 3-22; Penry *et al.* 2011, Pisces 2018, 2019, Purdon *et al.* 2020a).

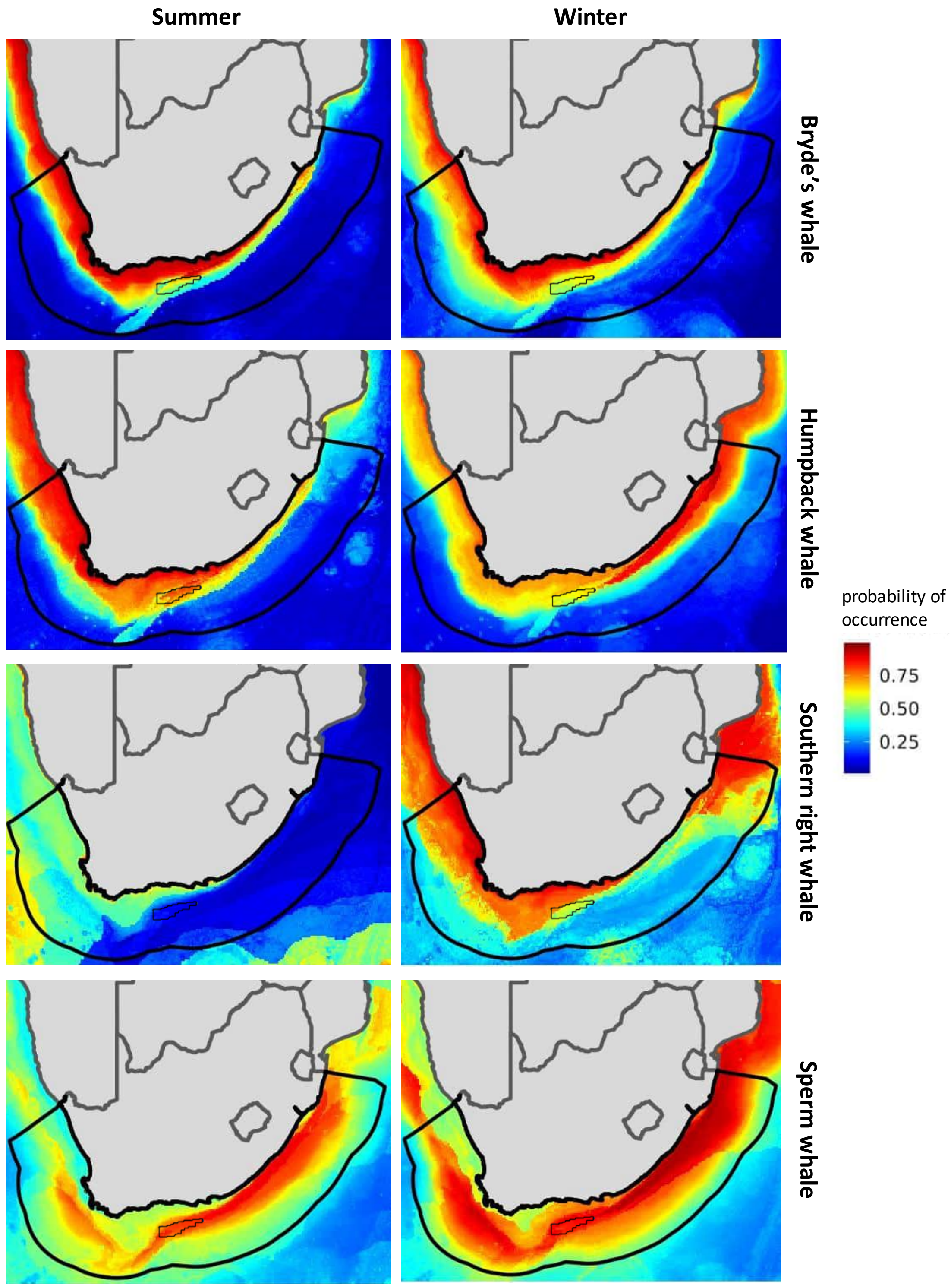


Figure 3-22. Summer and winter probability of occurrence for the Bryde's whale, humpback whale, southern right whale and sperm whale. The legend depicts the habitat suitability, the darker red the colour, the higher the predicted occurrence. The South African exclusive economic zone and the Application Area are indicated in black (adapted from Purdon *et al.* 2020a).

Humpback whale: The majority of humpback whales on the south and east coasts of South Africa are migrating past southern Africa from their Antarctic feeding grounds to their winter breeding grounds in the tropical waters off both east and west Africa (Rosenbaum *et al.* 2009, Barendse *et al.* 2010). The main winter concentration areas for humpback whales on the

African east coast include Mozambique, Madagascar, Kenya and Tanzania on the east coast. The humpbacks migrating up South Africa's east coast are identified as breeding stock C1, which was estimated to have a population of 7 035 individuals in 2010 and a population growth rate of 10% per annum (Findlay *et al.* 2011). Those feeding in the southern Benguela are defined as breeding stock B2 by the International Whaling Commission (IWC), and are classified as Vulnerable, with a population estimated at only 500 individuals in 2001-2002 and a population growth rate of 5% per annum (Barendse *et al.* 2011, Barendse & Carvalho 2016, IWC 2012). The number of humpback whales feeding in the southern Benguela region has increased substantially since estimates made in the early 2000s (Barendse *et al.* 2011). Since around 2011, 'supergroups' of up to 200 individual whales have been observed feeding within 10 km from shore (Findlay *et al.* 2017). With the increases in population sizes and the regular occurrence of hundreds of whales feeding in the Benguela ecosystem, humpback whales are now seen in all months of the year along the coast of South Africa, although the main peaks in abundance still occur (Penry *et al.* 2011, Purdon *et al.* 2020a, Pisces 2018, 2019).

Three principal migration routes for humpbacks in the south-west Indian Ocean have been identified. The first route extends along the East Coast of South Africa, reaching the coast near Knysna and continuing as far north as central Mozambique. This migration route therefore passes through the Application Area. The second route approaches Madagascar directly from the south, with the humpbacks possibly following the Mozambique Ridge. A third, less well-established route appears to move up the centre of the Mozambique Channel to Aldabra and the Comoros Islands (Findlay *et al.* 1994, Best *et al.* 1998).

It was generally understood that 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 southward return migration, although considerable variation in the departure time from breeding areas has been recorded (Barendse *et al.* 2010). Off Cape Vidal, whale abundances peak around June/July on their northward migration (although some have been observed still moving north as late as October). Southward moving animals on their return migration are generally first seen off Cape Vidal in July, peaking in August and continuing to late October (Findlay & Best 1996a, b). Humpbacks have been recorded by Marine Mammal Observers in Block 11B/12B (CapMarine 2020b, BSL & CapMarine 2023). Humpback whales are likely to be present in the Application Area during summer and winter, with higher probability of occurrence in summer (October-February) (Figure 3-22; Purdon *et al.* 2020a). Members of the Vulnerable B2 breeding stock may be encountered year-round (Rosenbaum *et al.* 2009, Pisces 2018).

Sei Whale: The Endangered Sei whale migrates through South African waters to unknown breeding grounds further north, peaking in abundance on the East Coast in June and September. Historically, sei whales were hunted in relatively high numbers. Whaling records from 1958-1963 indicate that all whales were captured offshore of 200 m deep, and mostly in waters deeper than 1 000 m (Best & Lockyer 2002). There is no contemporary information on their abundance or distribution patterns in the region. However, given their historical migration routes they are likely to occur in Block 11B/12B in low densities (Pisces 2018).

Sperm whale: Sperm whales are the largest of the toothed whales and have a complex, well-structured social system. They live in deep ocean waters usually >1 000 m, but occasionally come inshore on the shelf into depths of 500-200 m (Best 2007). Seasonality of catches off the East Coast suggest that medium- and large-sized males are more abundant during winter (June to August), while female groups are more abundant in summer (December-February), although animals occur year-round (Best 2007). Although considered relatively abundant worldwide, no current data are available on density or abundance of sperm whales in African waters, and they are now classified as Vulnerable (Whitehead 2002, IUCN 2022). Recent results on their distribution suggest that they have a relatively high probability of occurring in the Application Area, increasing in winter (Figure 3-22; Purdon *et al.* 2020a). They have been frequently encountered or detected via Passive Acoustic Monitoring (PAM) during seismic surveys in Block 11B/12B (CCA Environmental 2005, CapMarine 2020a, 2020b, BSL & CapMarine 2023).

Beaked whales: Little is known about the distribution of beaked whales, as they were never targeted commercially, and they tend to be inaccessible to researchers. They are usually seen in waters over 1 000-2 000 m deep (Best 2007). Beaked whales are known to undertake dives over 2 km, lasting over an hour, making them more difficult to detect visually (Tyack *et al.* 2011). This group is particularly vulnerable to some sources of anthropogenic noise, especially mid-frequency naval sonar, with evidence of decompression sickness often present in stranded animals (Fernandez *et al.* 2005).

***Kogia species*:** Pygmy Sperm Whales *Kogia breviceps* and Dwarf Sperm Whales *K. sima* are widely distributed species that inhabit deep water in tropical, subtropical and temperate habitats across the globe (McAlpine 2018). Due to their cryptic nature, distributional ranges are inferred from strandings, or occasional individuals captured in fisheries, rather than live sightings at sea (McAlpine 2018). While the Pygmy Sperm Whale seems to occur more commonly in cooler temperate regions, the Dwarf Pygmy Whale seems to prefer warmer waters (Plön & Relton 2016). Both species are likely to occur in the Application Area year around. The South African Red List of Mammals (Plön & Relton 2016) notes that, "*as they are deep-diving species (up to 800 m), the effects of marine noise pollution should be monitored (although thus far no strandings have been linked to this threat), and we urge more research into the severity of this threat within South African waters*".

Common dolphin: Two species of common dolphin are currently recognised, the short-beaked common dolphin *Delphinus delphis* and the long-beaked common dolphin *D. capensis*. Until recently these were considered as two species, now recognised as likely to be a single species with multiple "forms" (Cunha *et al.* 2015). While the distribution of common dolphins tends to be in warm-temperate and tropical waters globally, off South Africa the short-beaked seems to prefer offshore habitats and the long-beaked appears to have multiple disjunct populations in nearshore waters <500 m deep. Collectively, they have a large area of predicted distribution around South Africa (Purdon *et al.* 2020b). Individually, common dolphins are wide ranging along the South African coast, sometimes moving hundreds of kilometres in short periods of time. When in groups, pods may be large, consisting of 100s to 1000s of animals. The long-beaked common dolphin is resident in the temperate waters of the Agulhas Bank out to the continental shelf edge and is sighted between St Helena Bay on the West Coast and Richards Bay on the East Coast in waters less than 500 m deep. In winter they follow the 'sardine run' from the Easten Cape to Kwazulu-Natal (Cockcroft & Peddemors 1990, O'Donoghue *et al.* 2010a, 2010b, 2010c, 2010d).

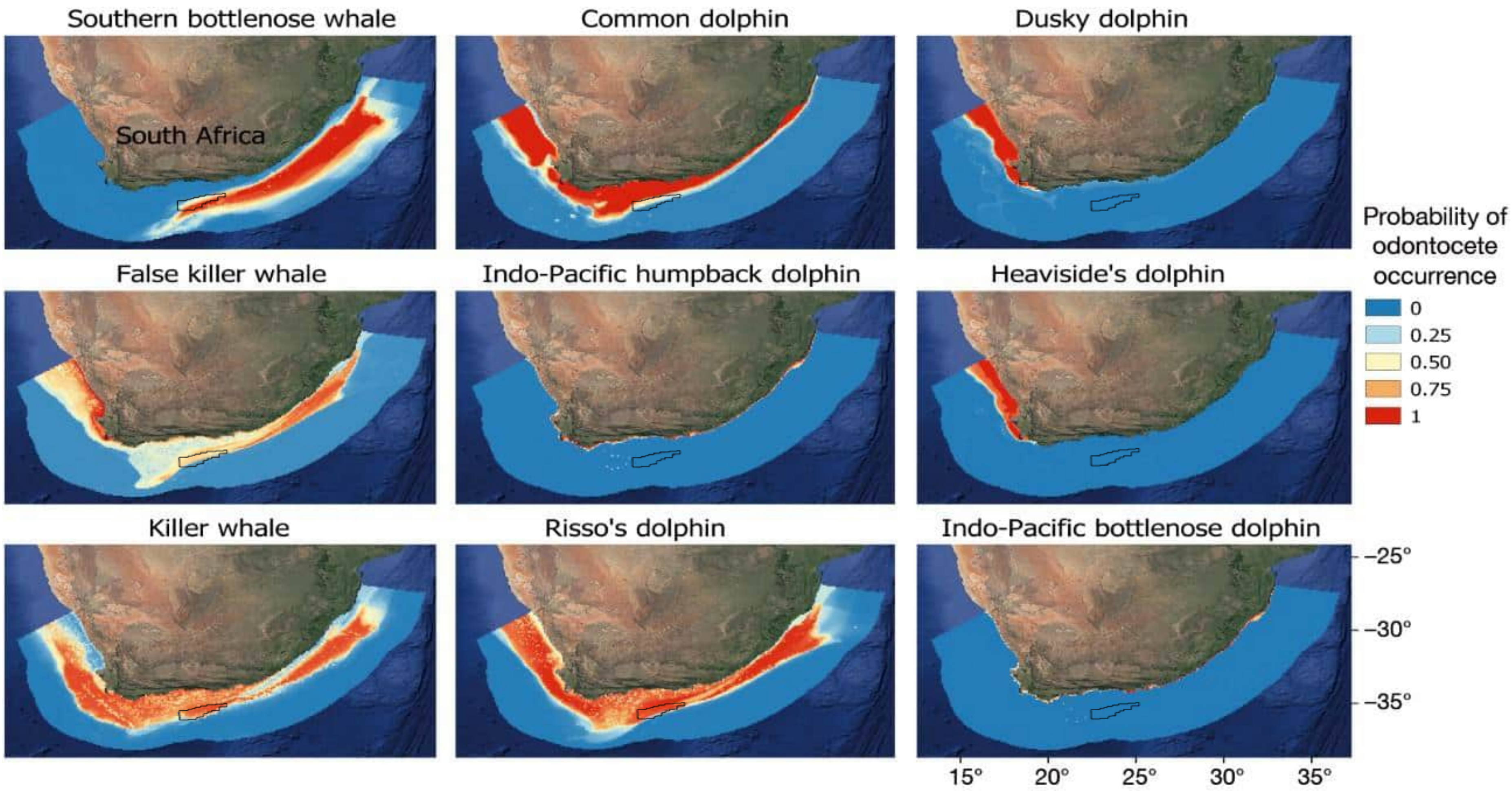


Figure 3-23. Predicted distributions for 9 odontocete species in the South African Exclusive Economic Zone. The colour scale represents probability of odontocete occurrence, where red (blue) indicates a high (low) probability of occurrence. The Application Area is indicated by the white polygon (adapted from Purdon *et al.* 2020b).

In 1988/89 the population of long-beaked common dolphins between Gqeberha and Richard's Bay was estimated at 15 000 – 20 000 animals, although this is thought to be an underestimate (Cockcroft & Peddemors 1990; Peddemors 1999) and estimates of the population size and seasonality for the subregion is lacking. Both species have been encountered in Block 11B/12B during seismic surveys (CCA Environmental 2005, CapMarine 2020a, 2020b, BSL & CapMarine 2023). Their predicted distribution indicates a high probability of occurrence in the Application Area (Figure 3-23; Purdon *et al.* 2020b).

Bottlenose dolphin: Two species of bottlenose dolphins occur around southern Africa. the smaller, Near Threatened Indo-Pacific Bottlenose dolphin *Tursiops aduncus* occurs exclusively to the east of Cape Point in water usually less than 50 m deep and generally within 1 km of the shore, while the larger common bottlenose dolphin *T. truncatus* generally further offshore around the shelf edge and pelagic waters on the south coast (Ross 1984, Ross *et al.* 1987). Their distribution is essentially continuous from Cape Agulhas eastwards to southern Mozambique. There are also seasonal movements of a genetically distinct 'migratory stock' of Indo-Pacific bottlenose dolphins along the South and East Coasts in association with the 'sardine run' (Natoli *et al.* 2008). Common bottlenose dolphins have been frequently sighted within Block 11B/12B (CCA Environmental 2005; CapMarine 2020a, 2020b) (Figure 3-23; Purdon *et al.* 2020b).

Risso's dolphin: Risso's dolphins *Grampus griseus* have worldwide distribution in tropical and temperate waters, showing a general preference for the shelf edge <1 500 m deep (Best 2007; Purdon *et al.* 2020). This species has been sighted many times along the shelf edge of the Agulhas Bank and has also been sighted in Block 11B/12B (CapMarine 2020a). Their predicted distribution indicates a high probability of occurrence in the Application Area (Figure 3-23; Purdon *et al.* 2020b).

Killer whale (Orca): Killer whales *Orcinus orca* occur circum-globally and are found in all oceans between the equator and the ice edge (Best 2007). They occur year-round in low densities off the South African coast (Best *et al.* 2010). Their predicted distribution indicates a moderate to high probability of occurrence in the Application Area and they have been encountered in low levels in the Block (Figure 3-23; CapMarine 2020b, Purdon *et al.* 2020b).

Long-finned and short-finned pilot whale: Long-finned pilot whales display a preference for temperate waters and are usually associated with the continental shelf or adjacent deep water (Mate *et al.* 2005, Weir 2011). 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, it is likely that most pilot whales encountered in the Application Area will be long-finned (Best 2007). However, due to the influence of the Agulhas Current in the area, the occurrence of short-finned pilot whales cannot be excluded. Pilot whales have been frequently encountered during seismic surveys in Block 11B/12B (CapMarine 2020b).

Other species: Other dolphins that may occur within the Application Area at low levels include the pygmy killer whale, Fraser's dolphin, pan-tropical spotted dolphin and striped dolphin (Findlay *et al.* 1992, Best 2007). Striped dolphins were frequently encountered during a seismic survey in Block 11B/12B in early 2020 (CapMarine 2020a, 2020b).

The **Cape fur** seal *Arctocephalus pusillus pusillus* is the only species of seal resident along the South Coast, occurring at numerous breeding and non-breeding sites on the mainland, namely at Seal Island in Mossel Bay (population of about 4 000 individuals), on the northern shore of the Robberg Peninsula in Plettenberg Bay (5 000) and at Black Rocks (Bird Island group) in

Algoa Bay (Pisces 2019). These colonies are all well inshore of the Application Area. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore. While the movement of seals from the three South Coast colonies are poorly known, limited tracking of the Algoa Bay colony has suggested these seals generally feed in the inshore region south of Cape Recife (Pisces 2019). The Cape fur seal population in South Africa is regularly monitored by the Department of Environment, Forestry and Fisheries (DFFE), and the overall population is considered healthy and stable in size, although there has been a westward and northward shift in the distribution of the breeding population (Kirkman *et al.* 2013).

The spatial distribution of all sightings of marine mammals from Marine Mammal Obser (MMO) surveys undertaken from December 2019 to end April 2020 within Block 11B/12B at depths from 100-2000 m is shown in Figure 3-24, while the spatial distribution of acoustic detections (via 1 946.33 hours of Passive Acoustic Monitoring) is shown in Figure 3-25.

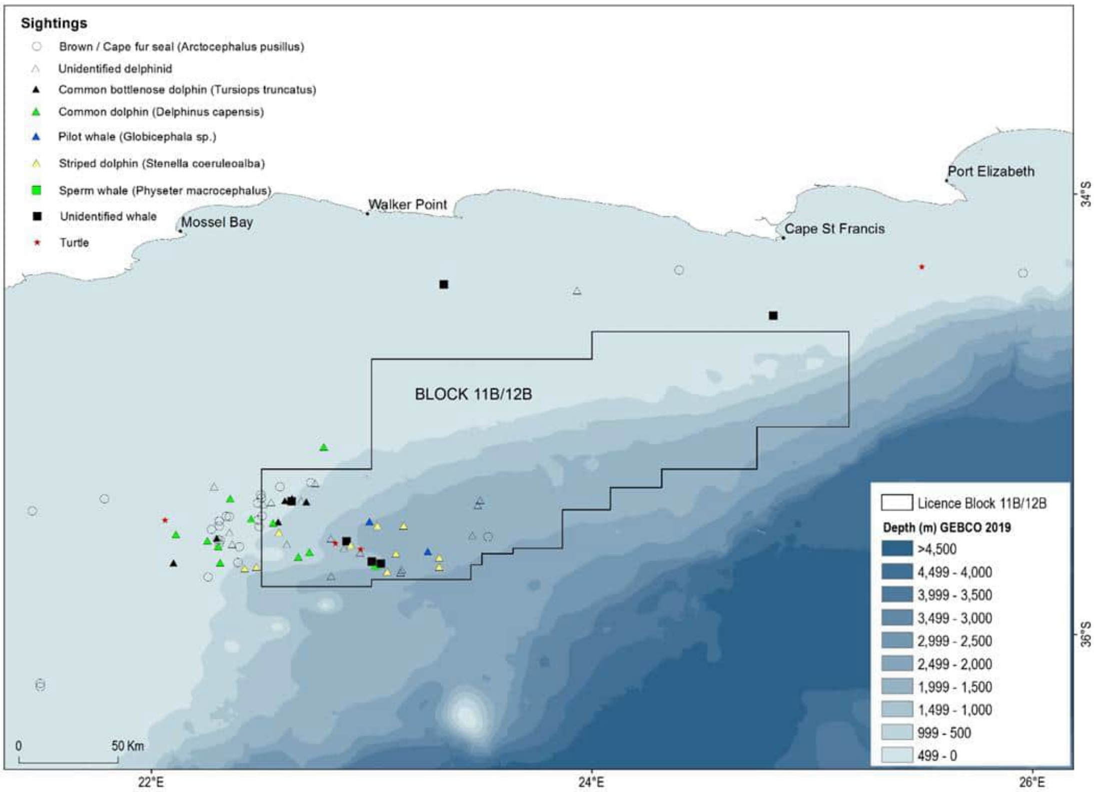


Figure 3-24. Location of cetacean sightings during visual watches from the MV PGS Apollo between 12 December 2019 to 30 April 2020. Sightings outside the Block were undertaken during line changes and transit to and from port (CapMarine 2020b).

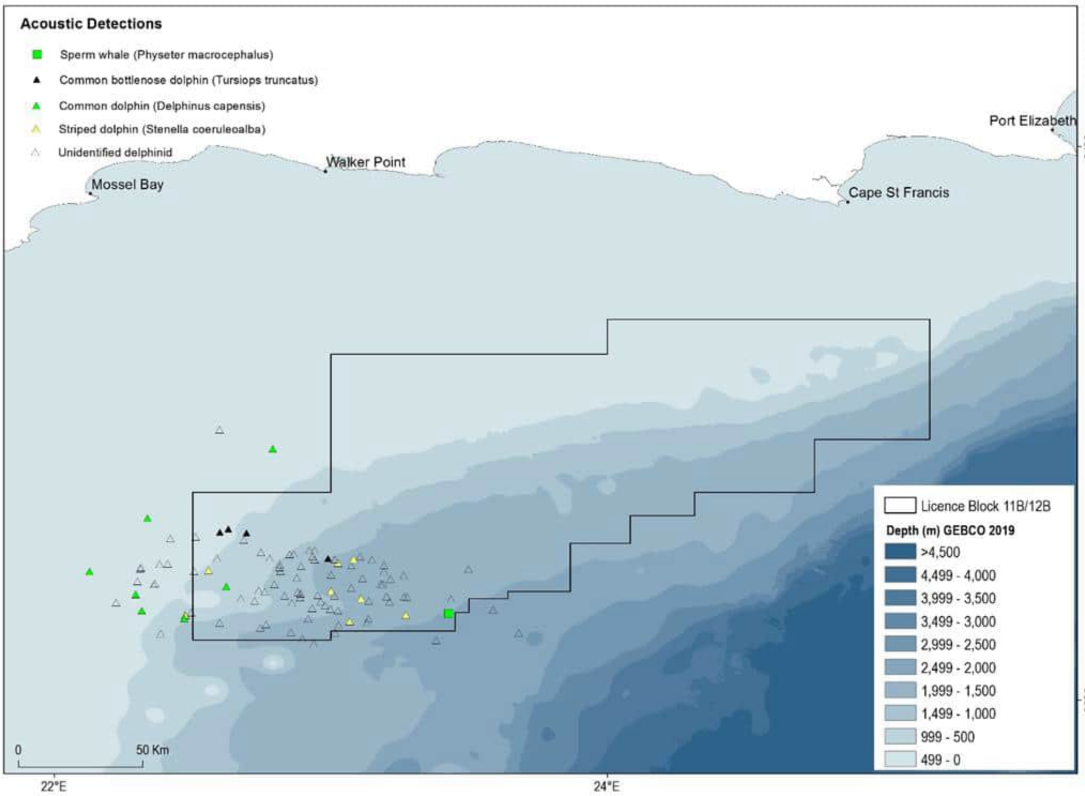


Figure 3-25. Location of acoustic detections recorded during watches from the MV PGS Apollo between 12 December 2019 and 30 April 2020. (CapMarine 2020b).

The 2022 Bourbon Evolution 807 environmental survey campaign of the Application Area and both pipeline routing options included opportunistic MMO surveys (BSL & CapMarine 2023). Between 28 November 2022 and 14 December 2022, there were 13 cetacean sightings in Block 11B/12B, consisting of 212 striped dolphins (*S. coeruleoalba*), 82 long-beaked common dolphins (*D. capensis*), six unidentified dolphins, four unidentified whales and two humpback whales (*M. novaeangliae*) (BSL 2023B). There were eight PAM acoustic detections within Block 11B/12B, including at least two sperm whales (*P. macrocephalus*), at least 40 unidentified Delphinidae and one Odontocete detections (BSL & CapMarine 2023).

3.4 The Nearshore Environment

3.4.1 Intertidal and Subtidal Habitats

The South Coast between Cape Agulhas and Gqeberha is approximately 730 km long and is characterised by a number of Capes (e.g., Cape Agulhas, Cape Infanta, Cape Seal, Robberg and Cape Recife) separated by sheltered sandy half-heart embayments (e.g., Algoa Bay, St Francis Bay, Plettenberg Bay, Mossel Bay and St Sebastian Bay) (Lubke and Moor 1998). The nearshore region comprises mainly sandy beaches, wave cut rocky platforms and exposed rocky headlands and cliffs, although pebble beaches are also present. The relatively high rainfall and regional topography has also resulted in the formation of a number of estuaries, (Lubke and Moor 2008). Most of the south coast nearshore and coastal zone is rocky shore (~53%), with a general zonation pattern typical of temperate systems (Jackson and Lipschitz 1984, Harris *et al.* 2019,). Some 47% of the coast is made up of sandy beaches and other sedimentary features

(Umvoto 2010). The subtidal environment is again divided between subtidal soft sediment communities and rocky subtidal areas. These nearshore rocky reefs host diverse communities of both epifauna and mobile biota (Dorrington *et al.* 2018). It should be noted too that the bulk of the South African population of the Damara Tern *Sternula balaenarum* breeds between the Sundays River and Woody Cape (BirdLife 2018).

3.4.2 ESTUARIES

An "estuary" or "estuarine system" is defined in terms of the ICM Act as "a body of surface water that (a) is permanently or periodically open to the sea; (b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or (c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water." In South Africa, a revised classification system has recently been introduced which categorises coastal outlets into nine different estuary types and three micro-system types. Based on this classification system, South Africa has 290 functional estuaries and 202 micro-systems (Van Niekerk *et al.* 2019a). The National Biodiversity Assessment (NBA) defines the Estuarine Functional Zone (EFZ) as "the area that not only encapsulates the estuary waterbody, but also the supporting physical and biological processes and habitats necessary for estuarine function and health. It includes all dynamic areas influenced by long-term estuarine sedimentary processes, i.e., sediment stored or eroded during floods, changes in channel configuration, aeolian transport processes, and changes due to coastal storms. It also encompasses all the multiple ecotones of floodplain and estuarine vegetation that contribute detritus (food source) and provide refuge from strong currents during high flow events". In other words, the EFZ defines the 'space' within which estuaries function over longer time scales, because the promotion of wise use of estuarine resources and the protection and conservation of estuarine biodiversity requires not only the protection of estuarine habitat and biota, but also the protection of the physical processes/functions that sustain ecological and evolutionary processes (Van Niekerk & Turpie 2012, Van Niekerk *et al.* 2013, Van Niekerk *et al.* 2019a).

Estuaries along the South Coast generally fall within the Warm Temperate bioregion, and range in scale from the moderately large Breede and Knysna River systems down to micro-estuaries with very little flow at all (van Niekerk *et al.* 2019a). There are 46 estuarine systems along the South Coast coastline between Cape Agulhas and Gqeberha, of which 23 are classed as Natural or Near Natural, three are listed as Endangered and 20 others are listed as Vulnerable (Figure 3-26) (Van Niekerk *et al.* 2019b). One of the estuaries (the Heuningnes) has been proclaimed as a Ramsar Site, while 13 fall within National Parks and four others are protected within local or provincial nature reserves (Russell *et al.* 2012).

Nine of the estuarine systems are classed as predominantly open and one (the Knysna estuary) as an estuarine bay. These ten systems are particularly important for recruitment for inshore linefish species and are the most vulnerable to marine pollution events as they receive tidal inflows almost constantly. Only six of the estuaries are fluvially dominated and therefore largely invulnerable to marine pollution, with the remainder vulnerable as often as the estuary mouth is open (Van Niekerk *et al.* 2019a). Tidal range varies greatly, with tidal range in the Breede estuary extending over 50 km inland, making it vulnerable to potential marine pollution (DWAF 2003).

Estuaries are highly productive systems and offer rich feeding grounds, warmer temperatures and sheltered habitat for many organisms. The high productivity is exploited by many line-fish and harvested invertebrate species either as a nursery or later in life either directly through habitat availability or indirectly through the contribution to overall coastal productivity (van Niekerk *et al.* 2019c). The contribution of the estuarine nursery function has been estimated as R960 million in 2018 terms (equivalent to over R1 billion in 2020) to the South African economy, with the highest value attributed to the estuaries of the south Western and Eastern Cape (Turpie *et al.* 2017).

3.5 RED LIST SPECIES

As per the International Union for Conservation of Nature (IUCN) Red listing, leatherback and loggerhead **turtles** are both described as "Vulnerable", and the green turtle is "Endangered" on a global scale (IUCN 2023). As a signatory of Convention on Migratory Species (CMS), South Africa has endorsed and signed two sister agreements specific to the conservation and management of sea turtles (these are the Africa-Atlantic and Indian Ocean South East Asia Memoranda of Understanding). South Africa, as a nation, is therefore committed to the protection of all species of sea turtles occupying its national waters, whether they are non-resident nesters (loggerhead and leatherback turtles) or resident foragers (green turtles) (Pisces 2014a). The NEM: BA Threatened or Protected Species Regulations (2007) list leatherback *Dermochelys coriacea* and loggerhead *Caretta caretta* turtles as Critically Endangered Species and the green turtle *Chelonia mydas* as Endangered.

Numerous **seabird** species have shown a steady deterioration in status around the world and South Africa (Butchart *et al.* 2004, Crawford *et al.* 2018, Sherley *et al.* 2019). This is reflected in the upgrading of some species to the IUCN Endangered list (2023), including the African penguin (upgraded from Vulnerable to Endangered in 2010), the Cape Gannet (upgraded from Vulnerable to Endangered in 2010), and the Cape Cormorant (upgraded from Near Threatened to Endangered in 2013). These declines have not been equal across South Africa, with the bulk of declines occurring at West Coast colonies. For example, the Eastern Cape African penguin population (specifically Algoa Bay) has declined at a slower rate than elsewhere in South Africa, the area has become increasingly important in terms of its relative contribution to the global population (Sherley *et al.* 2020). In a similar way, the Cape Gannet colony at Bird Island/Algoa Bay grew from ~22 000 pairs in 1956/57 to ~95 000 pairs in 2004/05 and subsequently plateaued, with >70% of all Cape Gannets (i.e., the global population) now nesting at Bird Island/Algoa Bay, at the eastern extremity of their breeding distribution (Sherley *et al.* 2019). Red list pelagic species likely to be encountered in the Application Area (as per observer data) include the endangered Indian yellow-nosed albatross, Atlantic yellow-nosed albatross and Cape gannet, the vulnerable White-chinned petrel, Spectacled petrel and Leach's storm petrel. Near threated species include the Shy albatross, Sooty shearwater and Flesh-footed Shearwater.

Of the 35 **cetacean** species listed as present/likely to occur in South Coast waters, the blue whale is listed as Critically Endangered, the sei whale and Indian Ocean humpback dolphin are considered Endangered, while fin, Bryde's (inshore), Humpback (B2 population) and sperm whales are considered Vulnerable (IUCN 2023). Although listed as Near Threatened in the IUCN Red Data book, the Indo-Pacific bottlenose dolphin is listed as Vulnerable in the South African Red Data Book, while the migratory subpopulation is considered Endangered (Peddemors & Oosthuizen 2004).

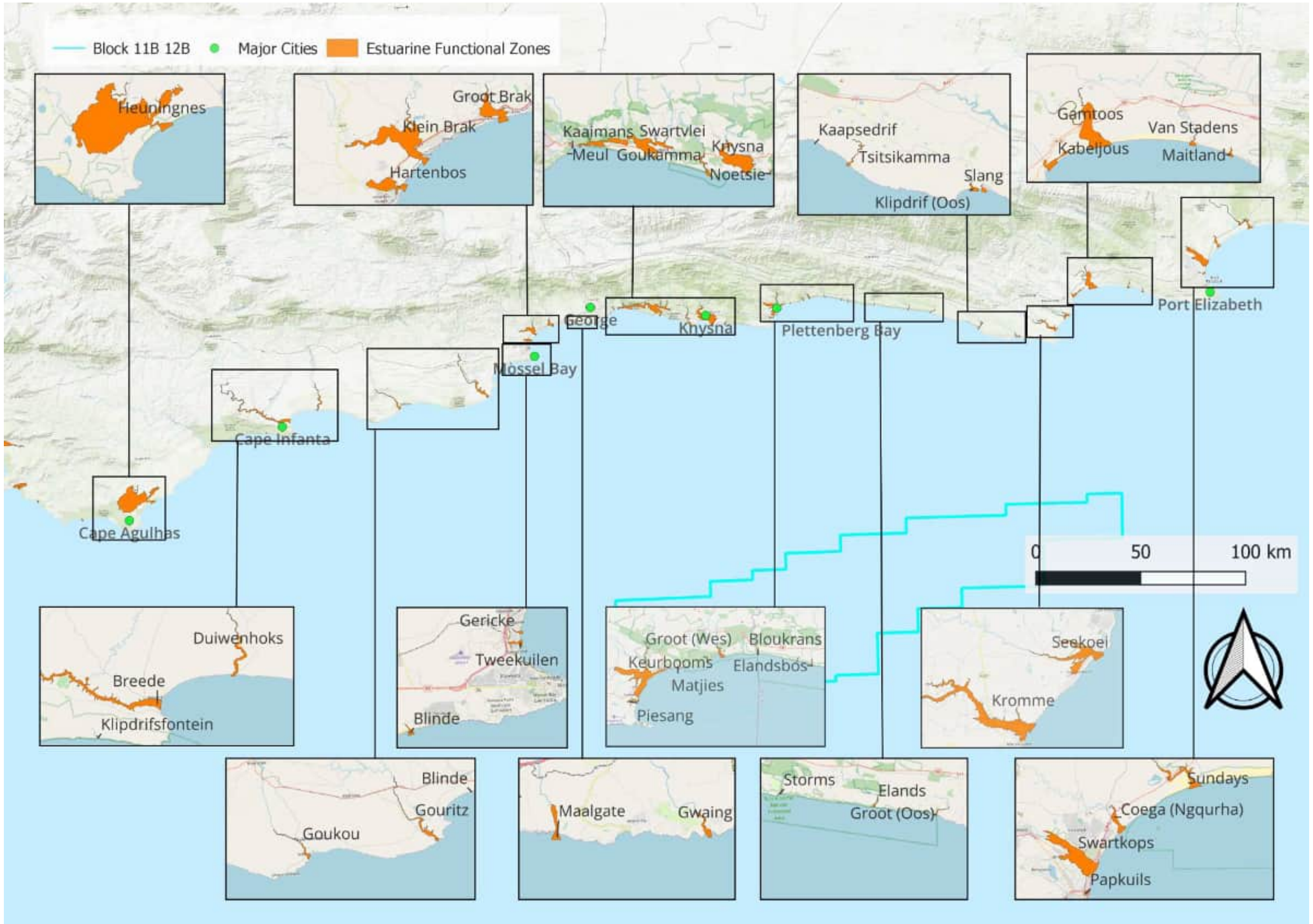


Figure 3-26. South Coast estuaries in proximity to the Block 11B/12B Production Right Application Area (blue polygon) The Estuarine Functional Zones (EFZ) are indicated in orange (NBA 2018).

Many of the **large pelagic fish** species likely to be encountered are considered threatened by the IUCN, primarily due to overfishing. Tuna and swordfish are targeted by high seas fishing fleets and illegal overfishing has severely damaged the stocks of many of these species. Globally, the Southern Bluefin tuna is considered Endangered, while Bigeye tuna and Blue marlin are 'Vulnerable' and Striped marlin is 'Near Threatened' (IUCN 2023).

Of the eleven **shark** species likely to occur in the Block 11B/12B Production Right Application Area, five are listed as Endangered by the IUCN Red List (the Pelagic Thresher shark, Dusky shark and Whale shark as well as the Shortfin and Longfin Mako shark), while the Great Hammerhead shark and Oceanic whitetip shark are listed as Critically Endangered (IUCN 2023). The great white shark *C. carcharias* is a significant apex predator in the Algoa Bay area, and while listed as Vulnerable by the IUCN (2023), it is species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II as a species in which trade must be controlled in order to avoid utilization incompatible with their survival and has been a Protected species in South Africa since 1991 (Pisces 2019). The bronze whaler shark is also listed as Vulnerable by the IUCN (2023).

3.6 Fisheries

3.6.1 Demersal hake trawl

Trawling involves dragging a fishing net (trawl) behind a vessel, or between two vessels. South African fisheries predominantly use "otter" trawls in which the mouth of the net is kept open by a pair of trawl doors, which are pushed outwards as they move through the water (Figure 3-27). In demersal trawling, the trawl is dragged along the seafloor, with the gear (including the trawl doors, net, and especially the groundrope) contacting the sediments and fauna on the seafloor (Sink *et al.* 2019).

The inshore and deep-sea sectors of the South African hake demersal trawl fisheries target shallow water hake *Merluccius capensis* and deep-water hake *M. paradoxus*. These species are also harvested by the long line and handline fisheries, but to a lesser extent (Hutchings & Turpie 2019a). Valuable bycatch of the trawl fisheries include monkfish *Lophius vomerinus*, kingklip *Genypterus capensis,* Panga *Pterogymnus laniarius,* and snoek *Thyrsites atun* (Norman *et al.* 2018).

Shallow water hake is mostly found between 100-300 m water depth from southern Angola to northern KwaZulu Natal, whilst deep water hake mainly occupy water depths from 150 m to deeper than 1 000 m between northern Namibia and East London (Hutchings & Turpie 2019a).

The deep-sea trawl fishery is active between Namibia and East London, but most of the fishing effort is focussed on the west coast of South Africa. The inshore trawl fishery (distinguished from the deep-sea trawl sector by vessel size, power) is restricted to the south coast (Figure 3-28 and Figure 3-29). The inshore (<110m depth) trawl grounds are located on the between Cape Agulhas in the west and the Great Kei River in the east (Walmsley *et al.* 2007, Japp *et al.* 2018). Along the west coast, 90% of catches are deep water hake, while on the south coast (inshore sector dominated) shallow water hake make up 70% of the catch.

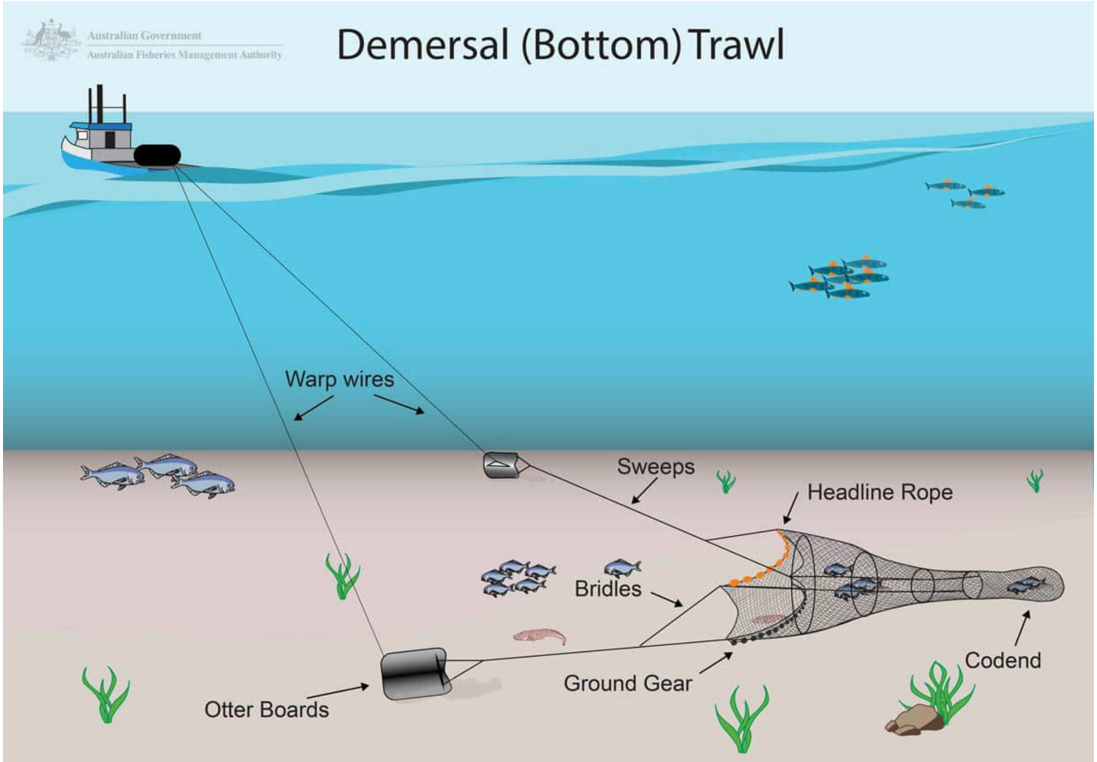


Figure 3-27. Trawl gear typically used by demersal trawlers targeting hake. Source: www.afma.gov.au/fisheries-management/methods-and-gear.

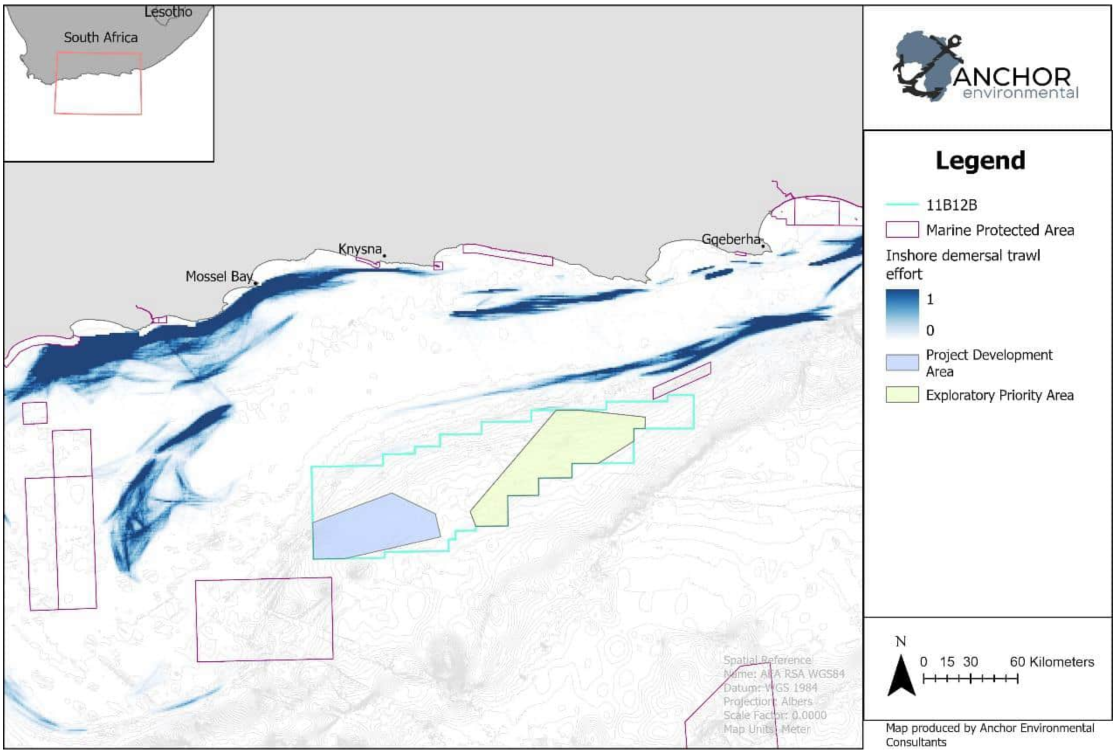


Figure 3-28. 'Footprint' of the inshore demersal trawl fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas and other spatial restrictions (e.g., restricted areas in Permit Conditions 2023) are overlaid. Figure uses catch and effort data from DFFE for the period 2009-2019.

The deep-sea trawl sector takes around 88% of the hake catch, with the inshore trawl and longline fisheries taking approximately equal shares of the remainder (Hutchings & Turpie 2019a). Catches of hake over recent decades have typically fluctuated around 150 000 tonnes per annum with most of the catch being landed by the deep-sea trawl sector (Durholtz *et al.* 2022.). For the inshore trawl sector landings have fluctuated around 8 000 tonnes per annum. The inshore fleet is restricted to vessels less than 30m and is required to use lighter ground tackle.

The hake trawl sector (inshore and deep-sea combined) has maintained Marine Stewardship Council (MSC) certification since 2004 (Norman *et al.* 2018). The MSC certification specifies a "Hake Trawl Ring Fence", outside which no trawling may take place, which restricts trawling to grounds which have been systematically fished in the past and in which the benthos has already been altered by trawling (Norman *et al.* 2018). In general, trawling occurs on areas that are relatively flat or have low profiles, and have sandy substrate, as these areas incur a lower risk of fouling the gear (Norman *et al.* 2018). The deep-sea trawl fishing effort is concentrated on the shelf edge (Sink *et al.* 2019).

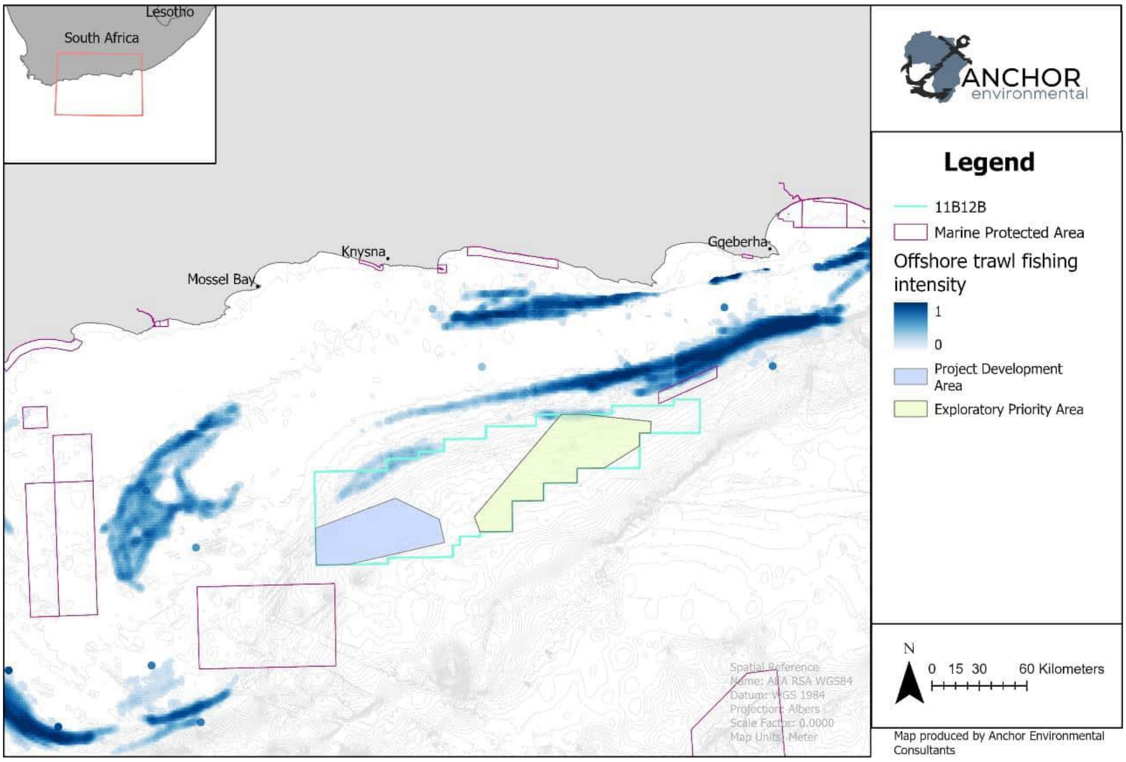


Figure 3-29. 'Footprint' of the offshore demersal trawl fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas and other spatial restrictions (e.g., restricted areas in Permit Conditions 2023) are overlaid. Figure uses catch and effort data from DFFE for the period 2009-2019.

The hake deep-sea trawl primarily uses two types of vessels: "wetfish" steel trawlers that have an average length of 45 m, an average tonnage of 600 tonnes and use ice to preserve their catch; and large freezer trawlers ranging from 30-90 m length and 300-2 900 tonnes. There are 30 "wetfish" trawlers and 21 freezer trawlers active in the hake deep-sea trawl sector

(Hutchings & Turpie 2019a). These vessels are mostly owned by large, vertically integrated companies that control all aspects of catching, processing and marketing.

In 2005, 15-year rights were allocated to 52 rights holders in the hake deep-sea trawl sector. These rights have been consolidated to result in 30 operational rights holders (DFFE 2021, Hutchings & Turpie 2019a). Although the latest rights allocation took place in 2021, these have not yet been finalised and the numbers of rights holders are not accessible. Approximately 30 trawlers participate in the inshore trawl sector. There are 17 rights holders in the inshore fleet (rights holders can own multiple vessels) with ongoing appeals process yet to be completed.

The hake deep-sea trawl industry employs approximately 12 400 South Africans, with about 6 600 employed directly on fishing vessels, at land-based processing plants and in a range of management, administrative or supportive roles, and another 5 800 indirectly (DFFE 2021, Hodge *et al.* 2018). Approximately half of these employees are sea-going staff who work on the wetfish and freezer trawlers. Freezer trawlers that have processing facilities have a much greater crew compliment (60-80 crew) than wetfish trawlers on which the fish is mostly gutted and preserved on ice (~30 crew) (Hutchings & Turpie 2019a). The inshore sector has employment creation of around 4 500 jobs.

Economically, the demersal trawl fishery is the largest South African fishing sector and contributes more than half of the total value of all commercial fisheries (Hutchings & Turpie 2019a). In most years, most of the hake total allowable catch (TAC) is landed, and in 2018, the TAC of ~112 000 tonnes had a landed catch value estimated at USD 280 million (assuming a 50:50 split in small: large hake with small hake selling at USD 2.5/kg and large hake at USD 2.9/kg). Several valuable bycatch species such as monkfish (USD 7.7/kg), kingklip (USD 6/kg), snoek (USD 1.7/kg) and horse mackerel (USD 1/kg) increased the value of the landed catch to approximately USD 300 million (Hodge *et al.* 2018). The value of landings for the hake and sole directed inshore trawl fishing was an estimated R180 million in 2021 (around 6-7 million USD) (Fiandeiro *et al.* 2019).

There is limited overlap between the Application Area and demersal hake inshore demersal trawl fishery of South Africa (Figure 3-29). For the deep-sea trawl area, the Application Area overlaps with 0.87% deep-sea fishing area, and this area is only fished 50% of the time (2009-2019). Landings of hake from the area of overlap has a total value of USD 121 800 per annum.

3.6.2 Demersal hake longline

Like the trawl fisheries, the demersal hake longline fishery targets shallow water hake *Merluccius capensis*, and deep-water hake *M. paradoxus* (the "Cape hakes"). Kingklip *Genypterus capensis* is an important and valuable "bycatch" (as it may be targeted) of this fishery, constituting 3-5% by mass of the catch (DAFF 2016). The hake longline fishery lands at least 17 species as bycatch, including Chondrichthyans (0.73%) and teleosts (2.13%), with the majority released alive (when possible) or discarded, and only about five of these (jacopever *Helicolenus dactylopterus*, panga *Pterogymnus laniarius*, skate spp. Rajidae, and Cape dory *Zeus capensis*) being retained despite their relatively low commercial value (Greenstone *et al.* 2016).

A demersal longline is comprised of a mainline or groundline, plus a series of shorter lines called gangions or snoods to which baited hooks are attached. Anchor lines are attached to the mainline and have surface floats. In the South African fishery, the mainline tends to be weighed down at regular intervals and can be up to 40 km long. The South African hake longline sector uses the Spanish double-longline system in which a top and bottom line is set between two anchor lines, with the number of hooks deployed varying from 6000-7000 for smaller vessels and 9000-14 000 for longer vessels (Figure 3-30). The lines are on average 30 km long and deployed around depths of 200-400 m (Sink *et al.* 2019) The gear is vulnerable to fouling and fouling by trawlers is common, with conflict occurring between the sectors (Norman *et al.* 2018).

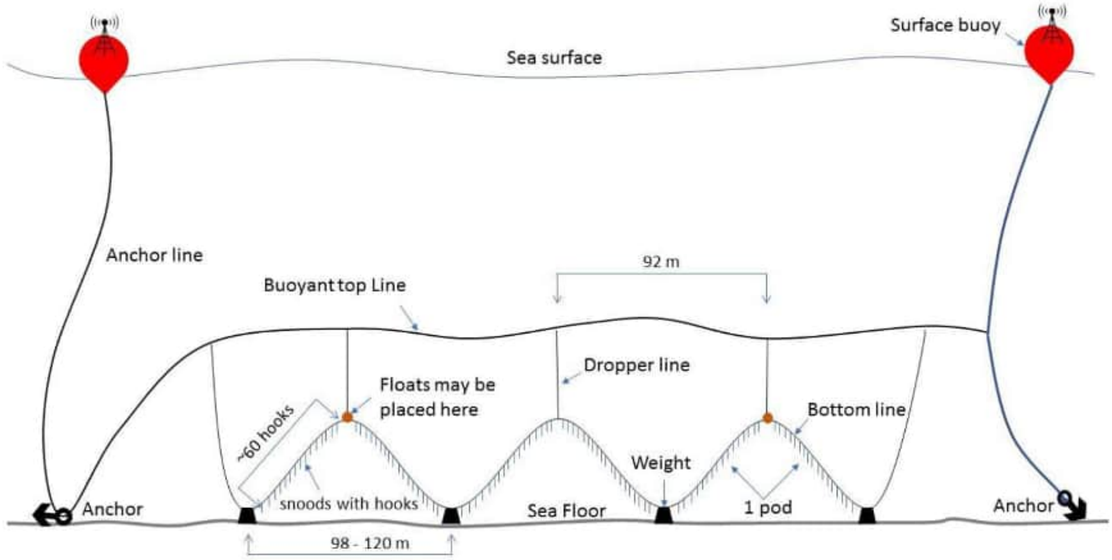


Figure 3-30. Schematic diagram of the double line demersal longline gear in South Africa (Nyengera & Angel 2019).

The South African hake-directed demersal longlining fishery developed relatively recently, starting in the early 1990's (Norman *et al.* 2018). Like the deep-sea trawl fishery, hake longlining occurs between Namibia and East London, with effort concentrated along the shelf edge (Hutchings & Turpie 2019b, Sink *et al.* 2019, Figure 3-31). The hake longline fishery operates in almost the same areas as the demersal trawl, although the longline fishery can also operate in hard (reef and/or high profile) grounds inaccessible to the trawlers and does not have the MSC ringfence restrictions that apply to the trawl fishery (Norman *et al.* 2018). Along the west coast, 90% of catches are deep water hake, while shallow water hake make up 70% of the catches on the south coast. The hake longline fishery is allocated 6.6% of the overall hake TAC, with the deep-sea trawl sector allocated 84% (Hutchings & Turpie 2019b). Most of the hake longline catches (more than 95% in recent years) are made on the West Coast of South Africa and 40-60% is made up of shallow-water hake (DFFE 2021).

Amongst the hake fishing sectors, the hake longline fishery has the greatest number of rights holders, with 109 operational rights holders (DFFE 2021). These right holders do not all operate vessels with catch agreements and other arrangements resulting in an estimated 40-50 operational vessels in the sector at any one time (DFFE 2021). Although the latest rights allocation took place in 2021, these have not yet been finalised and the numbers of rights holders are not accessible.

The South African hake longlining vessels are 10-20 m long wooden or fibreglass displacement hull decked vessels. Nearly all are "wetfish" vessels, i.e., the catch is iced at sea and sold fresh, undertaking 7–8-day trips. A single larger vessel with freezer capacity recently entered the sector and is able to undertake longer (14-18 day) trips. Many of the vessels participate in multiple fishery sectors, particularly the tuna pole sector (Hutchings & Turpie 2019b).

The hake longline fishery provides between 1 500 and 2 000 jobs (DFFE 2021). Due to the small quotas allocated to the hake longline fishery, after 3-7 months of the year most vessels switch to targeting different species (in primarily the tuna pole and pelagic longline sectors) (DFFE 2021). Seafood processors and wholesalers typically process products from multiple sectors (including demersal trawl, squid, handline, tuna pole, etc) and employ approximately 500 full-time staff, although these jobs cannot all be attributed to the hake longline sector alone (Hutchings & Turpie 2019b). The value of the landed catch of the hake longline fishery is estimated at over R360 million per annum (DFFE 2021). There is no perceived overlap between the Production Right Application Area and demersal hake longline effort (Figure 3-31).

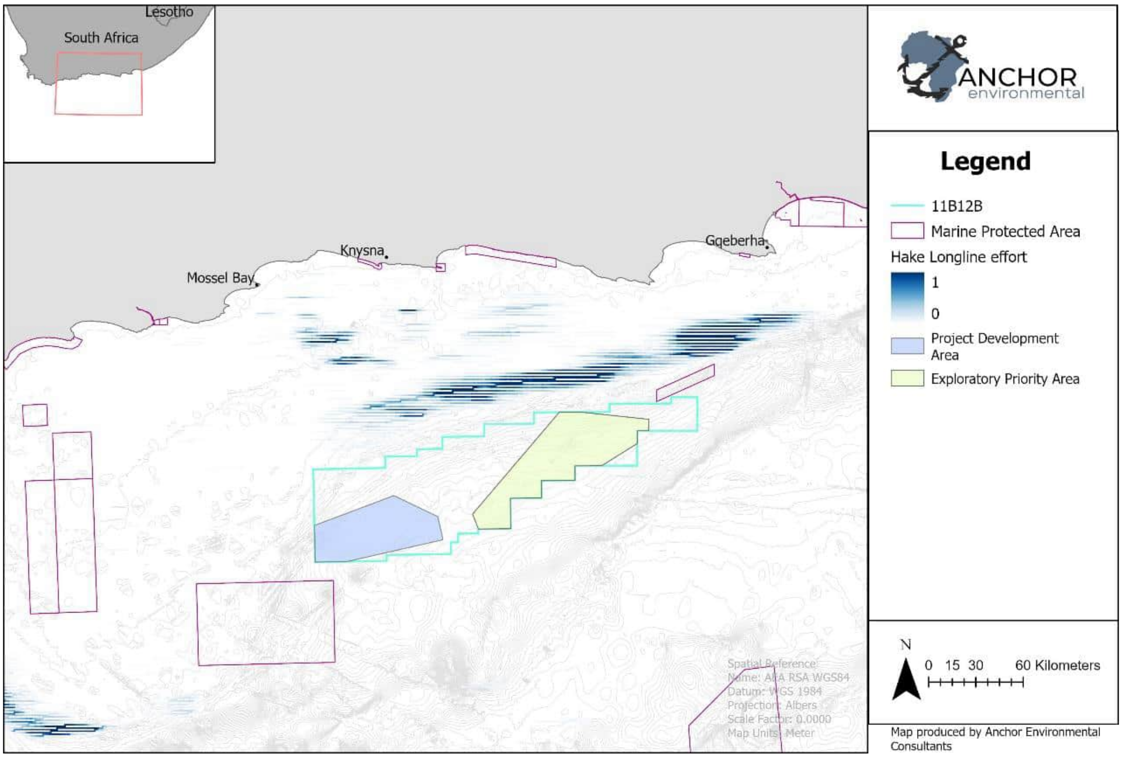


Figure 3-31. 'Footprint' of the demersal hake longline fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses catch and effort data from DFFE for the period 2010-2022.

3.6.3 MID-WATER TRAWL

Mid-water trawling involves dragging a trawl net through the water column. The nets tend to be much larger than those used in demersal trawling and rarely interact with the seafloor, targeting pelagic species in the water column and at the surface rather than at the seafloor (Figure 3-32, Sink *et al.* 2019).

The South African mid-water trawl fishery targets Cape horse mackerel Trachurus capensis, a semi-pelagic fish that occurs on the continental shelf from southern Angola to the Wild Coast of South Africa (Figure 3-33). This species undertakes a distinct diurnal vertical migration, rising in the water column to feed on plankton at night. The midwater trawl sector targets adult

Cape horse mackerel as they migrate upwards in the water column. The fishery is focused on the Agulhas Bank, particularly on the shelf edge along the South and East Coasts and is spatially restricted to east of 20° E (Norman *et al.* 2018).

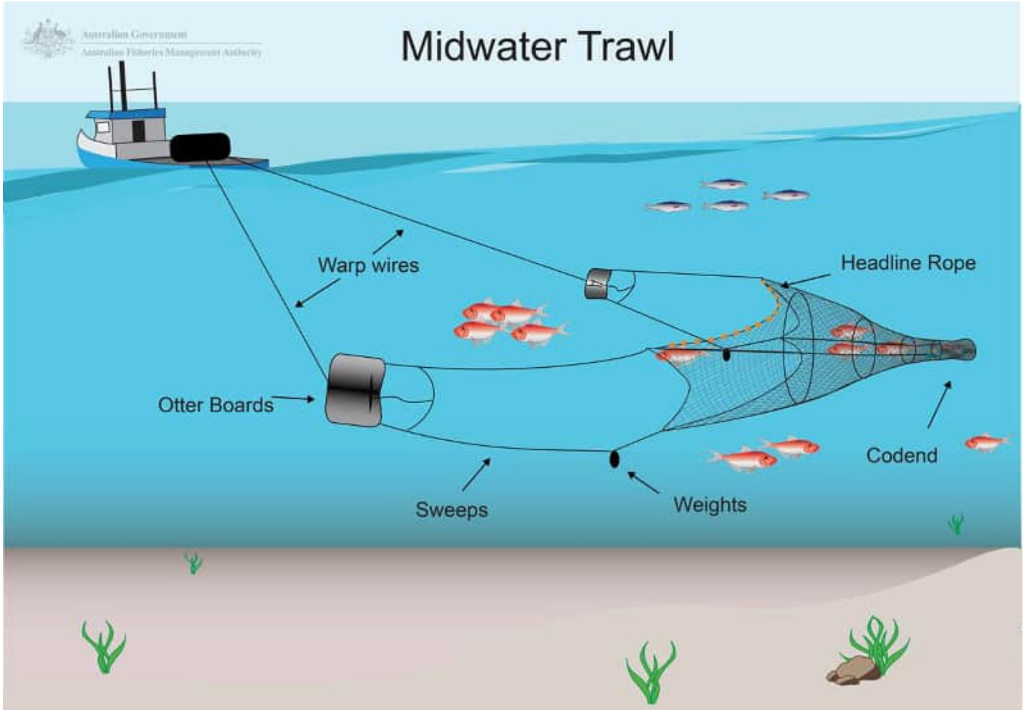


Figure 3-32. Typical configuration of mid-water trawl gear. Source: www.afma.gov.au/fisheries-management/methods-and-gear.

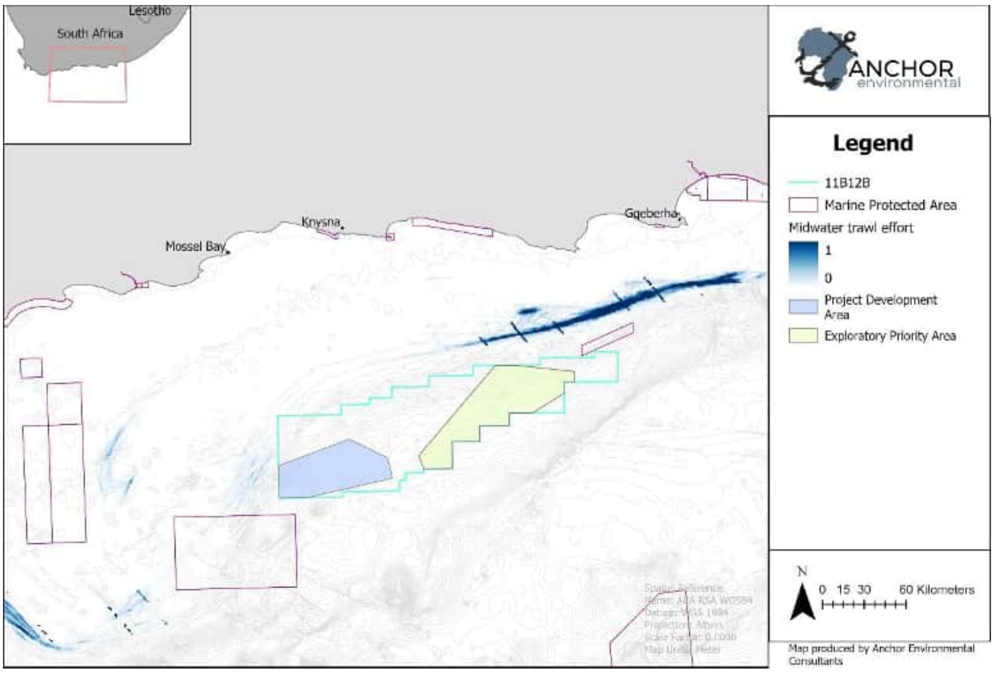


Figure 3-33. 'Footprint' of the mid-water trawl fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses catch and effort data from DFFE for the period 2009-2019.

A single, large midwater trawler, the FV Desert Diamond, dominates the midwater trawl fishery, having started operating in 1997. This is the largest South African registered commercial fishing vessel (Sink *et al.* 2019, Norman *et al.* 2018). A few smaller hake trawlers that have dual hake and horse mackerel rights, occasionally and opportunistically target horse mackerel with midwater trawl gear, primarily on the West Coast. In total, there are six vessels and 34 rights holders that land 9 674 tonnes (as of 2016) (Norman *et al.* 2018). Catches have increased since 2016 and the 2019 midwater trawl horse mackerel TAC was set at 27 670 tonnes, based on the expected catch (DEFF 2020). The midwater trawl fishery is focused on the Agulhas Bank, and particularly on the shelf edge on the south and east coasts. It is only in these areas that viable catches of horse mackerel are made. There is no perceived overlap between the Application Area and mid-water trawl fishing effort (Figure 3-33).

3.6.4 LARGE PELAGIC LONGLINE

The pelagic longline fishery targets large, predatory, highly mobile fish including bigeye tuna *Thunnus obesus*, yellowfin tuna *T. albacares*, southern bluefin tuna *T. maccoyii* and swordfish *Xiphias gladius*. The main bycatch species are albacore tuna *T. alalunga*, blue shark *Prionace glauca* and shortfin mako shark *Isurus oxyrinchus* (DEFF 2020, Sink *et al.* 2019). Drifting longlines can be as long as 100 km, with 700- 1500 hooks set per line, depending on the size of vessel. To reduce seabird mortality, lines are set at night. The lines are weighted and so are not visible at the surface, except at the positions of the floats and radio buoys (Figure 3-34). Longlines drift with the currents and thus have unpredictable movement, which can mean that they can drift into areas where they become entangled with the gear of other activities (Norman *et al.* 2018).

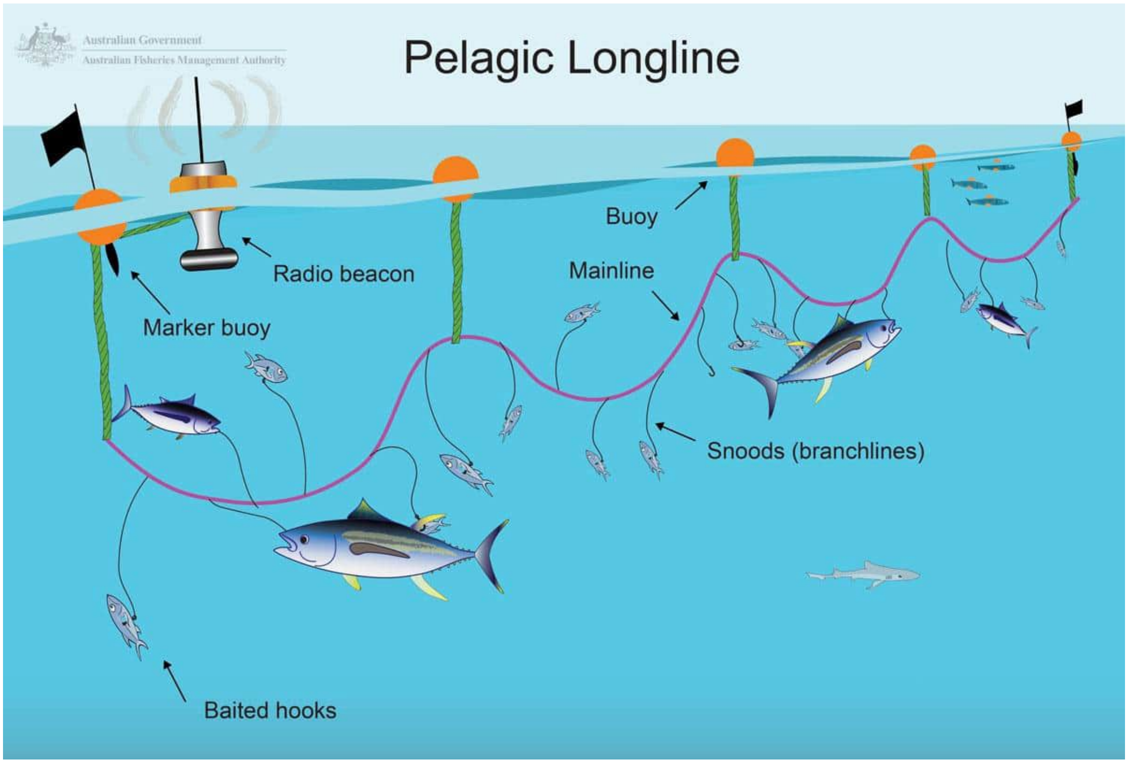


Figure 3-34. Typical large pelagic long-line gear. Source: https://www.afma.gov.au/fisheries-management/methods-and-gear.

The South African large pelagic longline fishery employs a significant number of people, including fishermen, crew members, and workers in associated industries such as processing, marketing, and distribution. The wholesale value of catch landed by the sector during 2017 was R155 Million, or 1.6% of the total value of all fisheries combined, with landings of 2 613 tonnes (The South African Fishing Industry Handbook and Buyers' Guide 2019). The large pelagic longline fishery is highly dependent on export markets, with more than 90% of the catch destined for international markets.

The opportunity to catch larger quantities of this extremely valuable southern bluefin tuna, combined with the current under-utilisation of quotas for other important target species, emphasises the substantial development potential of South Africa's large pelagic fisheries sector, as perhaps the most promising in terms of landed value of South Africa's fisheries.

In 2017, 60 fishing rights were allocated for a period of 15 years. The total number of active longline vessels within South African waters is 15 with a vessel size range of 20-32 m and a trip duration of 1-94 days (Parker *et al.* 2021). In 2020, the 15 large pelagic longline vessels were active around south Africa. The number of hooks set in 2020 (572 461). Rights Holders in the large pelagic longline fishery are required to complete daily logs of catches, specifying catch locations, number of hooks, time of setting and hauling, bait used, number and estimated weight of retained species, and data on bycatch.

The domestic component of the fleet historically fished out of Durban and Richards Bay Harbours, but vessels now operate predominantly out of the Cape Town and Hout Bay Harbours. The vessels currently in operation are typically small fibreglass or wooden hulled and have a maximum sea-going range of two weeks. This small size (~24m) and short range of vessels limits the extent of their operations. Sixty new large pelagic longline fishing rights were allocated in 2017, for a period of 15 years, with 34 domestic South African registered vessels and three chartered (foreign) vessels authorised by DFFE to take part in the fishery (Norman *et al.* 2018). The fishery operates extensively within the South African EEZ, primarily along the continental shelf break and further offshore. Many vessels reported to fish near the edge of or on the continental shelf (Sink *et al.* 2019, Figure 3-35). As a result, there is some overlap between the spatial footprint of the fishery and the Application Area (Figure 3-35). The Application Area overlaps with 7.37% of large pelagic fishing area (4.56% falls with the Exploratory Priority Area). This area is fished between 40-100% of the time by the large pelagic fishery but the average for this area was 38.55% (meaning the area was fished 38.55% of the time on average, per annum).

3.6.5 Traditional/Commercial line fishery

The South African commercial line fishery is a boat-based fishery that dates to the 1500's (Thompson 1913). By the end of the 1990s there were approximately 3 000 fishing boats ranging from 3 m dinghies to 15 m deck boats carrying a total of around 3 000 crew (Griffiths 2000, Mann 2000). Currently, there are approximately 455 licenced commercial vessels with over 3 000 crew, ranging from 6-8 m ski-boats capable of surf-launching, to a few harbour-based freezer vessels (generally longer than 20 m) that can remain at sea for more than 2 weeks at a time (Hutchings & Turpie 2018a, Mann 2013). Lines are set with no more than 10 baited hooks and boats operate mostly in inshore waters. Employing an estimated 27% of all fishers, the commercial line fishery has the largest fleet, but its catches make up only 6% of the total value of all commercial marine fisheries (DFFE 2020).

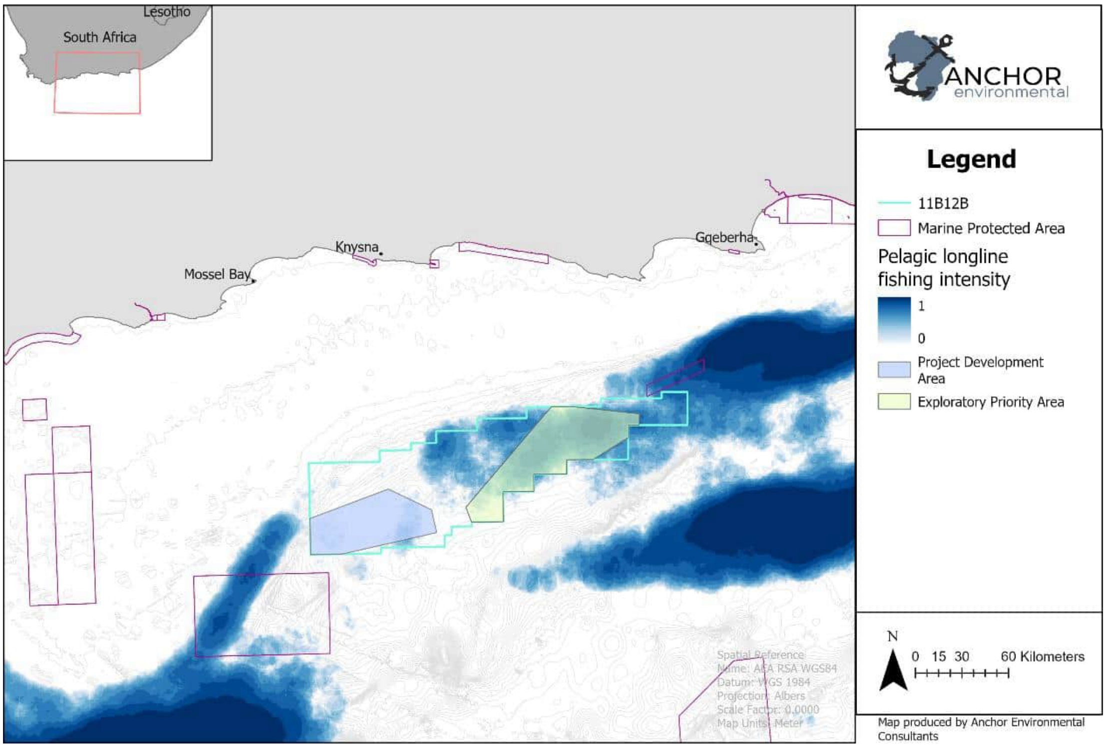


Figure 3-35. 'Footprint' of the large pelagic longline of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses Fishing Intensity layers produced from the National Biodiversity Assessment 2018 (Sink *et al.* 2019).

Fishers are constrained in terms of what species they can target, as well as by bag and size limits, but effort is primarily limited by weather and sea conditions as ski boats generally go out only when the wind is less than 15 knots. Fishing takes place throughout the year but there is some seasonality in catches. Boats are limited to 40 NM offshore and are constrained by MPAs (e.g., Tsitsikamma MPA west of Port St Francis) (Figure 3-36). Marine recreational anglers in South Africa tend to use similar gear and target similar species to their commercial counterparts. There is no perceived overlap between the Production Right Application Area and commercial line fishing effort (Figure 3-36).

The line fishery lands about 250 different species annually, although only about 20 of these are commercially important (Lamberth & Joubert 1999). The most important commercial line fish species, making up 90% of the catch, in order of annual average catch (2000-2013), include snoek *Thyrsites atun*, geelbek *Atractoscion aequidens*, yellowtail *Seriola lalandi*, two sciaenid species of the genus *Argyrosomus* silver kob *A. inodorus* and *A. japonicas*, carpenter *Argyrozona argyrozona*, slinger *Chrysoblephus puniceus*, hottentot *Pachymetopon blochii*, and santer *Cheimerius nufar*. Many species targeted in the linefishery have life-history characteristics that make them particularly vulnerable to overfishing, including long lifespans (>20 years), estuarine-dependence, sex change, residency and aggregating behaviour (Hutchings & Turpie 2018a). At least 11 line fish species are considered overexploited, while another 19 species have experienced stock collapse (Mann 2013).

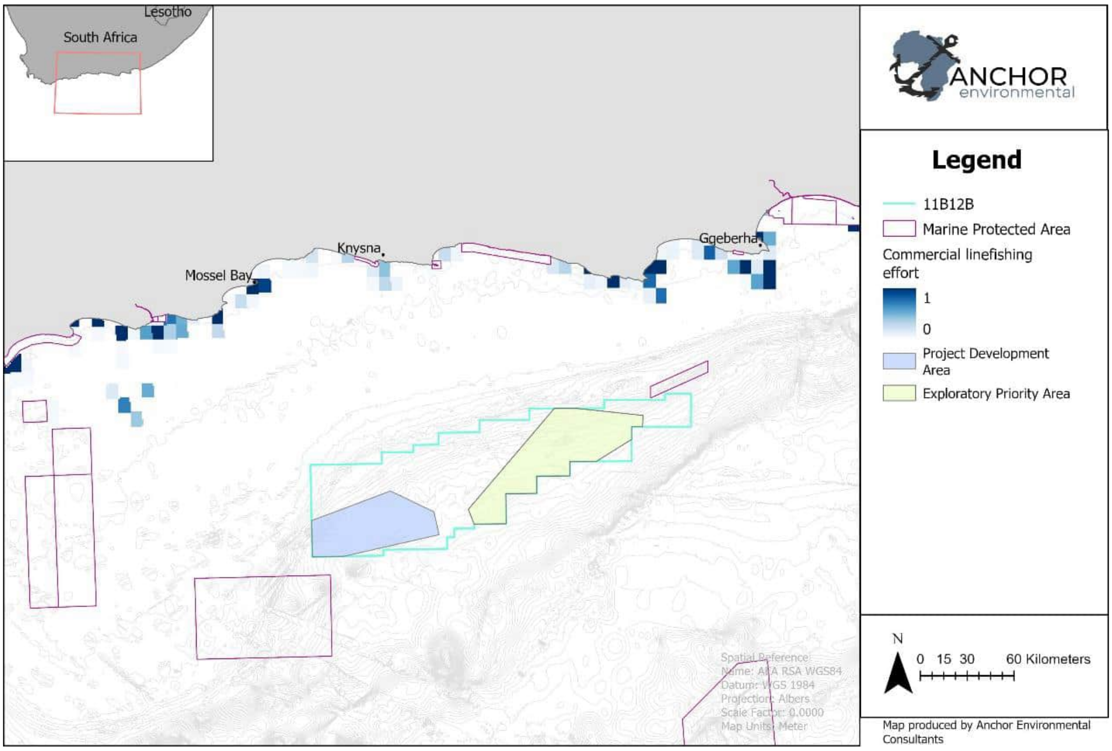


Figure 3-36. 'Footprint' of the commercial line fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses catch and effort data from DFFE for the period 2010-2020.

A management framework that led to a comprehensive suite of regulations was introduced in 1985, including revised minimum size limits equal to sizes at maturity, daily bag limits, closed seasons, commercial fishing bans for certain species, and the capping of the commercial effort. The Minister of Environmental Affairs and Tourism declared an environmental emergency in the traditional line fishery in December 2000 and restricted the number of vessels and fishers in the commercial fishery, as well as bag and size limits for commercial and recreational line fishers. After 2003, the number of licensed vessels in the commercial fleet was reduced by a tenth; however, effective effort has not diminished to the same degree due to improved efficiency driven largely by technological advances (DFFE 2021). During the last rights allocation in 2005/2006, a total of 424 long-term traditional linefish rights were issued nationally, of which 62 licences were for the area from Cape Infanta to Port St Johns. The 2021 commercial fishing rights allocation aimed for similar numbers but has not yet been finalised (DFFE 2021). The results of DFFE stock assessments conducted in 2017 indicated that the drastic reduction of fishing effort from 2003 onwards resulted in the partial recovery of some species, including slinger, santer, hottentot seabream and carpenter. However, other important stocks such as silver kob are still being overfished (DFFE 2020).

3.6.6 Small Pelagic Purse-Seine

Purse-seining involves rapidly sinking a wall of fishing net around a group of fish and then closing the bottom edge using purse strings, before hauling the catch onboard. Once a shoal of fish is detected, the purse seine nets are deployed using a smaller vessel to encircle the shoal (Figure 3-37; Sink *et al.* 2019). The small pelagic purse-seine fishery is South Africa's largest fishery by landed mass and second to the hake fishery in terms of value, estimated to be worth R5.5

billion at present (DEFF 2020, DFFE 2021). The fishery in South Africa originated in St Helena Bay on the west coast, originally targeting sardine or pilchard *S. sagax* and horse mackerel *T. capensis* (Sauer *et al.* 2003). These resources declined after 1962 due to overfishing, and mesh sizes were reduced to target the smaller anchovy *E. encrasicolus*. The fishery also exploits the red-eye round herring *Etrumeus whiteheadi* and the chub mackerel *S. japonicas*, which is a valuable bycatch species. These fish are Lower Trophic Level species that are near the bottom of the food chain and are food for many other commercially important species such as hake, snoek and tuna (Norman *et al.* 2018).

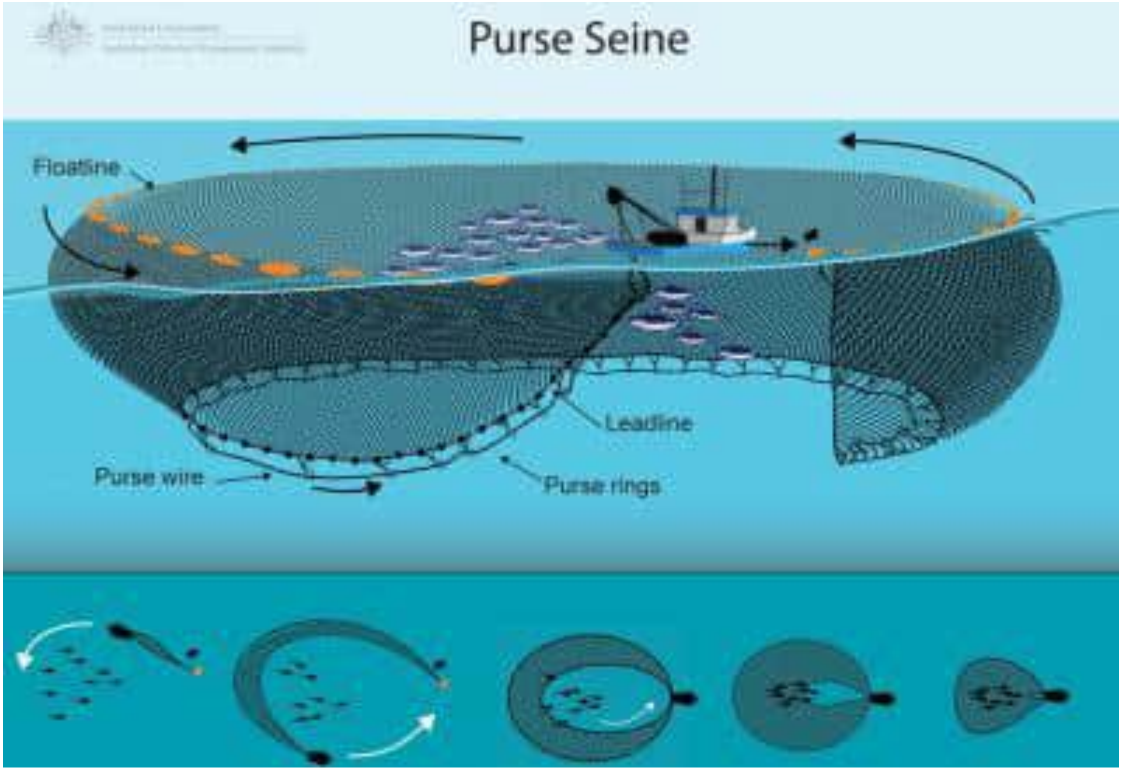


Figure 3-37. Typical configuration and deployment of a small pelagic purse-seine for targeting anchovy and sardine as used in South African waters. Source: www.afma.gov.au/fisheries-management/methods-and-gear.

The fishery is managed through quota allocations in the form of Total Allowable Catches (TACs) for adult sardine, anchovy, and sardine by-catch. Between 1950-2020 there has been an average annual small pelagic catch of around 380 000 tonnes, of which 80% has been anchovy and sardine (although these two species have accounted for less than 80% of the total catch in recent years).

The fishery mainly occurs inshore, predominantly on the West and South Coast (DFFE 2021, Coetzee *et al.* 2022). While the fishery is still concentrated on the west coast, operating from St Helena Bay, Laaiplek, Saldanha and Hout Bay, it has spread to the south coast, centred around Gaansbaai, Mossel Bay and Gqeberha (Norman *et al.* 2018, Figure 3-38). These ports tend to correspond to the location of canning factories and fish meal plants (Sink *et al.* 2019).

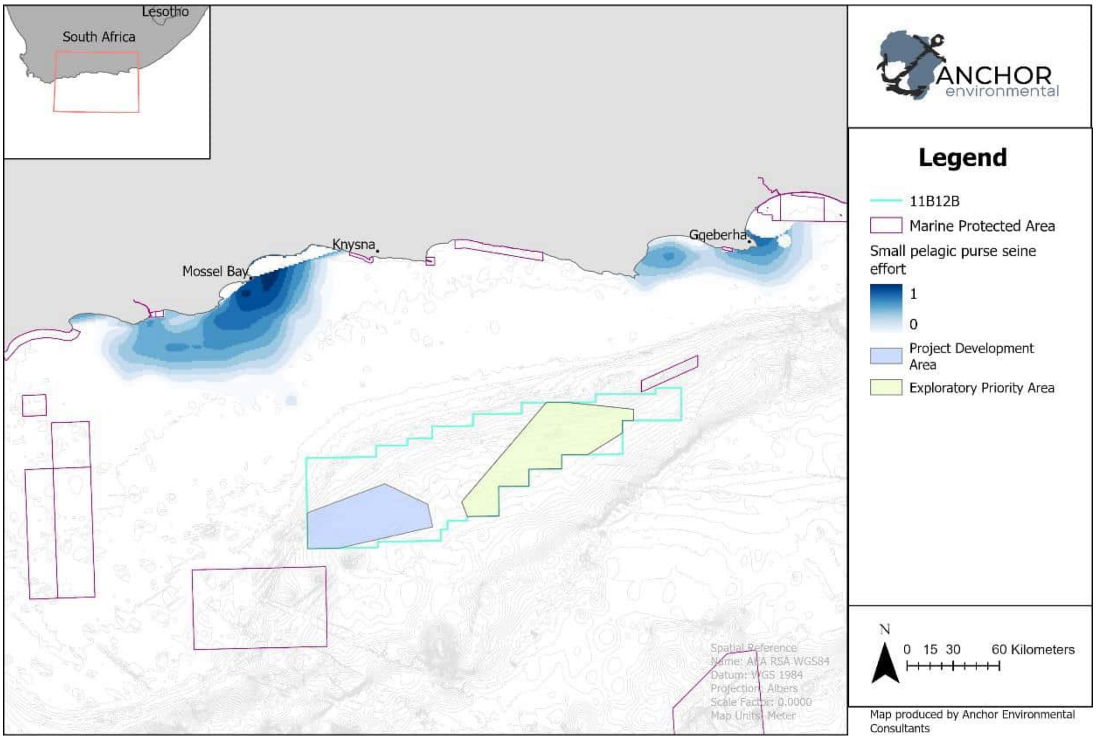


Figure 3-38. 'Footprint' of the small pelagic purse-seine fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses Fishing Intensity layers produced from the National Biodiversity Assessment 2018 (Sink *et al.* 2019).

The small pelagic purse seine fleet mainly consists of Glass Reinforced Plastic and steel-hulled vessels, with a few remaining wooden vessels. Vessels range in size from 15-39 m. The number of active vessels has declined from 95 in 2006 to 63 in 2020 (DFFE 2021). As of 2015 there were 101 rights holders but only approximately 40% are active in the catching and processing of fish, the remaining ~60 % are either "third party quota holders" who simply receive a fee for the use of their quota, or at most "investors" in the industry and have little direct socio-economic impact in terms of providing employment or generating revenue, on the industry (Hutchings & Turpie 2018b, Norman *et al.* 2018). Although the latest fishing rights allocation process took place in 2021, the number of rights has not been finalised.

Approximately 5 800 people are employed by the small pelagic sector, with the majority employed full-time. The sea-going workers earn the highest salaries in the fishing industry (DFFE 2021). This employment is split between the west and south coasts.

The geographical distribution and intensity of the fishery is largely dependent on the seasonal fluctuation and distribution of the targeted species. The sardine-directed fleet concentrates effort in a broad area extending from Lambert's Bay, southwards past Saldanha and Cape Town towards Cape Point and then eastwards along the coast to Mossel Bay and Gqeberha. The anchovy-directed fishery takes place predominantly on the South-West Coast from Lambert's Bay to Kleinbaai (19.5°E) and similarly the intensity of this fishery is dependent on fish availability and it is most active in the period from March to September. Round herring (a 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. This fishery may extend further offshore than the sardine and anchovy-directed fisheries.

On the South Coast, there is no perceived overlap between the Application Area and recent small pelagic purse seine fishing effort (Figure 3-38).

3.6.7 South Coast Rock Lobster

The South African longline trap fishery targets the endemic South Coast Rock Lobster (SCRL) *Palinurus gilchristi*. The SCRL fishing vessels are large, steel-hulled boats 30-60 m long, rigged for longline trap-fishing (Sauer *et al.* 2003). Each vessel uses 2 000-6 000 barrel-shaped plastic traps that are tied to longlines in sets of 100-200 traps, with each line of traps being 2-3 nautical miles long. Up to 12 lines may be set daily (Sink *et al.* 2019, Pollock 1989). Each line is weighted so that is lies along the seafloor and is connected at each end to a marker buoy on the sea surface. The traps set for period of 24 hours to several days (Norman *et al.* 2018).

The SCRL fishery mainly operates in rocky areas 90-200 m deep between Cape Point and East London, with the highest effort recorded off Gqeberha and East London (Sink *et al.* 2019, Pollock 1989, Groeneveld & Branch 2002, Figure 3-39). The fishery may extend up to 250 km offshore along the outer edge of the Agulhas Bank (DEFF 2020). There are currently 7 vessels operating from Cape Town and Gqeberha ports (Norman *et al.* 2018).

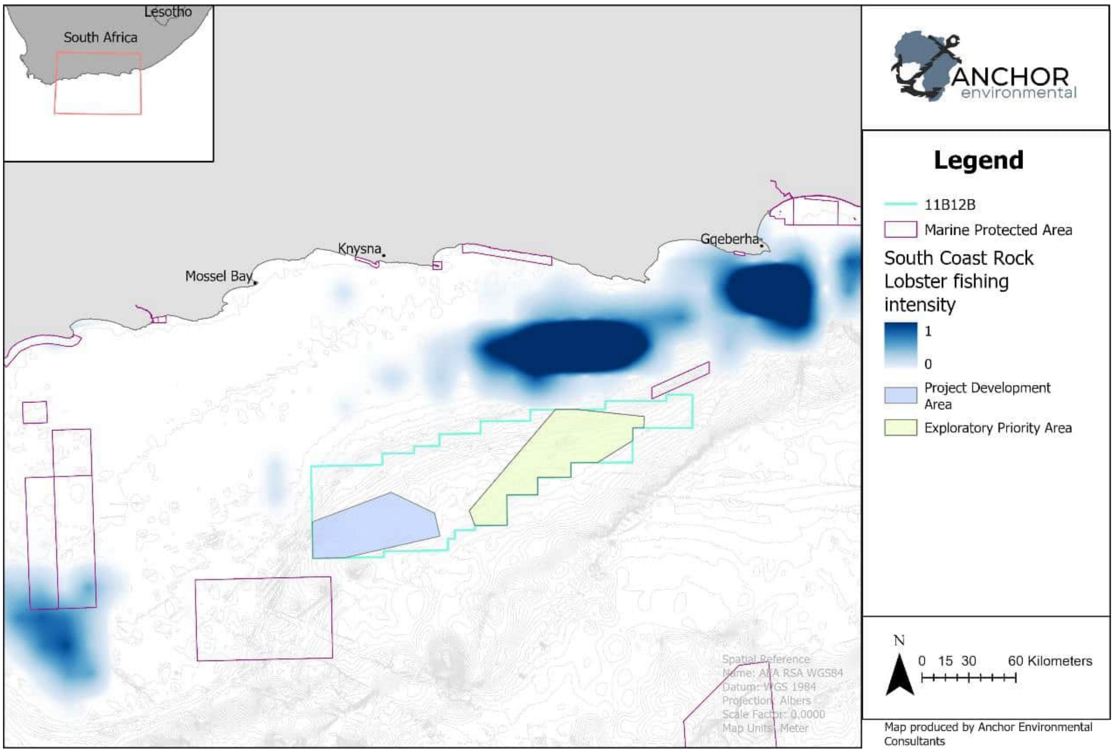


Figure 3-39. 'Footprint' of the South Coast Rock Lobster fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses Fishing Intensity layers produced from the National Biodiversity Assessment 2018 (Sink *et al.* 2019).

This fishery is labour intensive and as a result each vessel employs about 30 officers and crew, with a total of 300 sea-going employees. Additionally, about 100 land-based processing and administrative personnel are employed (DEFF 2020). The catch of SCRL was 319 000 tonnes (tail mass) in 2016, slightly low than the TAC (Norman *et al.* 2018). In 2012, the total export value was approximately R320 million (DEFF 2020). In 2005, 15-year fishing rights were allocated to 17 companies (DFFE 2021). The latest fishing rights allocation process in 2021 has not yet been finalised. There is no perceived overlap between the Application Area and south coast rock lobster fishing effort (Figure 3-39).

3.6.8 CHOKKA SQUID JIG

Squid *Loligo reynaudii* was historically (prior to the 1980s) targeted by a (mostly foreign) demersal trawl fishery and landed as by-catch in the South African inshore trawl fishery. A dedicated jig fishery for squid was initiated in 1984 and the landed catch is now worth more than R480 million in good years. Fishing is undertaken off boats that range from small ski-boats to deck boats of about 20 m length, though the latter have come to dominate the fleet. The boats are equipped with powerful lights for night fishing and blast freezers. The fishery operates in depths of 20-120 m, though mostly in the shallower waters (see below), where adult squid are targeted in spawning aggregations. The squid jig fishery usually produces in the order of 6-7000 tons per annum, though catches of up to 12 000 tons have been recorded in the past. By-catch in the demersal trawl fishery fluctuates between 200 tons and 600 tons annually. The jig catch is exported, mostly to Europe; whilst trawl caught squid are sometimes sold on the local market.

The commercial squid jig fishery is concentrated in inshore Eastern Cape Waters between Plettenberg Bay and Gqeberha where the squid breeding aggregations occur (termed "nests") (Figure 3-40). Squid appear very sensitive, particularly during spawning, to water turbidity, suspended sediment and probably also the nature of the substratum (Sauer *et al.* 1992).

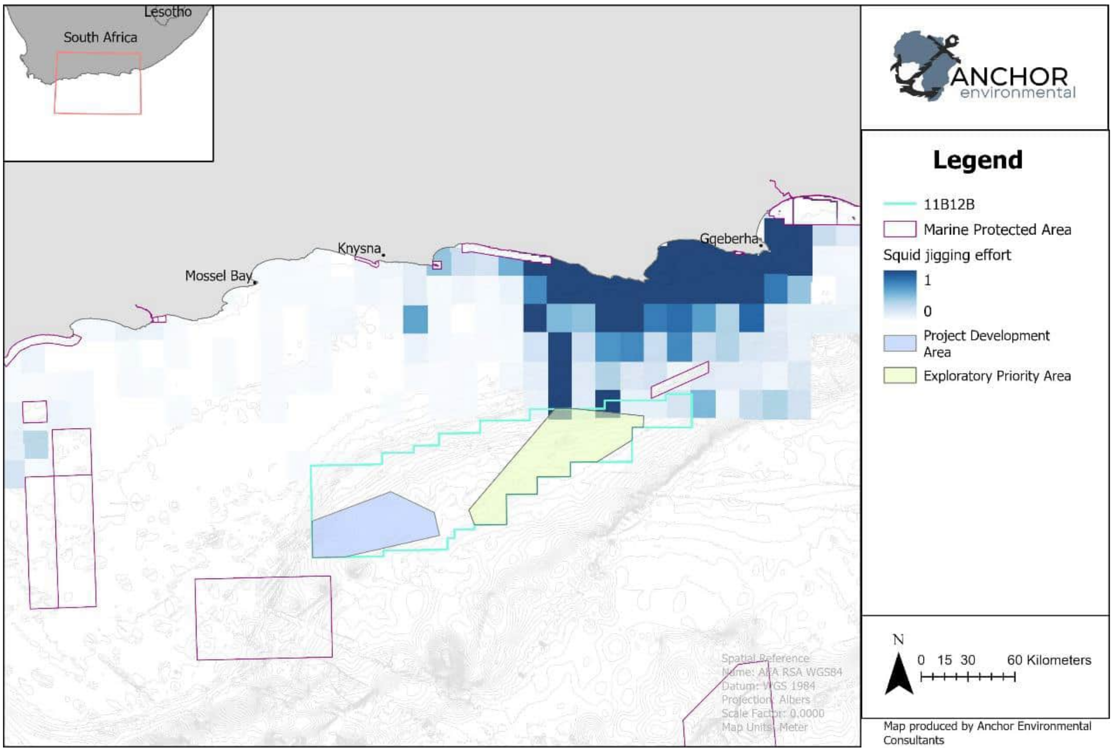


Figure 3-40. 'Footprint' of the Chokka squid fishery of South Africa ('south coast' selection only). The footprint is scaled (by colour) in terms of frequency of trips being a proxy measure for relative fishing effort. Dark blue areas = most effort. Marine Protected Areas are overlaid. Figure uses catch and effort data from DFFE for the period 2012-2019.

Squid only live for two years, and there is substantial inter-annual variability in stock abundance (reportedly amongst the highest for all South African fisheries) that is linked to a variety of influencing factors. There is a high level of uncertainty regarding the status of the squid stock, with initial estimates suggesting that effort levels (~3.6 million man hours per annum) were unsustainable and were placing the resource at a high risk (~90%) of collapse. Assumptions implicit in this assessment included the contention that jig-fishing has a negative impact on recruitment, invoked to account for the decline in trawl CPUE observed at the time that the jig fishery commenced. Subsequent refinements of the model led to the conclusion that spawning success is not strongly affected by jig fishing activity and that the current level of effort may in fact be sustainable, although further increases above current effort levels carry a high estimated risk of stock-collapse.

The squid jig fishery is currently regulated by means of total applied effort (TAE), which limits the number of vessels and crew allowed. The fishery currently comprises 109 rights holders, 136 vessels and 2422 crew. Since 1988, the fishery has been closed once a year for four weeks to counter the effects of "creeping effort" associated with increases in vessel efficiency and catch technology. The closed season corresponds with the peak spawning season for this species, and generally occurs around the month of November. Stock assessment results in 2013 indicated that a reduction in fishing effort was required to continue exploiting the SA squid stock without undue risk. This was achieved via the implementation of an additional 3 month closed season. The squid stock status and fishing pressure is currently considered optimal.

The production right application area overlaps with 1.84% of reported squid fishing grounds and includes some areas where fishing effort is reported as "high". Since 2010, an average of 530 individual fishing trips per year have been undertaken within the north-east border of the Application Area, amounting to 111 fishing hours (average per annum) and yielding 218 tonnes of squid catch (average per annum). This is equivalent to 2.4 % of the overall total squid fishing effort and 2.91% of overall squid catch landed by the sector.

3.6.9 SMALL-SCALE AND RECREATIONAL FISHERIES

Small scale fisheries, both in South Africa and abroad, are an important source of income and food security for many thousands of people, and has been so for generations (Clark *et al*. 2002, Sowman *et al*. 2014, Auld & Feris 2022). Small-scale fishing in South Africa has been considered to include various fishing methods targeting more than 30 species (Griffiths & Branch 1997) from a range of habitats (Branch *et al.* 2002, Clark *et al.* 2002). Although small-scale fisheries contribute less than 1% to South Africa's GDP, they play an important role in the provision of protein and employment for an estimated 136 coastal communities distributed along South Africa's 3 000 km coastline (Figure 3-41). The extent and spread of small-scale fishers covers the four provinces with coastlines, especially the Western Cape, where fishing has been an important source of protein among the coastal communities since the 1700s (Isaacs 2013). Small-scale fishers are found both in urban and rural coastal areas.

Small scale fishery operations have historically not been included in the fisheries policy development in South Africa — the definition of "commercial fishing" as per the 1998 Marine Living Resources Act (MLRA) excluded small-scale and artisanal fishers who catch and sell fish to sustain livelihoods, despite commercial fisheries around South Africa spanning a wide spectrum, and in 2005, the government adopted long-term fishing policies that made no provision for small-scale fishers.

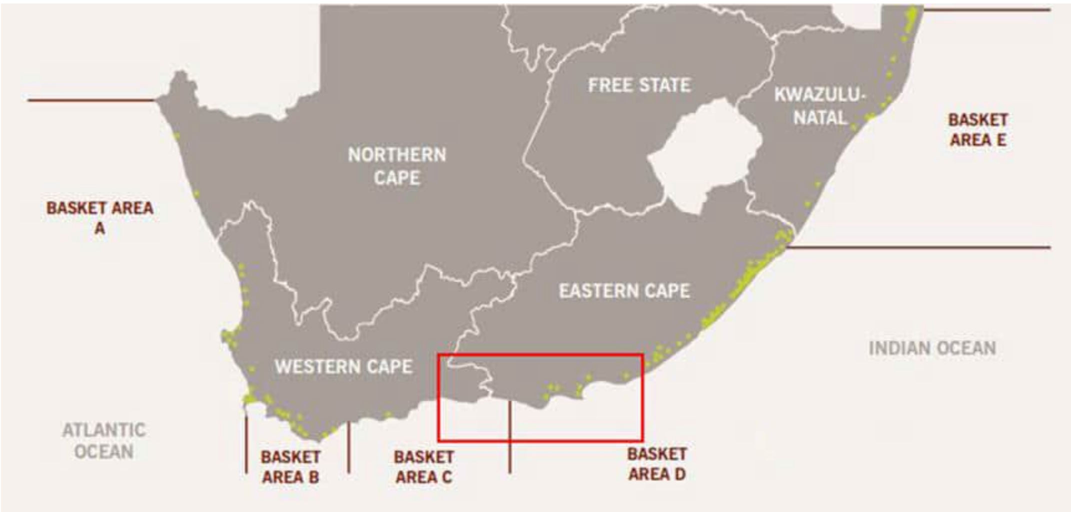


Figure 3-41. Map of small-scale fishing communities in South Africa (taken from Isaacs *et al.* 2022). Yellow dots = small-scale fishing community within each recognised 'basket' area.

In response to an Equality Court order in 2007, South Africa's cabinet adopted the Small-Scale Fisheries Policy (SSFP) in June 2012, which sought to address imbalances of the past and ensure that small-scale fishers were accommodated and properly managed. The policy proposed that fishing rights be allocated on a group, rather than an individual, basis. The policy further aimed to support investment in community entities who could take joint responsibility for sustainably managing the fisheries resources and assist in addressing the depletion of critical fisheries stocks.

Accordingly, the MLRA was amended in 2014 (commencement date 8 March 2016) to allow the Department of Forestry, Fisheries and the Environment (DFFE) to proceed with the SSFP implementation process. As part of the amendments, a definition of 'small-scale fishers' and the communities involved was provided (Section 1) as follows:

" *'small-scale fisher' means a member of a small-scale fishing community engaged in fishing to meet food and basic livelihood needs, or directly involved in processing or marketing of fish, who—*

- *a) traditionally operate in near-shore fishing grounds;*
- *b) predominantly employ traditional low technology or passive fishing gear;*
- *c) undertake single day fishing trips; and*
- *d) is engaged in consumption, barter or sale of fish or otherwise involved in commercial activity, all within the small-scale fisheries sector".*

'small-scale fishing community' means a group of persons who—

- *i. are, or historically have been, small-scale fishers;*
- *ii. have shared aspirations and historical interests or rights in small-scale fishing;*
- *iii. have a history of shared small-scale fishing and who are, but for the impact of forced removals, tied to particular waters or geographic area, and were or still are operating where they previously enjoyed access to fish, or continue to exercise their rights in a communal manner in terms of an agreement, custom or law; and*
- *iv. regard themselves as a small-scale fishing community;";*

The amended MLRA also replaces any refence to 'subsistence fisheries' with 'small-scale fisheries', essentially encasing the 'subsistence' definition within the larger understanding of 'small-scale fisheries'. As such, all 'subsistence fisheries' are encompassed within the 'small-scale fisheries' group.

In terms of resource management, the amended MLRA includes 'small scale fishing" alongside 'commercial fishing' in terms of fisheries management, and explicitly includes small-scale fishing within the definition of total allowable catch alongside commercial, recreational and foreign fishing (Section 1). In this way, small-scale operations range from fulfilling food security to full-blown commercial operations.

The amended MLRA also replaces any refence to 'subsistence fisheries' with 'small-scale fisheries', essentially incorporating the 'subsistence' definition within the broader definition of 'small-scale fisheries'.

In terms of resource management, the amended MLRA includes 'small-scale fishing" alongside 'commercial fishing' in terms of fisheries management and explicitly includes small-scale fishing within the definition of total allowable catch alongside commercial, recreational and foreign fishing (Section 1). In this way, small-scale operations range from fulfilling food security to full commercial operations. The amended MLRA does not however provide a definition of 'small-scale fisheries', instead stating in Section 1 that "*small-scale fishing must be interpreted accordingly*".

In 2016, a Schedule pertaining to the Small-Scale Fishing Regulations in terms of Section 19 of the MLRA (as amended) was published. As per these regulations, communities wishing to be recognised as small-scale fishing communities needed to register their expression of interest with the Department, organise themselves into cooperatives, with small-scale fishing rights only being allocated to one cooperative per small-scale fishing community which includes within its membership, all the verified small-scale fishers in the community. The 2016 Small-Scale Fishing Regulations also required that, to be considered a small-scale fisher, a person must derive, "*the major part of his or her livelihood from traditional fishing operations and be able to show historical dependence on fish, either directly or in a household context, to meet food and basic livelihoods needs*." Later that same year, the former Department of Agriculture, Forestry, and Fisheries (DAFF) verified 8 488 individuals in fishing communities that had expressed interest in the small-scale fisheries sector. This was followed by the declaration of 2 802 registered small-scale fishers, but this process was considered inadequate which prompted re-evaluation. In the minutes of a 2022 meeting of the National Council of Provinces Committee Land Reform, Environment, Mineral Resources and Energy entitled, "Small-scale commercial fishery sector & aquaculture development; with Minister", there were a reported 5 335 small-scale fishers in the Eastern Cape, with 2 741 small-scale fishers in the Western Cape (the number of co-ops still under review).

In November 2019 and March 2020, the DFFE granted 15-year small-scale fishing rights to 73 small-scale fishing co-operatives in the Eastern Cape (OR Tambo, Alfred Ndzo and Amatole Municipalities) (DFFE 2021). The basket of species granted to these fishers included squid (see below), hake hand line, traditional linefish, seaweed, South Coast Rock Lobster and abalone ranching. The majority of species applied for were linefish species, some of which required use of a vessel.

Of the estimated 30 000 small-scale fishers active along the South African coastline in 2002, 85% of them harvested linefish (Clark *et al.* 2002). Currently, the small-scale fishing sector will be given priority in the subsequent Linefish Rights-allocation process. Furthermore, the number of recreational angling permits may have to be limited to accommodate the newly established small-scale fisheries sector so as not to compromise resource sustainability.

Various species have been set aside for the small-scale fishing sector. Some have already been allocated to the existing small-scale fishing co-operatives in other coastal provinces as part of the 2021 Fishing Rights Allocation Process. Many species allocated to the small-scale "baskets" are primary targets of the commercial and recreational linefish sectors, and these shared resources will need to be carefully monitored given the increased fishing pressure expected. Total Allowable Effort (TAE) will be apportioned between small-scale and commercial sector when the Department allocates commercial rights in 2021 (the outcome of which has been delayed due to an ongoing appeals process expected to be completed in October 2023). In the meantime, co-operatives will be able to fish from shore using hook and line while the fishing rights allocation process (FRAP 2021) is being concluded.

In 2021, the DFFE allocated 15% of the squid catch to the small-scale fisheries sector (with the provision that this could be increased to up to 25% in the future). Prior to this decision, squid was not in the basket of species available to the 15 co-operatives and 600 individual small scale fisher men and women who operate in the areas of the Eastern Cape where squid is harvested. Small scale allocation for hake handline in 2023 allocation was 2 081 tons (1.5% of the total TAC). There is no specific small-scale allocation for South Coast Rock Lobster (2022), with 359 tons and 2 525 Sea Days allocated across the whole fleet.

The south coast area of South Africa in closest proximity to the Application Area has a number of recognised small-scale fishing communities (red box on Figure 3-41). These communities comprise of estuarine fishers (42%) and marine fishers (58%) which target a range of intertidal invertebrates (marine and estuarine) and fish (Figure 3-42). There will be limited overlap between small-scale fishers that operate mostly close to the shore with the Application Area.

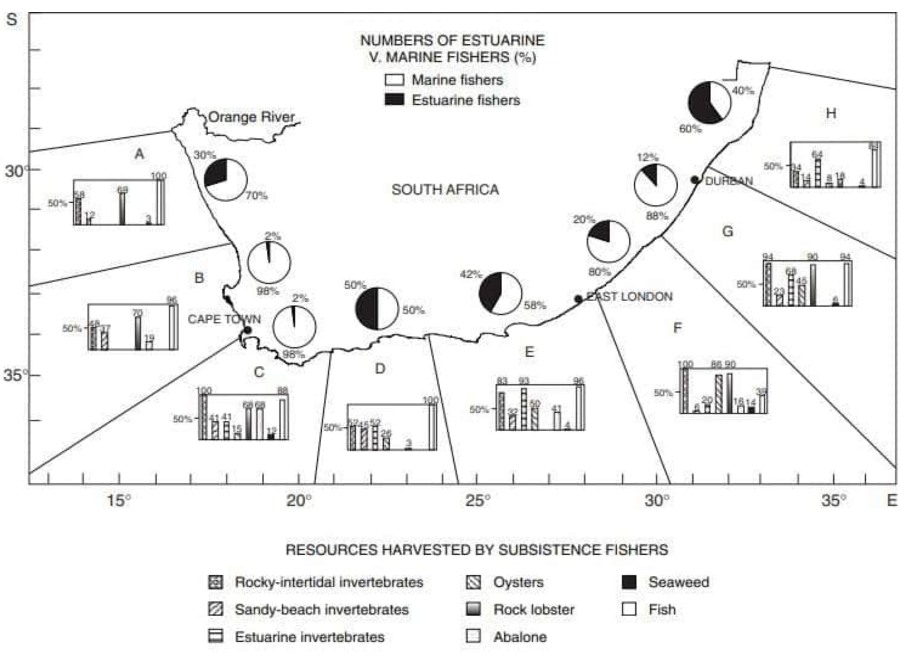


Figure 3-42. Proportions of marine and estuarine fishers, and relative importance of various different resources to 'subsistence' fishers in each of the eight regions taken from Clarke *et al.* (2002).

However, there may be a handful of small-scale rights holders that operate further from shore, accessing offshore fishing grounds either through cooperative means or as crew on existing commercial linefish or squid fishing vessels. There may therefore be some overlap between the area of operation of these fishers and the Application Area. These fishers are expected to access mostly linefish and squid resources (DFFE personal communication, January 2023). At time of writing, spatial activity and catch data for these fishers is lacking but is presumed to be similar to that of the existing fishery. The outcomes of the right allocation appeals process are also currently not known. However, it is considered likely that these offshore operations will overlap with existing spatial footprints for these resources, given that fisheries, both "traditionally commercial" and small-scale, are likely to operate where the resource is present. Given that the TAC for these small-scale offshore fisheries operations will come from the existing commercial sector, the overlap with the Application Area is considered to be suitably captured in the commercial linefishing and squid assessments, with impacts proportional to the proportion of TAC allocated to the small scale sector in question:

- As per Section 3.6.5, there is no perceived overlap between the Application Area and commercial line fishing effort (which includes hake handline). Thus, it is unlikely that there will be any overlap with the offshore small-scale line fishery.
- As per Section 3.6.8, there is an overlap of 2.4% of the overall total squid fishing effort and 2.91% of overall squid catch landed with the Application Area. If 15% of the squid TAC is allocated to the small-scale sector, and impacts are assumed to be directly proportional, this equates to an overlap of 0.44% of the squid catch landed by the small-scale fisheries.

Recreational fishers: Recreational fisheries in South Africa include line fisheries, rock lobster fisheries and harvesting of intertidal resources such as mussels, redbait and oysters (Griffiths *et al.* 2004, Cooke & Cowx 2006, Lewin *et al.* 2006, Winker *et al.* 2014, Maggs *et al.* 2016, Parker *et al.* 2016, Kerwath *et al.* 2019, Steyn *et al.* 2019). In the MLRA, "*recreational fishing*" means any fishing done for leisure or sport and not for sale, barter, earnings or gain. The recreational fishing sector is managed by a permitting scheme for entrants and catches are subject to TAE like the other fishing sectors. Recreational linefishing is a popular activity in South Africa and takes place along the entire coast. Between 1994 and 1997, the first nation-wide survey was conducted to evaluate participation in South Africa's recreational shore angling fishery, and its management (Brouwer *et al.* 1997, Mann *et al.* 2003). Recreational fishing in South Africa includes participation from approximately 1.32 million fishers, of which approximately half are marine, targeting mainly linefish and rock lobster (Saayman *et al.* 2017). The MLRA legally recognises recreational fishers and along South Africa's south coast there are a number of areas where recreational fishers operate very close to shore. It is assumed this activity takes place from the shore and so impacts from the prosed development that reach the shore could have knock-on consequences for these recreational fishers (Figure 3-43).

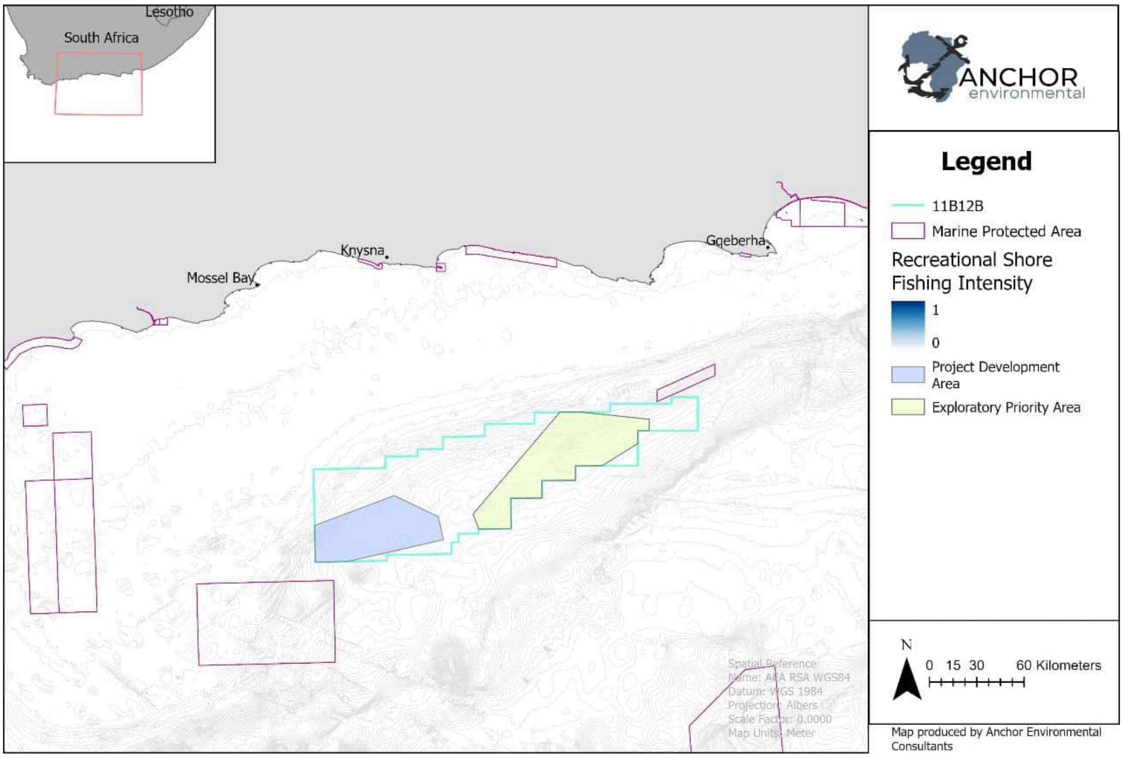


Figure 3-43. 'Footprint' of the recreational fisheries of South Africa ('south coast' selection only). Dark blue areas = fished areas. Marine Protected Areas are overlaid. Figure uses Fishing Intensity layers produced from the National Biodiversity Assessment 2018 (Sink *et al.* 2019). Note that the intensity is not easily visible at this scale.

3.6.10 MARICULTURE

Aquaculture incorporates the breeding, trading or rearing of aquatic organisms in a controlled or selected aquatic environment for recreational, commercial or subsistence purposes (DFFE 2018). It is typically divided into freshwater culture and mariculture. Mariculture species farmed in South Africa include dusky kob, abalone, Pacific oysters, Mediterranean mussels and black mussels, among others. South Africa's aquaculture sector is relatively small, contributing about 0.8% to the country's fish production, accounting for less than 0.2% of the national GDP (DFFE 2018).

South Africa is, however, one of the largest producers and exporters of abalone and is famous for its farmed premium abalone (*Haliotis midae*). The country produces about 1 700 tonnes of abalone per year (DFFE 2018). *H. midae* are one of five abalone species that are endemic to South Africa and is the only farmed abalone species in South Africa. Globally, abalone are one of the most expensive seafood products, with high demand specifically in the Asian countries because of the cultural, traditional, and medicinal qualities associated with abalone. In South Africa, the abalone industry has experienced rapid growth and development, and today is considered one of the most important and valuable species to the South African aquaculture industry. Abalone production in South Africa is found along the Eastern Cape, Western Cape and Northern Cape coastline as the ocean temperatures offer optimal production conditions for the abalone (Figure 3-44).

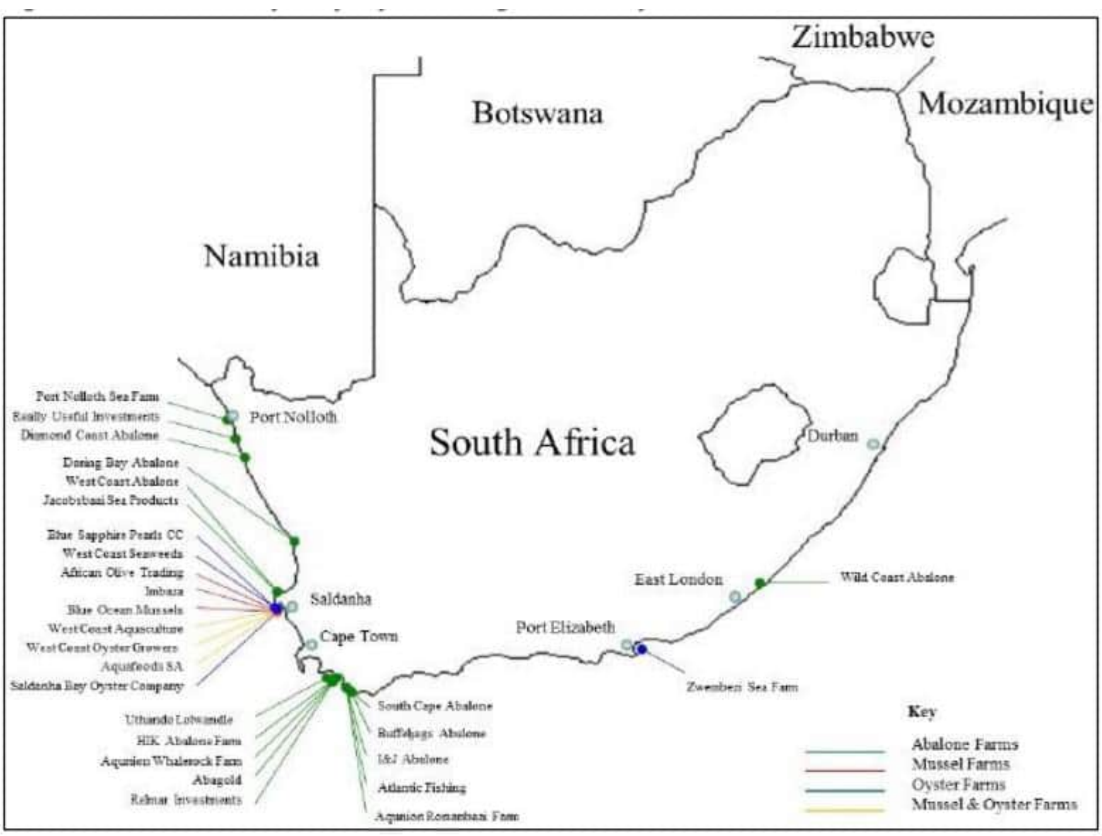


Figure 3-44. Shellfish mariculture farms in South Africa (DAFF 2017).

According to DAFF (2016), 18 abalone farms were identified in 2015, 12 of which are land-based facilities with independent hatcheries Three farms were registered as ranching operations. The abalone farms are distributed along the Cape coastline from the Northern Cape and Western Cape to the Eastern Cape (DAFF 2016). There are four farms in the Northern Cape, twelve farms in the Western Cape and two farms in the Eastern Cape (DAFF 2016).

Together these operations produced an estimated farm gate value of US$ 42.3 million. Abalone farming (on-shore, ranching, and cages) is a potentially high-growth industry providing social upliftment, revenue, and sustainability of rural communities along the coastline of South Africa (DFFE 2018). Specifically, the use of ranching could become a substitute for the recovering, depleted natural abalone resources in South Africa, which have diminished and, as a result, until recently all abalone fishery activities were banned. The revival of the South Africa abalone fishery industry and the new abalone ranching operations could provide economic upliftment for these areas suffering from high levels of unemployment and poverty within the fishing communities, provided the introduction of such activities would include a strong buy-in from the local communities (Krohn, *et al.* 2016).

4 SPATIAL CONSTRAINTS

4.1 Ecosystem threat status

The Ecosystem Threat Status developed by SANBI (2018) is an indicator of how threatened ecosystems are, specifically the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function, or composition (Harris *et al.* 2018). Ecosystem types are categorised as "Critically Endangered", "Endangered", "Vulnerable", "Near Threatened" or "Least Concern", based on the proportion of the original extent of each ecosystem type that remains in good ecological condition relative to a series of biodiversity thresholds.

The habitat threat status[7] of most the ecosystem types within the Application Area and both associated pipeline routing corridor options is "Least Concern" (Figure 4-1). The Agulhas Blues habitat to the northwest (see Section 3.3.1) is considered "Near Threatened" and the Agulhas Coarse Sediment Shelf Edge is "Vulnerable" (Figure 4-1) (Sink *et al.* 2019). The Kingklip Ridge habitat type to the northeast falls within the Port Elizabeth Corals Marine Protected Area and is considered to be 'Endangered' (Figure 4-1) (Sink *et al.* 2019).

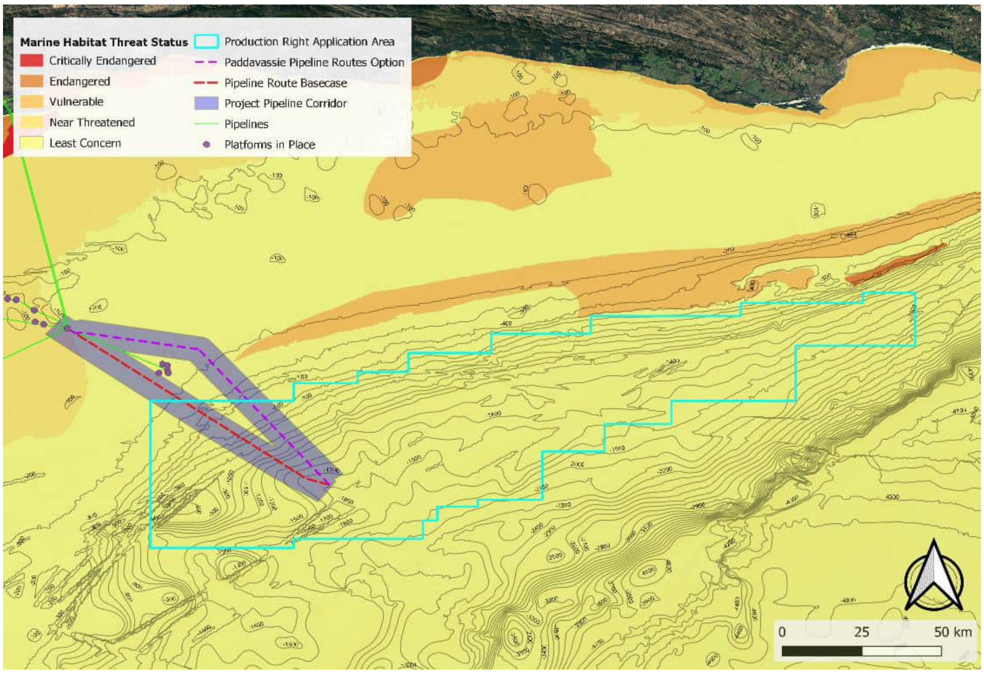


Figure 4-1. Ecosystem types categorised as "Critically Endangered" (CE), "Endangered" (E), "Vulnerable" (V), "Near Threatened" (NT) or "Least Concern" (LC) as per the NBA (Sink *et al.* 2019) within and around the Application Area (blue polygon).

[7] This threat status is undertaken through the application of International Union for the Conservation of Nature (IUCN), (IUCN) Criteria C3 (Degradation) and a supplementary assessment to consider ecosystem extent (B*, a criterion aligned to IUCN Criteria B) and ongoing decline (Sink *et al.* 2019).

4.2 Marine Protected Areas

A Marine Protected Area (MPA) is an area of ocean and/or coastline specifically protected for the benefit of people and the environment. It is stated in the Protected Areas Act (Act No. 57 of 2003) that "no person may conduct commercial prospecting or mining, exploration, production or related activities in a protected environment without the written permission of the Minister and the Cabinet member responsible for minerals and energy affairs". Therefore, these areas provide some refuge from human induced impacts for marine species and ecosystems. Prior to 2019, South Africa had 25 formally declared MPAs which covered a total ocean area of 0.43% of South Africa's mainland ocean territory (not including the Prince Edward Island in the Southern Ocean). In May 2019, the government formally gazetted the addition of 20 new or expanded MPAs (identified through Operation Phakisa), thereby increasing the total number of MPAs to 41 and the protected area of South Africa's Exclusive Economic Zone (EEZ) to 5% (Government Gazette 42478, Notice No. 757). These areas provide some protection to 87% of the different marine ecosystem types found in South African waters, ensuring that the MPA network is representative of the country's important diversity (SANBI 2019). Included in this was the addition of several new offshore MPAs, the purpose of which is to help ensure the sustainability of food and job security provided by fisheries, by securing the spawning grounds of numerous marine species as well as protecting vulnerable and unique habitats.

The seabed communities in the Application Area are known to exhibit high levels of endemism, and as such, the coastal area in the vicinity of Mossel Bay has been recognised as one of seven areas in the biozone in need of additional protection which has been granted in the form of these offshore MPA designations. Offshore MPAs in close proximity to Block 11B/12B include the Southwest Indian Seamounts MPA (Notice No. 42478) to the southwest of the Block and the Port Elizabeth Corals MPA (Notice No. 42478) to the northeast (Figure 4-2). There is no overlap of the proposed production area or either pipeline corridor with any offshore MPAs (Figure 4-2).

The **Southwest Indian Seamount MPA** was declared in 2019, and was designed to, inter alia, protect sensitive canyon gazetted habitats, deep cold-water coral reefs, seamounts and lace coral gardens (NBA 2019). The Notice (No. 42478) states the purpose for declaring this MPA as:

1. To contribute to a national, regional and global representative system of marine protected areas by conserving and protecting benthic and pelagic habitats of the outer shelf, shelf edge, slope and abyss including the Natal seamount and the associated deep water coral habitats in different depth ranges;

2. To conserve and protect the ecologically sensitive biodiversity and the ecological processes associated with these ecosystems thereby facilitating seabed management and supporting eco-certification;

3. To conserve and protect an area of importance for migratory species including seabirds, turtles, sharks and other fish; and,

4. To protect and provide an appropriate environment for research and monitoring particularly research on habitat description, habitat and climate resilience, mapping and monitoring and also to promote and contribute to environmental education.

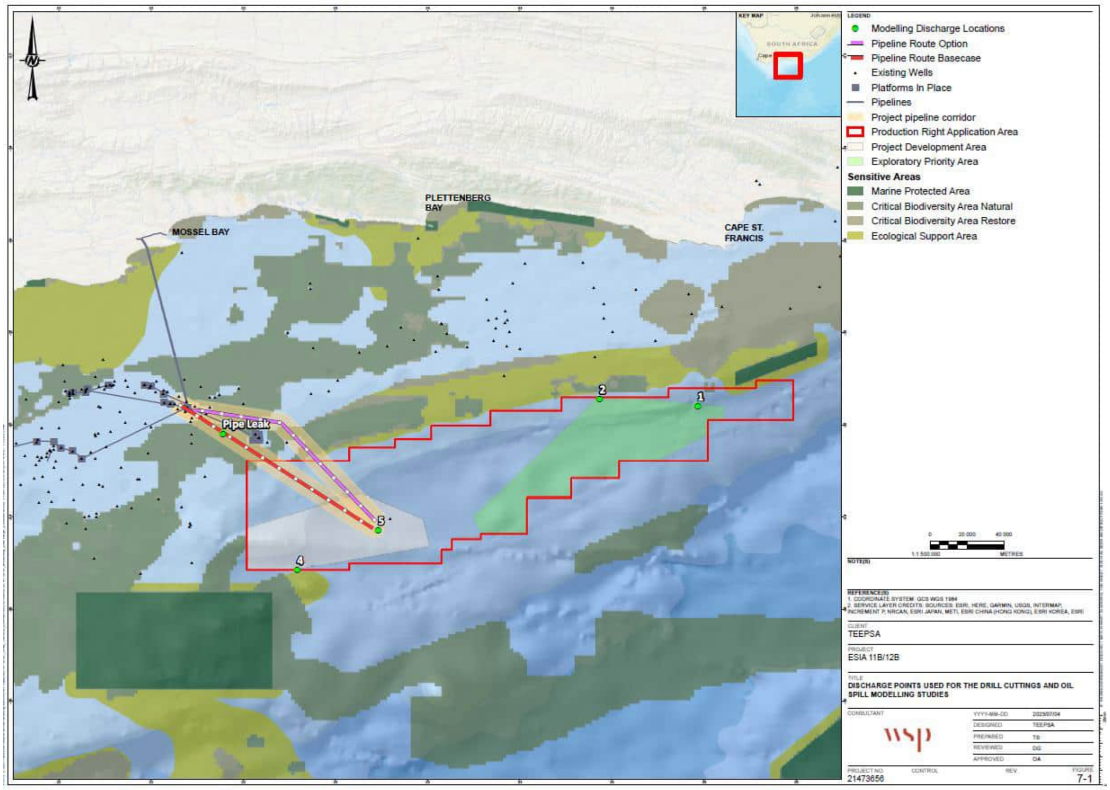


Figure 4-2. Designated Marine Protected Areas (MPAs), Ecologically or Biologically Significant Marine Areas (EBSAs) and Critical Biodiversity Area (CBAs) in the area surrounding the Application Area.

The **Port Elizabeth Corals MPA** was also declared in 2019, and the gazetted Notice (No. 42478) states the purpose for declaring this MPA as:

1. To contribute to a national, regional and global representative system of marine protected areas by conserving and protecting cold water coral reefs and associated benthic ecosystems of the shelf edge and slope;

2. To conserve and protect the ecologically sensitive biodiversity and the ecological processes associated with these ecosystems including spawning areas;

3. To facilitate seabed and species management including the protection of part of an area of life history importance for kingklip, thereby supporting Eco certification and its associated economic benefits; and,

4. To protect and provide an appropriate reference environment for research and monitoring particularly research on fisheries impacts and recovery, kingklip and climate change; and also to promote and contribute to environmental education.

There are also a number of MPAs closer to shore to the north of the Application Area (Figure 4-2). These include **Tsitsikamma MPA**, one of the oldest MPAs in South Africa that protects 60 km of intertidal and subtidal habitat. This MPA is located approximately 95 km to the north of the concession area. The MPA is especially important for the protection of over exploited, endemic seabream fish species, including dageraad *Chrysoblephus cristiceps*, red stumpnose *Chrysoblephus gibbiceps*, red steenbras *Petrus rupestris*, seventy-four *Polysteganus undulosus*, black musselcracker *Cymatoceps nasutus*, white steenbras *Lithognathus lithognathus* and dusky kob *Argyrosomus japonicus* (Buxton & Smale 1989, Attwood *et al.* 1997, Heyns-Veale *et al.* 2019).

Robberg MPA (~100 km to the north of the Application Area) protects 9.5 km of rocky shore and sandy beach habitat, and 42 km^2 in total. Offshore, the MPA protects subtidal reefs which provide important habitat for linefish species like red steenbras *P. rupestris*, and black musselcracker *C. nasutus*, as well as nearshore soft sediment areas which are important areas for east coast sole *Austroglossus pectoralis*, silver kob *Argyrosomus inodorus* and hake (WWF 2023a). The MPA is also host to a Cape fur seal *Arctocephalus pusillus* breeding colony.

The **Goukamma MPA** (~115 km to the northwest of the Application Area) is about 10 km west of Knysna, and protects 16 km of coastline and extends one nautical mile (1.85 km) out to sea, protecting about 5 km of sandy shores, 5 km of rocky shores and 3.5 km of mixed rocky/sandy shore (WWF 2023b). The offshore reefs within the MPA provide habitat for commercially important species (including shallow water hake *Merluccius capensis*, east coast sole *A. pectoralis*, dusky kob *Argyrosomus japonicus* and geelbek *Atractoscion aequidens*) and endemic fish species (such as maintaining a spawning stock of roman *Chrysoblephus laticeps*) (Albrecht *et al.* 2009). The MPA is also an important breeding area for the African black oystercatcher *H. moquini* (Loewenthal *et al.* 2015). The Goukamma estuary is classified by Van Niekerk *et al.* (2019a) as Near Natural and is one of a few estuaries that functions naturally with no artificial opening or closing of the mouth (WWF 2023b).

The **De Hoop MPA** lies 170 km to the northwest of the 11B/12B Application Area and protects some 51 km of shore and extend 5.6 km out to sea (WWF 2023c). This MPA provides protected habitats for close inshore fish species like galjoen *Dichistius capensis*, black tail *Diplodus capensis*, black mussel cracker *C. nasutus*, white mussel cracker *Sparodon durbanensis* and wildeperd *Diplodus curvinus hottentotus* (WWF 2023c). The MPA is also an important site for southern right whales *E. australis*, which arrive from the south in May and June to give birth to their calves. The MPA is host to species that show high site fidelity, like the Indian Ocean humpback dolphin *Sousa plumbea* which is listed as Endangered by the IUCN (Braulik *et al.* 2015, IUCN 2023), and the Vulnerable smooth hammerhead *Sphyrna zygaena* (IUCN 2023, Albano *et al.* 2023). Currently, there are ongoing efforts to establish a new colony of African penguins *S. demersus* on the mainland within the De Hoop MPA, the goal of which is to bridge the 600 km gap between the colonies at Dyer Island and Algoa Bay, and as such to support a south and eastward shift of these Endangered birds to follow their small pelagic prey species which have shifted from the West Coast onto the Agulhas Bank (SANCCOB 2023).

Sardinia Bay Marine Protected Area is a small, 12.9 km^2 MPA situated along 7 km of coast and 1.8 km out to sea and lies some 100 km to the northeast of the Application Area. The MPA protects mixed, rocky and sandy shores and offshore sub-tidal reefs, and has the highest number of endemic species of any other MPA. The MPA provides valuable protection to abalone and musselcracker, which are heavily over-exploited in open areas.

Gazetted in May 209, the **Addo Elephant National Park Marine Protected Area** (~130 km to the northeast of the Block 11B/12B Production Right Application Area) covers an area for 1 200 km^2 and was an expansion of the existing Bird Island MPA. This expansion was in response to the significant biodiversity importance attributed to many areas in Algoa Bay due to the high diversity of habitats, marine organisms and seabirds (several of which are of conservation concern) (Figure 4-3) (Chalmers 2012). The MPA extends the land based Addo Elephant National Park protection to include further large marine species such as the great white shark *C. carcharias* and several whale species that frequent the Algoa Bay coastline (including Bryde's, Minke, Humpback and Southern Right whales). In addition, the MPA protects the breeding and important feeding grounds two Endangered bird species, the African penguin *S. demersus* and Cape gannet *M. capensis* which breed on the St Croix and Bird Islands located within the MPA.

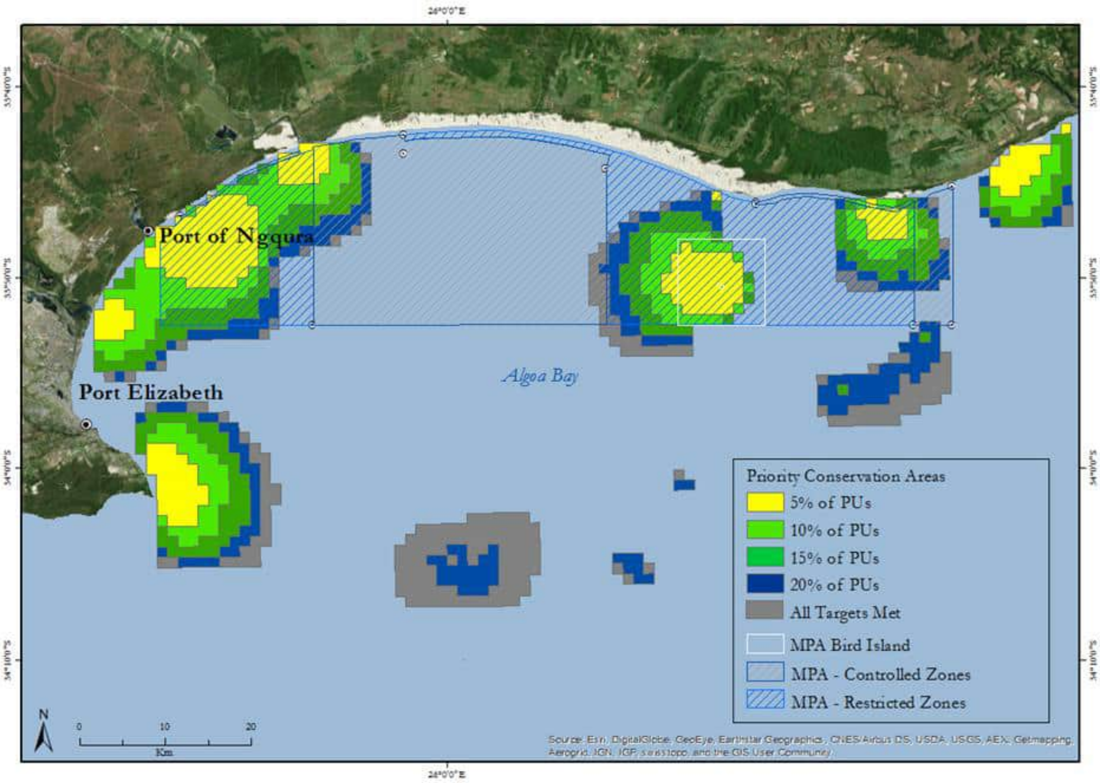


Figure 4-3. Priority conservation areas within Algoa Bay. PU = Planning Unit (data source: Chalmers 2012).

4.3 Ecologically or Biologically Significant Marine Areas

Ecologically or Biologically Significant Marine Areas (EBSAs) are defined by the Convention on Biological Diversity (CBD) as "geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the [EBSA] criteria". In the marine realm, South Africa has a network of EBSAs, based on original focus areas for offshore MPAs, which were adopted by the CBD in 2014 (see CBD 2016 and MARISMA 2020). The Benguela Current Commission (BCC) and its member states have been working on a regional Marine Spatial Management and Governance Programme (MARISMA 2014-2020). The intent is to refine the boundaries of existing EBSAs and identify relevant new ones, assess their status and management requirements, and incorporate these into Marine Spatial Planning (MSP) processes in each country to achieve sustainable ocean use in the Benguela Current (Harris *et al.* 2019). Through the MARISMA Project (https://cmr.mandela.ac.za/Research-Projects/EBSA-Portal/MARISMA), South Africa currently has 12 EBSAs solely within its national jurisdiction and shares 8 transboundary EBSAs with other countries (Namibia and Mozambique) and/or the high seas.

The principal objective of these EBSAs is identification of features of higher ecological value that may require enhanced conservation and management measures. The northern border of the Application Area falls alongside the full extent of the 'Kingklip Corals' EBSA, and the Block lies just to the northeast of the Shackleton Seamount Complex EBSA. While the Basecase route for the pipeline is located approximately 16 km from the Kingklip Corals EBS, the proposed Option pipeline route passes through the southwestern corner of the Kingklip Corals EBSA (Figure 4-2).

Implications of EBSAs and other spatial management tools for this project are discussed in detail in Section 4.7.

4.4 Critical Biodiversity and Ecological Support Areas

A Critical Biodiversity Area (CBA) assessment presents a spatial plan for the natural environment, designed to inform planning and decision-making in support of sustainable development, and CBA maps are developed using the principles of systematic biodiversity planning (SANBI 2017, Proposed Approach to Spatial Development and Management for South Africa's Marine Planning Areas 2019, and the Draft marine sector plan for the Biodiversity Sector 2023). These maps comprise three categories of biodiversity priority areas, namely Protected Areas, CBAs (called "Biodiversity Conservation/Restoration Areas" in the Draft marine sector plan for the Biodiversity Sector 2023) and Ecological Support Areas (ESAs) ("Biodiversity Impact Management Zones"), which are jointly important for the persistence of a viable representative sample of all ecosystem types and species, as well as the long-term ecological functioning and connectivity of the landscape or seascape as a whole.

Both of the proposed pipeline routing options pass through a Critical Biodiversity Area (CBA), specifically a CBA Natural area (a Biodiversity Conservation Area) (Figure 4-2). Linear development of Basecase pipeline routing will impact 369 km^2 of CBA Natural area (a Biodiversity Conservation Areas) (red line in Figure 4-2), and the Option pipeline routing (purple line in Figure 4-2) will impact 415 km^2. The implications of this for management are presented in Section 4.7.

There are two categories of CBA, namely 'CBA Natural' areas and 'CBA Restore' areas. CBA Natural sites have natural/near-natural ecological condition, with the management objective of maintaining the sites in that natural/near-natural state. CBA Restore sites have moderately modified or poorer ecological condition, with the management objective to improve ecological condition and, in the long term, restore these sites to a natural/near-natural state, or as close to that state as possible. As a minimum in CBA Restore sites, further deterioration in ecological condition must be avoided, and options for future restoration must be maintained. The ESAs include all portions of EBSAs that are not already within MPAs or CBAs, and a 5 km buffer area around all MPAs (where these areas are not already CBAs or ESAs). Within ESAs, negative impacts of human activities on key biodiversity features are managed and minimised to maintain the features in at least a functional, semi-natural state and/or to allow the area to improve in ecological condition.

The preliminary benthic epifauna ROV survey results suggest a hotspot of VME indicator species in the south-east west of the Application Area, and that fossilized forest remains are also concentrated in the centre and in the southwestern corner of the Block (Figure 3-16) (Dawson *et al.* 202023, in BSL 2023). Based on these results, it is considered highly likely that the CBA Natural Area should extend through the southwest corner of Block 11B/12B, connecting the area to the south to the Kingklip Corals EBSA. The delineated CBA areas stop at the borders of the Block 11B/12B Production Right Application Area, but the preliminary in situ ROV campaign results suggests that the CBA areas should extend into the Block in the south west corner, at minimum (as per Section 3.3.1 and Section 3.3.2). These areas must be considered in the assessment of impacts (see Section 8, management requirements detailed in Section 9.2.1).

4.5 IFC Standards

As detailed in Section 2.2.3, the IFC Performance Standards are incorporated into this assessment as per international best-practise guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in an environmentally and socially sustainable manner. This assessment was undertaken in line with IFC Performance Standard 1 and Performance Standard 6, with the implications of the latter detailed in Section 4.5.1 and 4.5.2 below.

4.5.1 Critical Habitat

Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources) defines "critical habitat" as habitat (both natural and modified) of high biodiversity value that includes areas required for the survival of critically endangered or endangered species (as defined by the IUCN Red List of Threatened Species or as defined in any national legislation), areas having special significance for endemic or restricted-range species, sites that are critical for the survival of migratory species, areas supporting globally significant concentrations or numbers of individuals of congregatory species, areas with unique assemblages of species or which are associated with key evolutionary processes or provide key ecosystem services, and areas having biodiversity of significant social, economic or cultural importance to local communities. These five "critical habitat criteria", the thresholds of each as per IFC Performance Standard 6 and the applicability to the proposed project are detailed in Table 4.1. Based on these criteria and applicable thresholds, both benthic and pelagic habitat of the Application Area is deemed Critical Habitat. The implications for management are detailed in Section 4.7.

Table 4.1. Critical habitat criteria thresholds as defined in Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources) and the implications thereof for proposed habitat classification in the Application Area. These requirements are captured in the "Sensitivity Categorisation and Description" portion of the Impact Assessment (as per the ESIA methodology).

Critical habitat criteria	Thresholds	Applicability to Production Right Application Area 11B/12B
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species	a) Areas that support globally important concentrations of an IUCN Red-listed EN or CR species (≥ 0.5% of the global population AND ≥ 5 reproductive unitsGN16 of a CR or EN species). b) Areas that support globally important concentrations of an IUCN Red-listed Vulnerable (VU) species, the loss of which would result in the change of	It is considered likely that pelagic species will migrate through the area in proximity to the Application Area, including EN and CR species of turtles, seabirds, cetaceans, large fish, and sharks, which have the potential to be directly harmed or disturbed by the project activities. However, the Application Area is not considered critical to the global population of these species.

Critical habitat criteria	Thresholds	Applicability to Production Right Application Area 11B/12B
	the IUCN Red List status to EN or CR and meet the thresholds in (a). c) As appropriate, areas containing important concentrations of a nationally or regionally listed EN or CR species.	
Criterion 2: Endemic or restricted-range species	a) Areas that regularly hold ≥10% of the global population size AND ≥10 reproductive units of a species.	n/a
Criterion 3: Migratory or congregatory species	a) Areas known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle. b) Areas that predictably support ≥10 percent of the global population of a species during periods of environmental stress.	Due to the position of the site adjacent to the Agulhas Current along the shelf edge, the Application Area falls within known migration corridors of EN and CR pelagic species of turtles, seabirds, cetaceans, large fish, and sharks. While numbers of individuals are difficult to quantify, it is considered likely that at least 1% of the global population of these species utilise the migration corridor that passes through Block 11B/12B and have the potential to be directly harmed or disturbed by the project activities. This fulfils (a), and this pelagic habitat is therefore defined as Critical Habitat.
Criterion 4: Highly threatened and/or unique ecosystems	a) Areas representing ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN status of CR or EN. b) Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or national systematic conservation planning.	The delineated EBSAs (Section 4.3) CBA Natural Areas (Section 4.4), Vulnerable Marine Ecosystem indicator species (Section 3.3.2) fulfil (b), and these benthic systems are therefore defined as Critical Habitat
Criterion 5: Key evolutionary processes.	Spatial features that are unique or idiosyncratic of the landscape have been associated with genetically unique populations or subpopulations of plant and animal species.	n/a

4.5.2 Natural Habitat

Performance Standard 6 divides habitats into two types: (1) natural habitats which are defined as 'land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area's primary ecological functions' and (2) natural modified habitats defined as areas 'where there has been apparent alteration of the habitat, often with the introduction of alien species of plants and animals, such as agricultural areas'. Given the data presented in Section 3.3, the Application Area, as well as both pipeline routing options outside of the CBA Natural areas, are delineated as Natural Habitat. The implications for management are detailed in Section 4.7.

4.6 OTHER DESIGNATIONS OF CONSIDERATION

4.6.1 IMPORTANT MARINE MAMMAL AREAS

Important Marine Mammal Areas (IMMA) are a marine spatial planning tool formulated by the joint IUCN Species Survival Commission/World Commission on Protected Areas, Marine Mammal Protected Areas Task Force. The areas considered as IMMAs include sites that host vulnerable species or a significant percentage of the members of a species, sites that are important for reproduction or feeding, and sites that are home to a wide variety of species. In South Africa, three IMMAs have been identified: the Cape Coastal Waters IMMA, Southern Coastal and Shelf Waters IMMA and the Southeast African Coastal Migration Corridor IMMA (Figure 4-4) (Purdon *et al.* 2020). The north-western corner of the Block 11B/12B Production Right Application Area intersects the Southern Coastal and Shelf Waters IMMA (Figure 4-4).

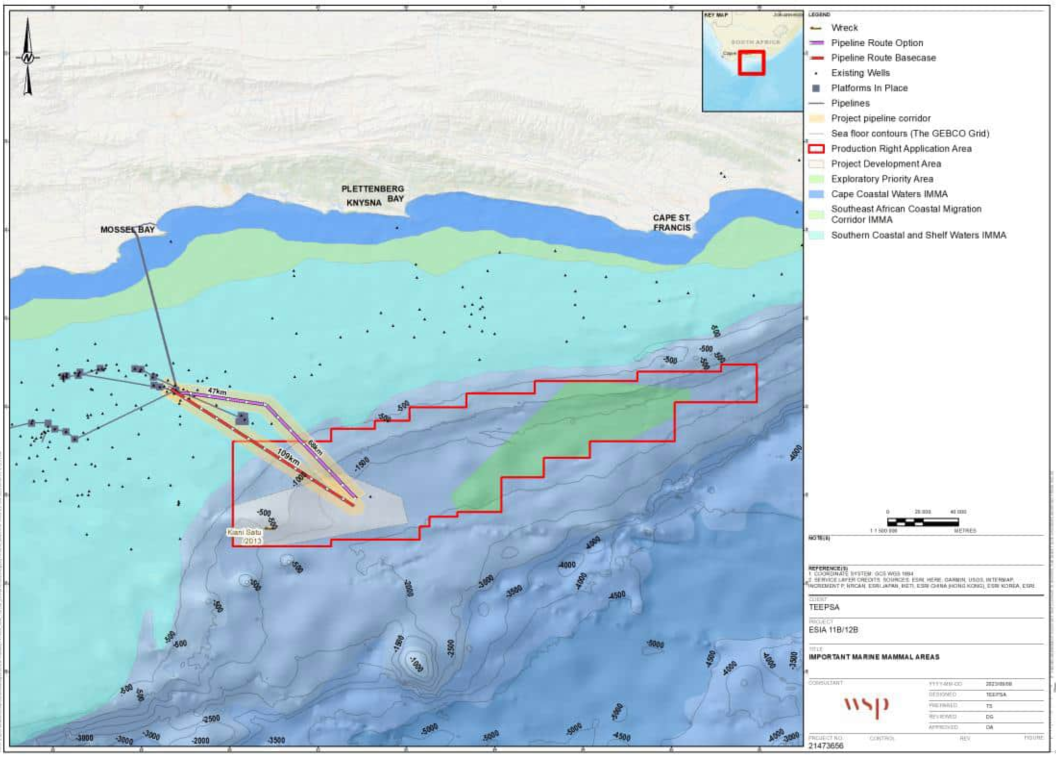


Figure 4-4. Important Marine Mammal Areas (IMMAs) in the area surrounding the Application Area (blue polygon) (Marine Mammal Protected Area Task Force 2023, https://www.marinemammalhabitat.org/portfolio-item/southern-coastal-shelf-waters-south-africa/).

All whales and dolphins are given protection under the South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished (in the Regulations for the management of boat-based whale watching and protection of turtles as part of the Marine Living Resources Act of 1998 the definition of "harassment" is given as "behaviour or conduct that threatens, disturbs or torments cetaceans"). The National Environmental Management: Biodiversity Act (NEM: BA, Act 10 of 2004) and regulations promulgated hereunder (Threatened or Protected Marine Species Regulations, Government Notice No. 40876 published 30 May 2017) provide for control of activities involving listed threatened or protected marine species, which includes numerous whale species that are potentially present in the Application Area. In term of these regulations, no person may carry out a restricted activity (which includes "harassment", defined as behaviour or conduct that "threatens, disturbs or torments a live specimen of a listed threatened or protected marine species, and includes— … (b) in the case of a whale, approaching a whale with a vessel or aircraft closer than 300 meters…") unless the Minister has exempted him/her from carrying out of such restricted activity in terms of section 57(4) of the Act. As such, no vessel or aircraft may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

4.6.2 RAMSAR SITES

Whilst they do not directly intersect with the Application Area, sensitive and significant coastal areas of biodiversity importance will be discussed here, given that potential far-field impacts (such as oil spills) may affect these areas. For example, there are several Ramsar sites along the South Coast adjacent to the Application Area. A Ramsar site is a wetland site designated to be of international importance under the under the Ramsar Convention on Wetlands of International Importance, to which South Africa is a signatory. These Ramsar sites include De Hoop (~160 km from the Production Right Application Area, ~130 km from the proposed pipe routing), De Mond (~220 km from the Production Right Application Area, ~200 km from the proposed pipe routing), and Wilderness Lakes (~130 km from the Production Right Application Area, ~106 km from the proposed pipe routing). These Ramsar sites are important wintering, staging and feeding areas for several species of breeding birds and locally migrant waterbirds.

4.6.3 EXISTING MINERAL RIGHTS AREAS

There are four main mining sectors of significance in the South African marine and coastal environment — diamonds, hydrocarbon resources, phosphates and heavy minerals (Biccard *et al.* 2018). Several offshore oil and gas basins have been identified in South Africa, including one off the Orange River Mouth (Orange Basin), off the south coast (including the Bredasdorp, the Outeniqua, the Gamtoos and the Algoa Basins) and another two off the east coast (Durban and Zululand Basins) with most wells drilled in less than 250 m water depth (Atkinson & Sink 2008, Biccard *et al.* 2018). Of all the marine mining sectors, oil and gas occupy the greatest proportion (87.7%) of South Africa's EEZ with approximately 941 943 km^2 under exploration, prospecting or mining rights as of 2018 (Biccard *et al.* 2018) (Figure 4-5).

There are several active offshore oil and gas exploration and production areas along the South African south coast (Figure 4-6). The Bredasdorp Basin on the Agulhas Bank has been the focus of most seismic and drilling activity in South Africa and mostly in the Oribi, Oryx and E-CE (originally the Sable oil field) fields located in Block 9, approximately 120 km south-west of Mossel Bay (Biccard *et al.* 2018) that are operated by the state-owned energy company PetroSA (Figure 4-6). In addition, the FA gas fields and satellites (situated about 90 km offshore of Mossel Bay) produce gas and condensate which are transported by pipeline to PetroSA's production facility at Mossel Bay (PASA 2007 in Biccard *et al.* 2018). In 2018, most of South Africa's natural gas was produced by PetroSA from the maturing offshore 65 000-boepd (barrels of oil equivalent per day) F-A and South Coast Complex fields, sent onshore via a pipeline to the gas-to-liquids (GTL) facility in Mossel Bay (Biccard *et al.* 2018).

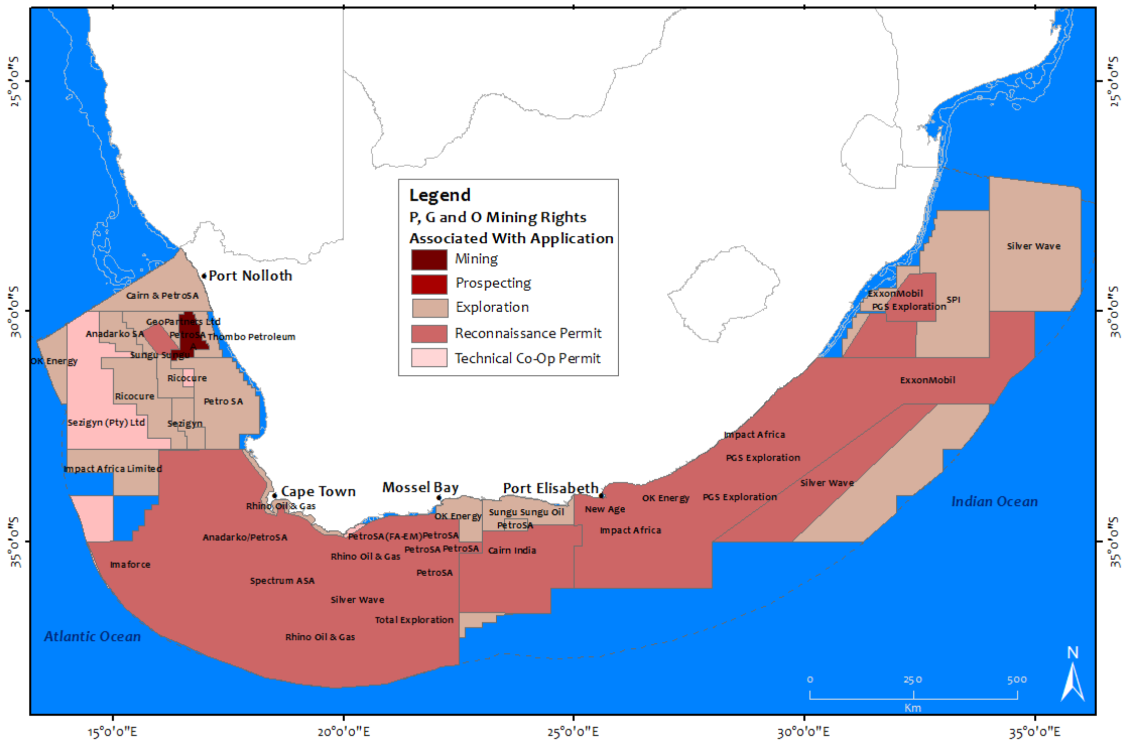


Figure 4-5. Petroleum, gas and oil exploration, prospecting and mining rights in South Africa. Data provided by DMR and PASA (2018), from Biccard *et al.* (2018).

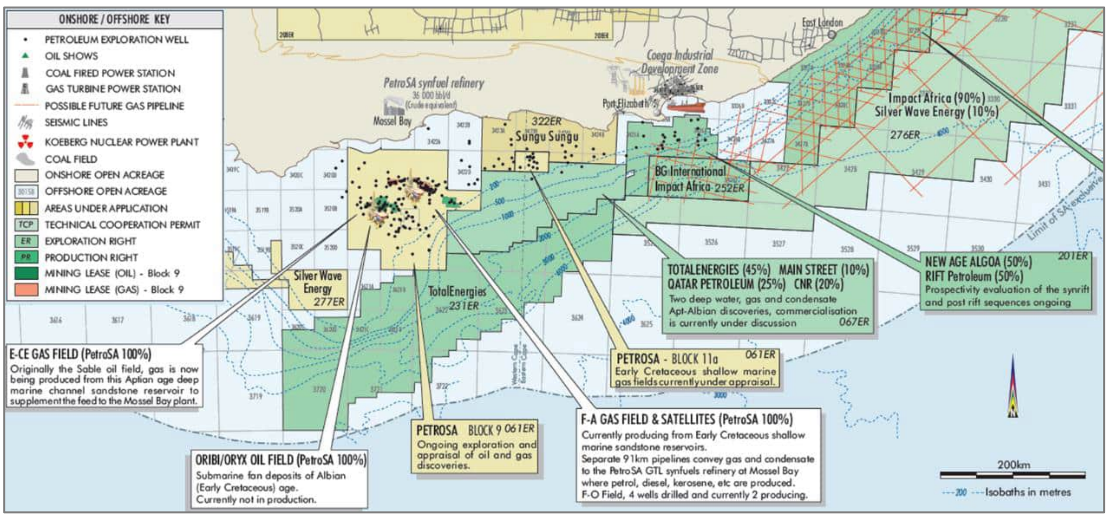


Figure 4-6. Exploration activities the South African south coast as of September 2022 (source: http://www.petroleumagencysa.com).

The Draft Offshore Oil and Gas Sector Plan which was developed through the Marine Spatial Planning (MSP) process also provides a map of offshore Oil and Gas Production Zones in the South African EEZ which highlights a number of production areas in the vicinity of the 11B/12B Application Area (Figure 4-7). The delineations of the Proposed Oil and Gas Prospective Zones are reportedly restricted for marine spatial planning purposes due to sensitivity.

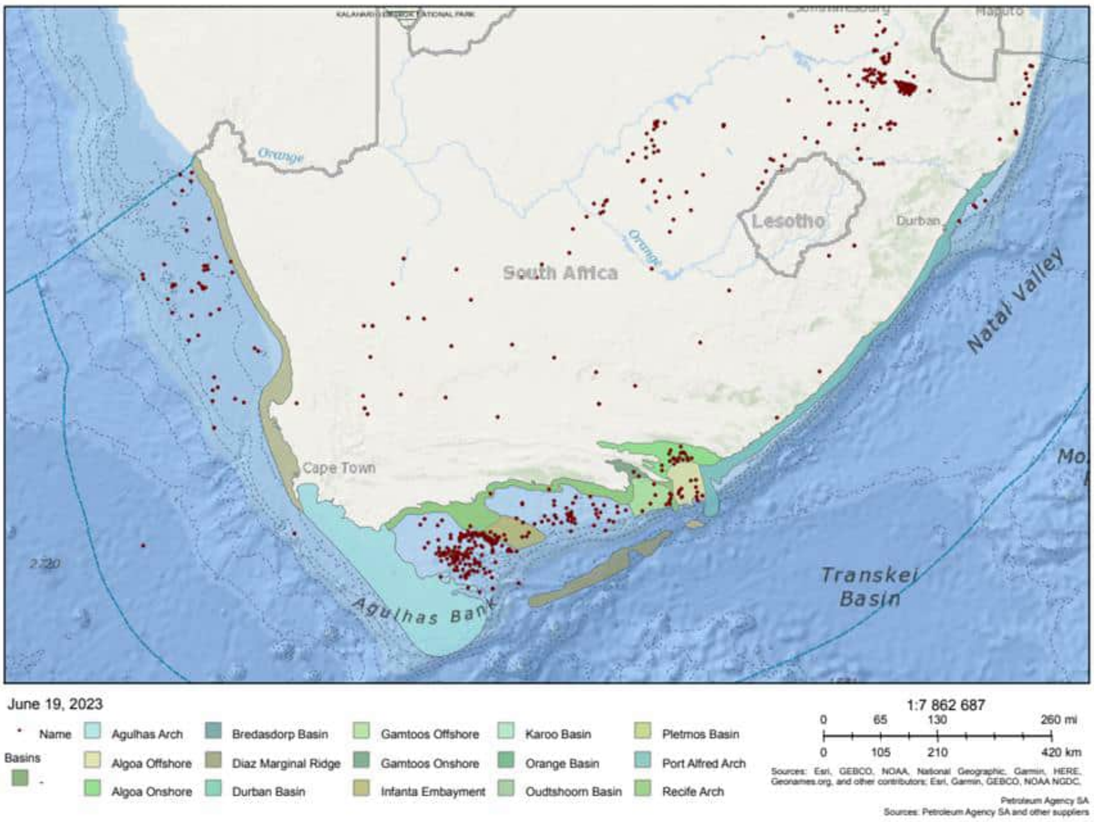


Figure 4-7. Location of exploration, appraisal and production well activities in South Africa (PASA).

4.7 IMPLICATIONS FOR MANAGEMENT

The Impact Management zones of EBSAs and the CBAs and ESA areas are encouraged to be managed by place-based regulations, informed by the reasons for their classification. A range of sea-use activities and recommendations as to their permissibility, subject to compatibility with different Critical Biodiversity Areas, is presented in Table 4.2 (from Harris *et al.* 2022, the Draft Marine Biodiversity Sector Plan 2023 and the Proposed Approach to Spatial Development and Management for South Africa's Marine Planning Areas 2019). Activities that were assessed as being compatible with the management objectives of CBAs and EBSAs are recommended to be permitted in those areas according to the existing rules and regulations for that activity; activities that are not compatible are recommended to be prohibited.

In this case, according to Harris *et al.* (2022) and the Draft Marine Biodiversity Sector Plan (2023), the development of the subsea pipelines associated with oil and gas processes are considered **non-compatible** within the CBA Natural areas (i.e., Biodiversity Conservation Areas) (Table 4.2). The environmentally preferable option is to reroute the pipeline to avoid CBA areas. However, avoidance may not be feasible, because all routing options from the western Project Development Area within the Application Area to the existing F-A gas platform pass through a CBA area (Table 4.2). There is provision made in Harris *et al.* (2022) that, should significant mineral or petroleum resources be identified during prospecting/exploration within a CBA area, alternative CBAs and/or biodiversity offsets are to be identified to meet targets for the same biodiversity features that are found at the site (Table 4.2, see Section 9.2.1). This provision would apply to the development of pipeline infrastructure critical to the production phase of this project (Section 3.3.2).

The Scoping Report (WSP 2023a) recommended that the substrate of these CBA Natural areas within both proposed pipeline routing options be assessed, and sensitive and/or significant areas, communities or species identified. This has been undertaken for both epifaunal and infaunal communities within the Production Right Application Area and both proposed pipeline servitudes (BSL 2023) allowing for a high confidence assessment of the impacts of these pipeline routing options on the marine environment (Section 3.3.2). The collection and presentation of this data is in line with the requirement that activities with restricted compatibility within CBAs Activities require "a detailed assessment to determine whether the recommendation is that they should be permitted (general), permitted subject to additional regulations (consent), or prohibited, depending on a variety of factors". Examples of these factors include the ecosystem type (Section 3.3), the intensity of the activity (Section 1.2). It is also critical to take cumulative impacts into account, which may have implications for the intensity, extent or even the presence of activities, especially new or expanding activities in a biodiversity priority area (Section 8).

It is critical to note that the **non-/restricted compatibility** of the activity in CBAs refers to the location of the biodiversity disturbance rather than the location of the petroleum resource (Harris *et al.* 2022, see Table 4.2). Therefore, while the likely direct impacts on the substrate as a result of pipeline construction are expected to be short-term, and of low impact (due to the sufficient adjacent habitat to allow for rapid recolonisation) (Section 8.2), operational impacts related to oil spills are considered of critical concern (modelling results are presented in Section 7, and assessed in Section 8). The Scoping Report (WSP 2023a) noted that it is considered essential that a comprehensive oil spill risk assessment be undertaken (results are presented in Section 7) and that a proactive and adaptive management plan be implemented to manage and mitigate the potential risks.

Table 4.2. Sea use activities, Marine Spatial Planning (MSP) Zones and compatibility with the management objective of Critical Biodiversity Areas (CBA-N = CBA Natural; CBA-R = CBA Restore) and Ecological Support Areas (ESA). Activity compatibility is given as R = restricted compatibility, or N = not compatible. (Source: Harris *et al.* 2022 and the Draft Marine Biodiversity Sector Plan 2023).

Broad sea use	**Associated MSP zones**	**Associated sea use activities**	**MPAs**	**Biodiversity Conservation Areas (i.e., CBA-N areas)**	**Biodiversity Restoration Areas (i.e., CBA-R areas)**	**Biodiversity Impact Management Zone (i.e., ESAs)**
Petroleum	Petroleum Zone	Petroleum: invasive exploration (1)	Gazetted regulations	R	R	R
		Petroleum: production (2, 3)		N	N	R
		Petroleum: new oil and gas pipelines		N	N	R

1. This activity has significant spatial overlap with some areas that are proposed for inclusion in the Biodiversity Conservation Areas and the Biodiversity Restoration Areas. Therefore, the consent category

<table>
<tr><th>Broad sea use</th><th>Associated MSP zones</th><th>Associated sea use activities</th><th>MPAs</th><th>Biodiversity Conservation Areas (i.e., CBA-N areas)</th><th>Biodiversity Restoration Areas (i.e., CBA-R areas)</th><th>Biodiversity Impact Management Zone (i.e., ESAs)</th></tr>
<tr><td colspan="7">was reduced from N to RC to accommodate activity in areas where this activity would not negatively impact the objectives in specific sites.
2. This activity should not be permitted to occur in CBAs because it is not compatible with the respective management objectives. However, if significant mineral or petroleum resources are identified during prospecting/exploration, then the selection of the site as a CBA could be re-evaluated as part of the compromise negotiations in current or future MPA consideration. This would require alternative CBAs and/or biodiversity offsets to be identified. However, if it is not possible to identify alternative CBAs to meet targets for the same biodiversity features that are found at the site, it is recommended that the activity remains prohibited.
3. The recommended prohibition of the activity in CBAs (because it is not compatible with the respective management objectives) refers to the location of the biodiversity disturbance rather than the location of the petroleum resource. If petroleum production is possible using lateral drilling or other techniques that do not result in any impacts on biodiversity within CBAs, then production may be treated as an activity with restricted compatibility (i.e., recommended to be a consent activity).</td></tr>
</table>

An assessment of the impacts of the proposed project activities considering the delineation of Critical Habitat as per Section 4.5, is undertaken in Section 8 as per the ESIA methodology described in the Scoping Report (WSP 2023a).

Performance Standard 6 requires that such natural habitats may not be converted or degraded unless all of the following are demonstrated:

- That no other viable alternatives within the region exist for development of the project on modified habitat;
- That consultation has established the views of stakeholders, including Affected Communities, with respect to the extent of conversion and degradation; and
- that any conversion or degradation is mitigated according to the mitigation hierarchy.

In areas of natural habitat, mitigation measures should be designed to achieve no net loss of biodiversity where feasible. Appropriate actions include the restoration of habitat, the avoidance of biodiversity impacts, and the offset of losses through the creation of ecologically comparable area(s).

As per IFC Performance Standard 6, project activities are not permitted within the delineation of these areas as Critical Habitats unless:

1. There are no measurable adverse impacts on the ability of the Critical Habitat to support the established population of species described in Section 4.5 or the functions of the Critical Habitat described in Section 4.5;

2. There is no reduction in the population of any recognized critically endangered or endangered species; and

3. Any lesser impacts are mitigated in accordance with IFC Performance Standard 6 requirements. These require that mitigation measures be designed to achieve no net loss of biodiversity where feasible, and may include a combination of actions, such as:

    - Post-operation restoration of habitats;
    - Offset of losses through the creation of ecologically comparable area(s) that is managed for biodiversity; and,
    - Compensation to direct users of biodiversity.

Indeed, in areas of critical habitat, a net gain in biodiversity values for which the critical habitat was designated must be demonstrated. Net gains[8] may be achieved through biodiversity offsets (see Section 9.2.1). A Biodiversity Action Plan (BAP) will be required for projects located in Critical Habitat and is recommended for high-risk projects in natural habitats.

[8] As described in Performance Standard 6, net gains of biodiversity values must involve measurable, additional conservation outcomes. Such gains must be demonstrated on an appropriate geographic scale (e.g., local, landscape-level, national, regional) as determined by external experts. In instances where a biodiversity offset is not part of the client's mitigation strategy (i.e., there are no significant residual impacts), net gains may be obtained by supporting additional opportunities to conserve the critical habitat values in question. In these cases, qualitative evidence and expert opinion may be sufficient to validate a net gain.

5 MARINE NOISE MODELLING RESULTS

5.1 Introduction and Approach

Anthropogenic noise in and around underwater habitats can impact marine species inhabiting these areas. The main adverse impacts of underwater sound on marine species can be broadly summarised as auditory injury (either permanent or temporary), and disturbance (Bailey *et al.* 2010). The Scoping Phase (WSP 2023a) identified that noise impacts may affect various biota, including marine mammals, sea turtles, fish and diving birds (penguins, gannets and cormorants). Marine invertebrates may also be impacted by underwater noise; however, available evidence suggests these impacts are very limited in nature (de Soto 2016). Long term noise exposure may cause chronic effects, including developmental deficiencies and physiological stress (Popper & Hawkins 2016). These may affect life functions, including individual health and fitness, foraging efficiency, avoidance of predation, swimming energetics and reproductive behaviour (Popper & Hawkins 2016). However, these responses to sound are dependent on the sound qualities.

Noise is characterised as either impulsive or non-impulsive. Impulsive noises are considered to have high peak sound pressure, short duration, fast rise-time and broad frequency content at source (Hastie *et al.* 2019, Southall *et al.* 2019). Non-impulsive sources are categorised as "steady state" noise (Southall *et al.* 2019). Explosives, impact piling and seismic airguns are considered impulsive noise sources while sonars, vibropiling, drilling, shipping and other relatively low-level continuous noises are considered non-impulsive (see Hastie *et al.* 2019, Martin *et al.* 2020, Guan *et al.* 2022, Mason & Midforth 2022). A non-impulsive noise does not necessarily have to have a long duration. The extent and likelihood of underwater noise causing adverse impacts on marine life is dependent on the qualities of the sound such as the sound level, source frequency, duration of exposure, and/or repetition rate (Hastings & Popper 2005).

The proposed activities in the Application Area are expected to result in mostly non-impulsive noise pollution of variable intensity and frequency. The main sources of project-generated underwater noise that were considered in this assessment included:

- Drilling of up to six (6) development and appraisal wells in the Project Development Area;
- Additional drilling of up to four (4) exploration wells in the Exploratory Priority Area;
- Vertical seismic profiling (VSP) in the Exploratory Priority Area to improve the understanding of the potential oil and gas bearing geology within the Block;
- Sonar surveys to investigate the structure of the seabed; and
- Helicopter use to transport personnel to and from the offshore facilities as required.

An assessment of underwater noise impacts from the project was undertaken by WSP (2023b). Underwater noise levels due to the project activities were predicted using underwater acoustic propagation modelling software which implements a range-dependent parabolic equation acoustic model for fluid seabeds. Environmental inputs to the prediction model included sound speed profiles for the water column, bathymetry, and seabed properties. The model produces a transmission loss (TL) as a function of range and depth from a sound source at a defined depth. Using source noise emission levels, the predicted TL is converted to noise levels in the form of two-dimensional noise contours. The model result outputs included distances to the acoustic thresholds for marine species (WSP 2023b). Based on the sensitivity analysis defined in the Scoping Report (WSP 2023a), drilling, VSP, and sonar surveys were modelled at two sites, a deeper water location (L1) and a shallow water location (L2) (Figure 5-1). These sites represent the 'worst-case' in terms of impacts as they are located close to identified sensitive receptors adjacent to the licence area.

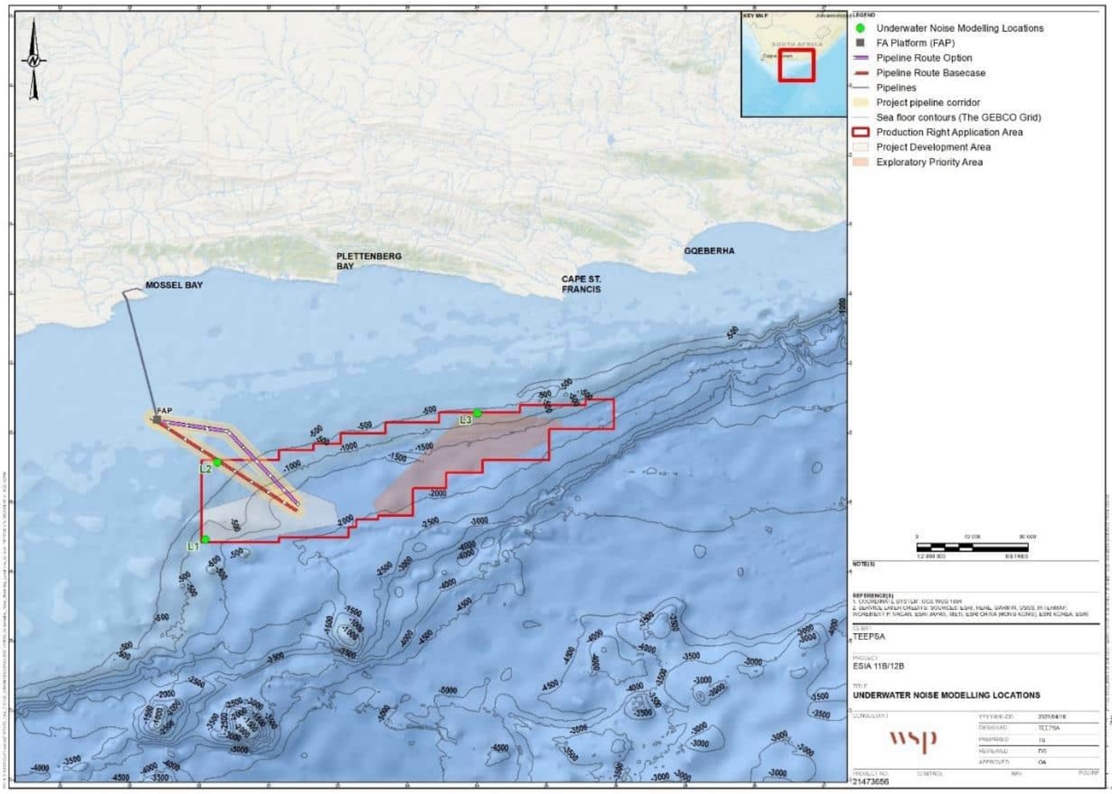


Figure 5-1. The noise modelling study simulated all project activities (VSP, drilling and sonar surveys) at sites indicated by green dots. Modelled activities at each of these sites were: (L1) drilling, VSP and sonar; (L2) sonar; and (L3) drilling and VSP. Note that these locations were selected to represent the range of water depths of the areas where the activities may occur, and project activities are not limited to the locations modelled (WSP 2023b).

5.2 Thresholds

The main metrics and criteria that have been used in the study come from two key papers covering underwater noise and its effects:

- Southall *et al.* (2019) marine mammal exposure criteria; and
- Popper *et al.* (2014) sound exposure guidelines for fishes and sea turtles.

To quantify the potential impacts of underwater noise on marine fauna, an assessment of acoustic thresholds was conducted for various biotic groups and species, against which received sound levels were compared. It is important to note that different species of marine mammals, sea turtles, and penguins and diving birds do not have equal sensitivity to noise at all frequencies, and therefore, NOAA specifies frequency weightings to be considered when predicting noise levels to be compared to thresholds for different marine species (WSP 2023b). These auditory weighting functions are used to emphasize frequencies where animals are more sensitive and deemphasize those where they are less sensitive (for further details, see WSP 2023b). The auditory weighting function for each hearing group was added to the predicted noise levels for each frequency prior to calculating the distances to the weighted hearing group-specific thresholds.

To assess the effect of anthropogenic sound on **marine mammals**, thresholds were defined for onset of temporary threshold shifts (i.e., temporary loss of hearing sensitivity, TTS), permanent threshold shifts (i.e., permanent loss of hearing sensitivity, PTS), and behavioural response in marine mammals due to both impulsive and non-impulsive noise sources, as well as injury criteria for impulsive sounds (Southall *et al.* 2019, NMFS 2016, 2018) (Table 5.1). The disturbance (behavioural response) threshold for all marine mammal species was set as 160 dB re 1 µPa (SPL_{rms}) for impulsive noise (e.g., VSP, sonar surveys) and 120 dB re 1 µPa (SPL_{rms}) for non-impulsive noise (e.g., drilling) (NMFS 2016, WSP, 2023b). These disturbance thresholds do not consider the overall duration of the noise or its acoustic frequency distribution to account for species dependent hearing. The disturbance thresholds are much lower for continuous sounds than impulsive sounds, which is attributed to the differences in the way the ear perceives loudness for these sound types.

Appropriate thresholds for **sea turtles** related to impulsive and non-impulsive noise sources were set as per Finneran *et al.* (2017), who derived both TTS and PTS thresholds and applicable frequency weighting functions (see Table 5.1). The behavioural disturbance noise thresholds for sea turtles for both impulsive and non-impulsive sources was set at 175 dB re 1 µPa (SPL_{rms}) (Finneran *et al.* 2017). Sea turtle functional hearing is limited to frequencies below approximately 2 kHz (Finneran *et al.* 2017, WSP 2023b).

Table 5.1. Marine mammal and sea turtle injury thresholds for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS). UW = unweighted; W = weighted (WSP 2023b).

Hearing Group	Impulsive Sources				Continuous Sources	
	TTS		PTS		TTS	PTS
	SPL_{peak} (dB re 1 µPa) (UW)	SEL_{24h} (dB re 1 µPa^2-s) (W)	SPL_{peak} (dB re 1 µPa) (UW)	SEL_{24h} (dB re 1 µPa^2-s) (W)	SEL_{24h} (dB re 1 µPa^2-s) (W)	SEL_{24h} (dB re 1 µPa^2-s) (UW)
Low Frequency Cetaceans	213	168	219	183	179	199
High Frequency Cetaceans	224	170	230	185	178	198
Very High-Frequency Cetaceans	196	140	202	155	153	173
Phocid Carnivores (true seals)	212	170	218	185	181	201
Other Marine Carnivores	226	188	232	203	199	219
Sea Turtles	226	189	232	204	200	220

Sound exposure guidelines for **fish**, fish eggs, and fish larvae have been developed by Popper *et al.* (2014) for impulsive and continuous (i.e., non-impulsive) noise sources. While the hearing range of fishes is generally considered to be from approximately 30 Hz to 10 kHz, there are some species of fish that can detect higher frequencies (WSP 2023b). Fish are grouped into three categories depending on whether they have a swim bladder, and if it has a role in their ability to hear (Popper & Hawkins 2019) (Table 5.2). Fishes with no swim bladder are less susceptible to injury from noise exposure, although some injury may still result from exposure to sound pressure. Fishes with swim bladders in which hearing both does and does not involve the swim bladder are both susceptible to injury although hearing, although the latter only detect particle motion, not sound pressure, while the former detect both. For fish, masking and behavioural effects are assessed qualitatively, in terms of relative risk (i.e., high, moderate, and low) at distances from a noise source (i.e., near, intermediate, and far) (Popper *et al.* 2014).

Table 5.2. Fish thresholds for continuous and impulsive sounds. SPL_{peak} is measured in dB re 1 μPa and SEL_{24h} is measured in re 1 μPa^2-s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F) (WSP 2023b).

Type of Fish	**Mortality/ mortal injury**	**Impairment**			**Behaviour**
		Recoverable Injury	TTS	Masking	
Continuous Sounds					
No swim bladder	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Swim bladder not involved in hearing	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Swim bladder involved in hearing	(N) Low (I) Low (F) Low	SPLrms: 170 dB for 48 hrs	SPLrms: 158 dB for 12 hrs	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low
Impulsive Sounds					
No swim bladder	SEL_{24h}: >219 dB SPL_{peak}: > 213 dB	SEL_{24h}: > 216 dB SPL_{peak}: > 213 dB	SEL_{24h}: >> 186 dB	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Swim bladder not involved in hearing	SEL_{24h}: 210 dB SPL_{peak}: >207 dB	SEL_{24h}: 203 dB SPL_{peak}: > 207 dB	SEL_{24h}: > 186 dB	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low

Type of Fish	Mortality/ mortal injury	Impairment			Behaviour
		Recoverable Injury	TTS	Masking	
Continuous Sounds					
Swim bladder involved in hearing	SEL_{24h}: 207 dB SPL_{peak}: >207 dB	SEL_{24h}: 203 dB SPL_{peak}: > 207 dB	SEL_{24h}: 186 dB	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	SEL_{24h}: >210 dB SPL_{peak}: >207 dB	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Sound exposure thresholds for **penguins** and other **diving birds** have been assessed in recent studies that have examined the behavioural response of penguins to impulsive noise (see Sørensen *et al.* 2020). Based on the findings of this study, a conservative behavioural threshold of 120 dB re 1 µPa (SPL_{rms}) was applied for impulsive and non-impulsive noise. In applying this threshold, a frequency weighting was considered to reflect the hearing sensitivities of penguins and diving birds. In the absence of specific frequency weighting functions for penguins or diving birds, the frequency weighting for other marine carnivores in water (OCW) was applied (WSP 2023b).

5.3 BACKGROUND NOISE LEVELS

Existing underwater noise levels are influenced by both natural and anthropogenic sources (Figure 5-2). The ocean is a naturally noisy place and marine animals are continually subjected to sounds from physical sources such as wind, rainfall, breaking waves and natural seismic noise, or biologically produced sounds generated during reproductive displays, territorial defence, feeding, or in echolocation (SRL 2021). Such acoustic cues are thought to be important to many marine animals in the perception of their environment, as well as for navigation purposes, predator avoidance, and in mediating social and reproductive behaviour. Anthropogenic sound sources in the ocean can be expected to interfere directly or indirectly with such activities affecting the physiology and behaviour of marine organisms (NRC 2003).

Of all human-generated sound sources, the most prevalent in the ocean is the noise of shipping, which generally overlaps with, and therefore impacts, the low frequencies range (WSP 2023b). Noise levels in the Application Area are primarily influenced by vessel traffic, as well as existing industry and natural sources such as wind and waves and marine mammal vocalizations (WSP 2023). With several major ports on the coast of South Africa, including Cape Town, Mossel Bay, Gqeberha, East London, and Durban, the 2020 vessel traffic map shown in Figure 5-3 demonstrates how existing underwater noise levels in the vicinity of the Project are significantly impacted by existing vessel traffic. Indeed, during Marine Mammal Observation (MMO) surveys within Block 11B/12B from 28 November 2022 to 9 December 2022 recorded 50 vessels, which mostly comprised of bulk carriers (17), crude oil tankers (9) and fishing vessels (9) (BSL & CapMarine 2023). It is noted in the MMO report that, "*Vessel traffic was not recorded during the transits between Block 11B/12B and Cape Town, as a large part of the transit was in the shipping lane*" (BSL & CapMarine 2023).

Ambient noise levels generally range from 80 dB to 120 dB re 1 µPa, and as shipping activities may increase short term noise levels by 20 dB to 30 dB, the average ambient noise levels within Block 11B/12B area are expected to be at the higher end of the typical ambient levels (i.e., 100 dB to 130 dB re 1 µPa) (Swan *et al.* 1994, National Research Council 2003, WSP 2023b).

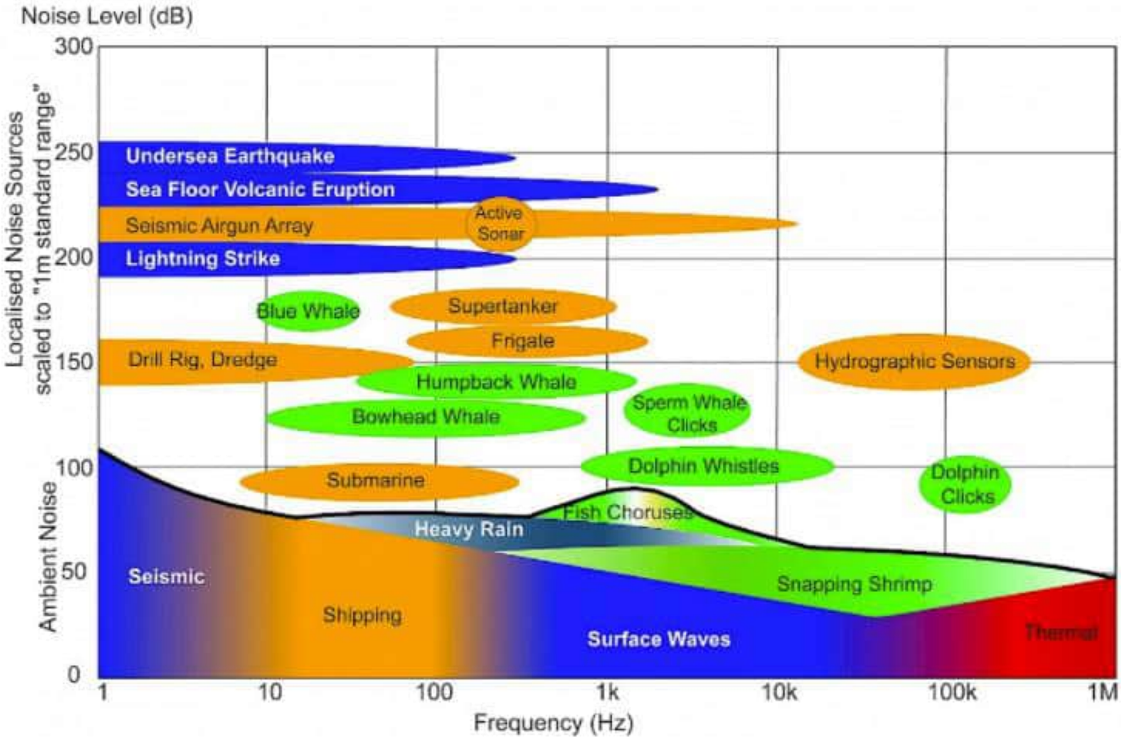


Figure 5-2. Noise levels and frequencies of anthropogenic and natural noise sources in the marine environment (WSP 2023, from https://www.ospar.org/work-areas/eiha/noise).

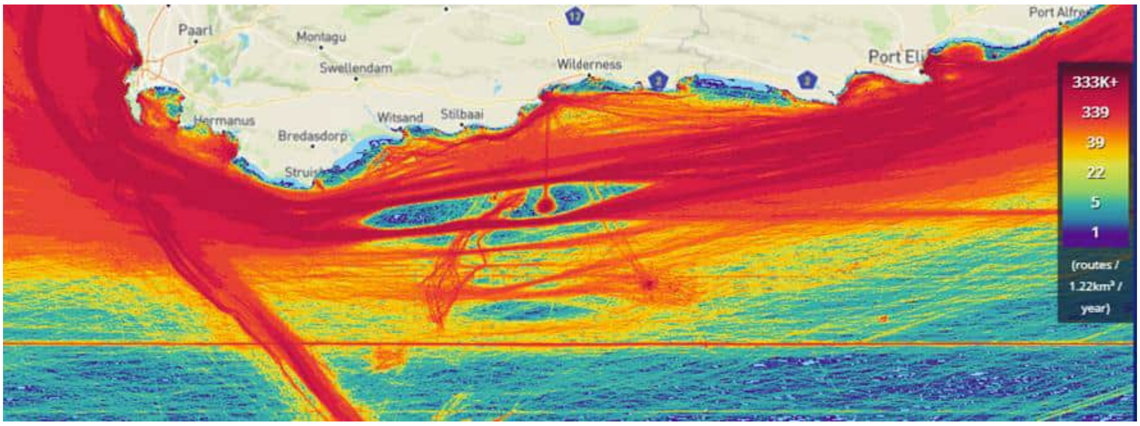


Figure 5-3. Existing vessel traffic in 2020 in the vicinity of the Project. (WSP 2023, from https://www.marinetraffic.com).

5.4 RESULTS

The results of the underwater noise modelling and predicted noise levels from drilling, VSP and sonar surveys on various marine biota as per the thresholds specified in Section 5.2 are presented below. Relevant injury and behaviour thresholds for marine mammals and sea turtles are divided based on the frequency weightings of their hearing sensitivities, whereas thresholds for fish depend on the presence or absence of a swim bladder and its role in their ability to hear.

5.4.1 DRILLING ACTIVITIES

The modelled drilling activities assumed the use of a semi-submersible drilling unit, one to two support tug vessels, as well as supply vessels. The source levels considered in the underwater noise modelling for drilling and support vessels (i.e., tugs and supply vessels) is presented in Figure 5-4 (WSP 2023b). Two scenarios were modelled: 1) a worst-case scenario, where an animal would be exposed to drilling noise for the entire 24 hours, and 2) an exposure to drilling noise of 30-minute period over 24-hours, assuming the likelihood that an animal would move away from the source of the noise (WSP 2023b).

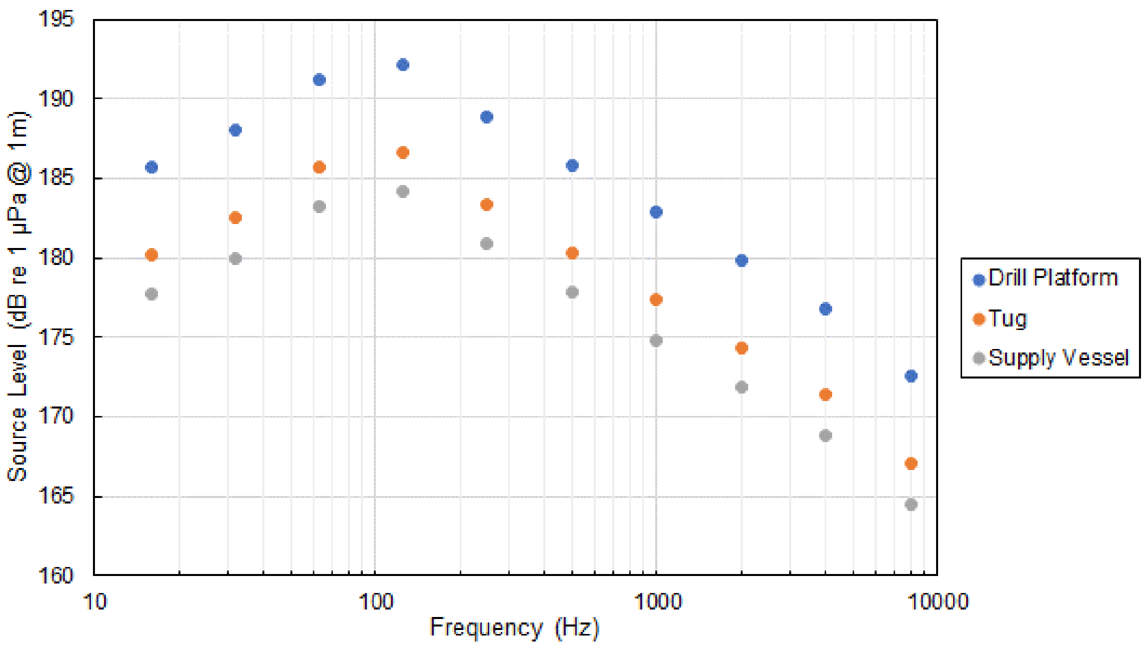


Figure 5-4. Source noise levels for the drilling scenario (WSP 2023b).

For 24-hour exposure, the predicted maximum Permanent Threshold Shift (PTS) threshold distances for drilling activities were 250 m for low frequency cetaceans (baleen whales like the southern right whale *Eubalaena australis*, humpback whale *Megaptera novaeangliae* and Bryde's whale *Balaenoptera edeni*) and 240-400 m for very high frequency cetaceans (pygmy sperm whale *Kogia breviceps* and dwarf sperm whale *K. sima*). Modelled PTS distances for drilling activities were 10 m for high frequency cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales), up to 50 m for phocid carnivores in water (seals), and up to 10 m for sea turtles (Table 5.3) (WSP 2023b). The modelled 30-minute exposure PTS distance was at maximum 20 m for low frequency cetaceans and very high-frequency cetaceans (Table 5.3).

As expected, the predicted Temporary Threshold Shift (TTS) threshold distances for drilling activities were greater than the PTS thresholds. The TTS threshold distance for low frequency cetaceans was predicted as 6.35 km from the deep-water site (L1) and 9 km from the shallow-water site (L2) (Table 5.3) (WSP 2023b). This means that baleen whales within a 6.35-9 km radius of the drilling sites are likely to experience a temporary loss of hearing sensitivity during drilling activities. Modelled drilling TTS threshold distances for other species include 240-330 m for high frequency cetaceans, 8.6 km for very high frequency cetaceans, 80 m for sirenians, ranged from 760-1 400 m for phocid carnivores in water, 60 m for other marine carnivores in water, and 330 m for sea turtles (WSP 2023b). The modelled 30-minute exposure TTS distance was at maximum 790 m for very high-frequency cetaceans, and 380 m for frequency cetaceans (Table 5.3).

Table 5.3. Predicted distances to marine mammal and sea turtle **injury thresholds** for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) for the modelled drilling scenario. A single distance to threshold number indicates the same predicted result at L1 and L3 (WSP 2023b).

Hearing Group	TTS			PTS		
	SEL_{24h} Threshold (dB re 1 μPa²-s)	Distance to Threshold (m) (L1 / L3)		SEL_{24h} Threshold (dB re 1 μPa²-s)	Distance to Threshold (m) (L1 / L3)	
		Scenario 1: 24 hr exposure	Scenario 2: 30 min exposure		Scenario 1: 24 hr exposure	Scenario 2: 30 min exposure
Low Frequency Cetaceans	179	6 350 / 9 000	350 / 380	199	240 / 250	20
High Frequency Cetaceans	178	240 / 330	20	198	<10	< 10
Very High-Frequency Cetaceans	153	8 450 / 8 600	490 / 790	173	240 / 400	20
Phocid Carnivores (true seals)	181	760 / 1 400	10	201	50	< 10
Other Marine Carnivores in Water	199	60	< 10	219	<10	< 10
Sea Turtles	200	310 / 330	10	220	10	< 10

For fish that utilise their swim bladder in hearing (primarily though pressure detection), the maximum TTS threshold distance is predicted to be 150-160 m, and 30 m for a recoverable injury (Table 5.4).

Table 5.4. Predicted distances for the modelled drilling scenario to the **impairment thresholds** for continuous noise for fish. A single distance to threshold number indicates the same predicted result at L1 and L3 (WSP 2023b).

Type of Fish	Recoverable Injury		TTS	
	SPL_{rms} for 48hrs Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)	SPL_{rms} for 12hrs Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)
Fish: Swim bladder involved in hearing (primarily pressure detection)	170	30	158	150 / 160

The maximum modelled predicted behavioural threshold distances for drilling activities were 66 km for marine mammals, 10 km for sea turtles, and 11.8 km for penguin/diving birds (Table 5.5, Figure 5-5).

Table 5.5. Predicted distances for the modelled drilling scenario to the **behavioural thresholds** for continuous noise for marine mammals, sea turtles, and penguins and diving birds. A single distance to threshold number indicates the same predicted result at L1 and L3. Calculation of distance to threshold for penguins/diving birds includes a frequency weighting for OCW (WSP 2023b).

Hearing Group	SPL_{rms} Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)
Marine Mammals	120	66 000 / 65 000
Sea Turtles	175	10
Penguins / Diving Birds	120	11 800 / 10 400

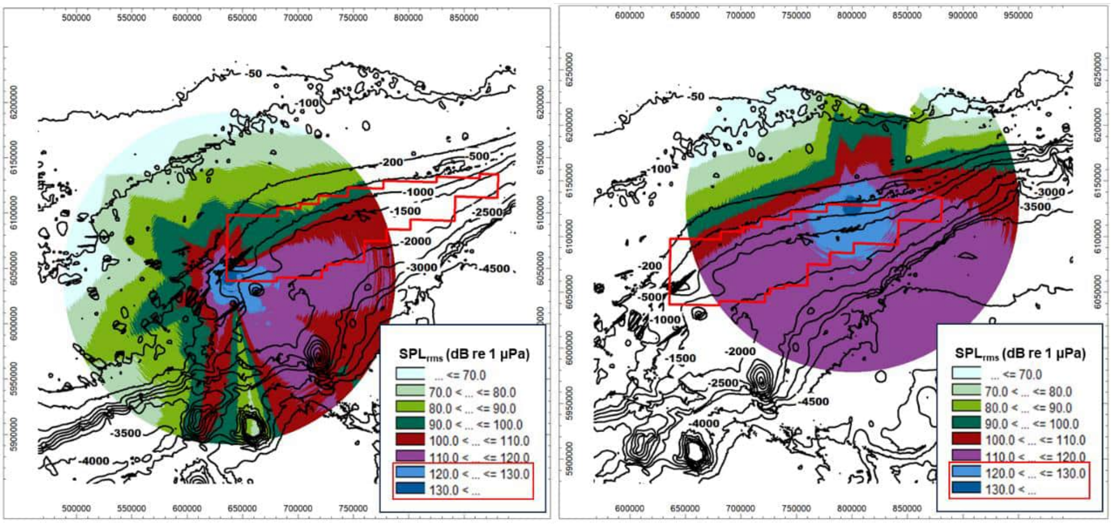


Figure 5-5. Maximum predicted noise level contours across the water column for drilling scenario at modelling location (left) L1 and (right) L2. Note that TSS and PTS for all groups occur at SEL_{rms} Threshold above 120-175 (see Table 5.5); this is indicated by the blue contours (WSP 2023b).

5.4.2 VERTICAL SEISMIC PROFILING

Vertical Seismic Profiling (VSP) generates a high-resolution seismic imagine of the geology in the well's immediate vicinity. The model assessed VSP operations utilising a small airgun array (a Dual Delta Sodera G-Gun or equivalent), with source levels considered in the underwater noise modelling presented in Figure 5-6 (WSP 2023b). It is expected that up to 250 pulses may occur during one operation which may last 8-12 hours, and as such two scenarios were modelled: 1) 50 pulses and 2) 250 pulses in a given 24-hour period (WSP 2023b).

Under modelled VSP operations, the predicted maximum peak exposure Permanent Threshold Shift (PTS) threshold distances for most species is less than 10 m and 20 m for very high frequency cetaceans (Table 5.6). Cumulative PTS threshold distances (250 pulses per 24-hour period) for low frequency cetaceans (baleen whales) are 200-210 m (Table 5.6). For all other species, PTS thresholds did not exceed 10 m under either the 50 or 250 pulse scenarios, except very high frequency cetaceans, where the maximum predicted distance to the threshold was 20 m (250 pulses) (Table 5.6) (WSP 2023b).

The predicted peak exposure Temporary Threshold Shift (TTS) threshold distances for most species is less than 10 m, and 50 m for very high frequency cetaceans (Table 5.6). Cumulative PTS threshold distances (250 pulses per 24-hour period) for low frequency cetaceans under VSP operations were predicted to reach 1 450-2 200 m for 250 pulses per 24-hour period (Table 5.6). TTS threshold distances (250 pulses) for Very High-Frequency Cetaceans were 100-130 m, and 70 m for sea turtles (Table 5.6) (WSP 2023b).

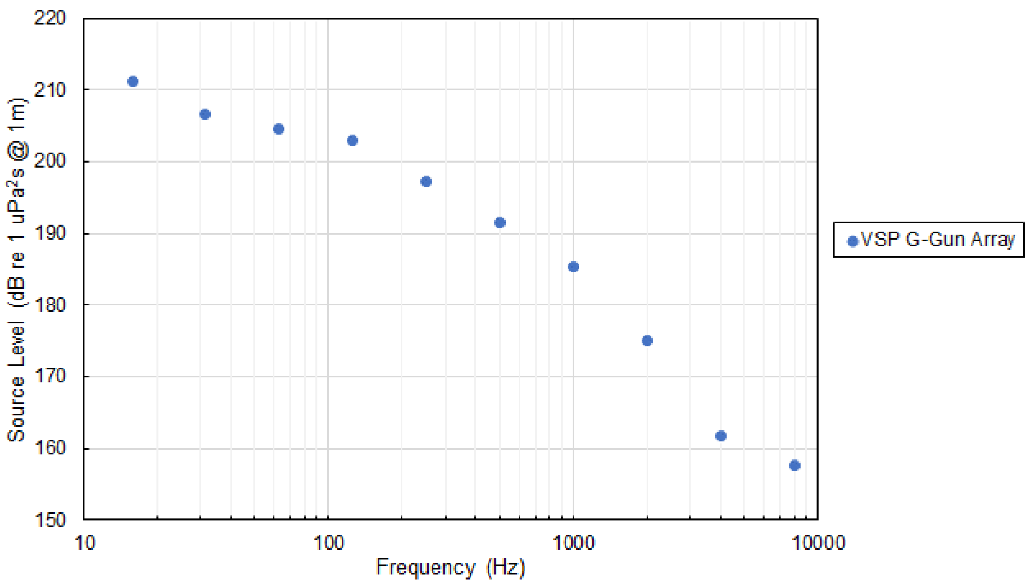


Figure 5-6. Source noise levels for the VSP operations (WSP 2023b).

Table 5.6. Predicted distances to marine mammal and sea turtle **injury thresholds** for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) for the modelled VSP scenarios. A single distance to threshold number indicates the same predicted result at L1 and L3 (WSP 2023b).

Hearing Group	Peak exposure			
	TTS		PTS	
	SPL_{peak} Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)	SPL_{peak} Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)
Low Frequency Cetaceans	213	< 10	219	< 10
High Frequency Cetaceans	224	< 10	230	< 10
Very High-Frequency Cetaceans	196	50	202	20
Phocid Carnivores (true seals)	212	< 10	218	< 10
Other Marine Carnivores in Water	226	< 10	232	< 10
Sea Turtles	226	< 10	232	< 10

Hearing Group	Cumulative exposure (24h exposure)					
	TTS			PTS		
	SEL_{24h} Threshold (dB re 1 µPa²-s)	Distance to Threshold (m) (L1 / L3)		SEL_{24h} Threshold (dB re 1 µPa²-s)	Distance to Threshold (m) (L1 / L3)	
		Scenario 1: 50 pulses	Scenario 2: 250 pulses		Scenario 1: 50 pulses	Scenario 2: 250 pulses
Low Frequency Cetaceans	168	550 / 600	1 450 / 2 200	183	80	200 / 210
High Frequency Cetaceans	170	< 10	< 10	185	< 10	< 10
Very High-Frequency Cetaceans	140	30	130 / 100	155	< 10	10
Phocid Carnivores (true seals)	175	< 10	< 10	190	< 10	< 10
Other Marine Carnivores in Water	170	70 / 60	150 / 160	185	< 10	20
Sea Turtles	188	10	10	203	< 10	< 10

For fish both with and without a swim balder, the peak exposure TTS and mortality and potential mortal injury is less than or equal to 10 m, while the cumulative TTS threshold distance for 50 pulses per 24-hour period is predicted to be 160 m, increasing to 370-400 m when 250 pulses per 24-hour period was modelled (Table 5.7). Mortality and potential mortal injury of fish eggs and fish larvae is predicted to occur within 10 m, while recoverable injury for fish species with a swim bladder is predicted to occur at 20 m (50 pulses) and 40 m (250 pulses in a 24-hour period) (Table 5.7).

Table 5.7. Predicted distances for the modelled VSP scenarios to the **impairment thresholds** for continuous noise for fish. A single distance to threshold number indicates the same predicted result at L1 and L3 (WSP 2023b).

Type of Fish	**Peak exposure**			
	Mortality and potential mortal injury		Recoverable Injury	
	SPL_{peak} Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)	SPL_{peak} Threshold (dB re 1 µPa)	Distance to Threshold (m) (L1 / L3)
No swim bladder	213	< 10	213	< 10
Swim bladder not involved in hearing	207	10	207	10
Swim bladder involved in hearing	207	10	207	10
Fish eggs and fish larvae	207	10	n/a	-

Type of Fish	**Cumulative exposure (24h exposure)**								
	Mortality and potential mortal injury			Recoverable Injury			TTS		
	SEL_{24h} Threshold (dB re 1 µPa²-s)	Distance to Threshold (m) (L1 / L3) 50 pulses	Distance to Threshold (m) (L1 / L3) 250 pulses	SEL_{24h} Threshold (dB re 1 µPa²-s)	Distance to Threshold (m) (L1 / L3) 50 pulses	Distance to Threshold (m) (L1 / L3) 250 pulses	SEL_{24h} Threshold (dB re 1 µPa²-s)	Distance to Threshold (m) (L1 / L3) 50 pulses	Distance to Threshold (m) (L1 / L3) 250 pulses
No swim bladder	219	< 10	< 10	216	< 10	< 10	186	160	370 / 400
Swim bladder not involved in hearing	210	< 10	20	203	20	40	186	160	370 / 400
Swim bladder involved in hearing	207	10	30	203	20	40	186	160	370 / 400
Fish eggs and fish larvae	210	< 10	20	n/a	-	-	n/a	-	-

The maximum modelled predicted behavioural threshold distances for VSP activities was 2 km for marine mammals, 350 m for sea turtles, and 19.2 km for penguin/diving birds (Table 5.8, Figure 5-7) (WSP 2023b).

Table 5.8. Predicted distances of the modelled VSP scenarios to the **behavioural thresholds** for impulsive noise for marine mammals, sea turtles, and penguins and diving birds. A single distance to threshold number indicates the same predicted result at L1 and L3. Calculation of distance to threshold for penguins/diving birds includes a frequency weighting for OCW (WSP 2023b).

Hearing Group	SPL_{rms} Threshold (dB re 1 μPa)	Distance to Threshold (m) (L1 / L3)
Marine Mammals	160	1 850 / 2 000
Sea Turtles	175	330 / 350
Penguins / Diving Birds	120	16 600 / 19 200

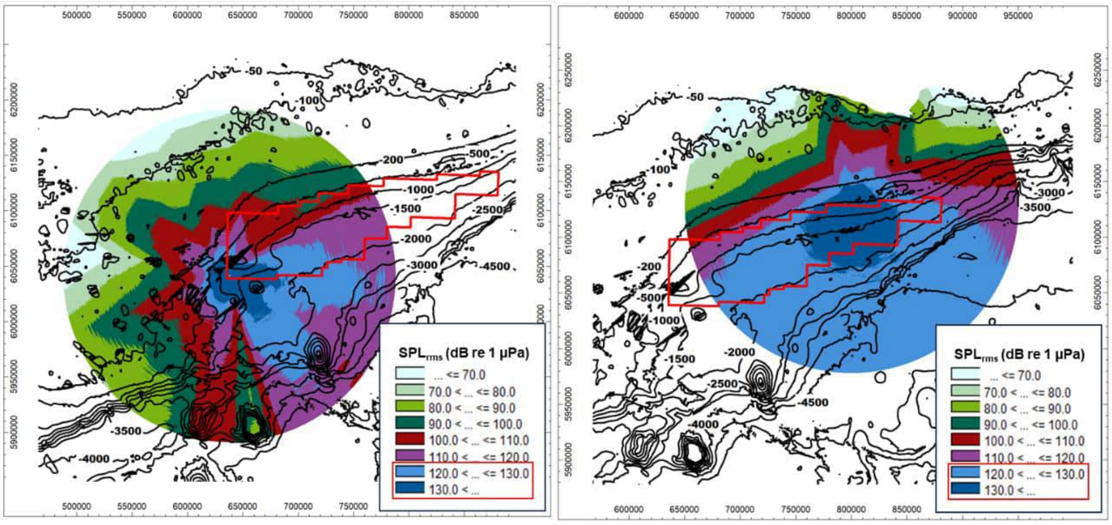


Figure 5-7. Maximum predicted noise level contours across the water column for VSP activities at modelling location (left) L1 and (right) L3. Note that TSS and PTS for all groups occur at SEL_{rms} Threshold above 120-175 (see Table 5.8); this is indicated by the blue contours (WSP 2023b).

5.4.3 SONAR SURVEYS

For the purposes of this assessment, it has been assumed that sonar surveys will be carried out using a Kongsberg EM 712 MBES system (or equivalent) within the development area and along the pipeline route with a worst-case sonar operating frequency of 40 kHz (WSP 2023b).

The predicted maximum Permanent Threshold Shift (PTS) for sonar surveys occurred at 60-70 m for very high frequency cetaceans (pygmy sperm whale *Kogia breviceps* and dwarf sperm whale *K. sima*), but <10 m for other marine species (Table 5.9). Modelled cumulative PTS threshold distances for sonar surveys (over 24-hours exposure) were less than 10 m for low frequency cetaceans, Phocid Carnivores (true seals) and other marine carnivores, 10 m for high frequency cetaceans, and 275-300 m for very high frequency cetaceans (Table 5.9).

Maximum Temporary Threshold Shift (TTS) threshold distances occurred at 110-120 m for high frequency cetaceans, 20 m for low frequency cetaceans and <10 m for sea turtles (Table 5.9). Modelled cumulative TTS for sonar surveys (over 24-hours exposure) for low frequency cetaceans was predicted as 20 m, 70-80 m for high frequency cetaceans, and 640-860 m for very high frequency cetaceans (Table 5.9) (WSP 2023b).

Table 5.9. Predicted distances to marine mammal **injury thresholds** for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) for modelled Sonar Surveys. A single distance to threshold number indicates the same predicted result at L1 and L3 (WSP 2023b).

Hearing Group	Peak exposure			
	TTS		PTS	
	SPL_{peak} Threshold (dB re 1 μPa)	Distance to Threshold (m) (L1 / L3)	SPL_{peak} Threshold (dB re 1 μPa)	Distance to Threshold (m) (L1 / L3)
Low Frequency Cetaceans	213	20	219	< 10
High Frequency Cetaceans	224	< 10	230	< 10
Very High-Frequency Cetaceans	196	110 / 120	202	60 / 70
Phocid Carnivores (true seals)	220	< 10	226	< 10
Other Marine Carnivores in Water	212	20	218	< 10
Sea Turtles	226	< 10	232	< 10
	Cumulative exposure (24h exposure)			
Hearing Group	TTS		PTS	
	SEL_{24h} Threshold (dB re 1 μPa²-s)	Distance to Threshold (m) (L1 / L3)	SEL_{24h} Threshold (dB re 1 μPa²-s)	Distance to Threshold (m) (L1 / L3)
Low Frequency Cetaceans	168	20	183	< 10
High Frequency Cetaceans	170	70 / 80	185	10
Very High-Frequency Cetaceans	140	640 / 860	155	270 / 350
Phocid Carnivores (true seals)	170	30	185	< 10
Other Marine Carnivores in Water	188	< 10	203	< 10

The predicted peak exposure thresholds distances for mortality and potential mortal injury or recoverable injury to fish was estimated at 20 and 40 m, respectively, while the predicted cumulative thresholds distances (over 24-hours exposure) were less than 10 m for fish without a swim bladder, fish with a swim bladder that is or is not involved in hearing and for fish eggs and fish larvae (Table 5.10) (WSP 2023b).

Table 5.10. Predicted distances for the modelled Sonar Surveys to the **impairment thresholds** for continuous noise for fish. A single distance to threshold number indicates the same predicted result at L1 and L3 (WSP 2023b).

Type of Fish	Peak exposure			
	Mortality and potential mortal injury		Recoverable Injury	
	SPL_{peak} Threshold (dB re 1 μPa)	Distance to Threshold (m) (L1 / L3)	SPL_{peak} Threshold (dB re 1 μPa)	Distance to Threshold (m) (L1 / L3)
No swim bladder	213	20	213	20
Swim bladder not involved in hearing	207	40	207	40
Swim bladder involved in hearing	207	40	207	40
Fish eggs and fish larvae	207	40	n/a	-

Type of Fish	Cumulative exposure (24h exposure)					
	Mortality and potential mortal injury		Recoverable Injury		TTS	
	SEL_{24h} Threshold (dB re 1 μPa^2-s)	Distance to Threshold (m) (L1 / L3)	SEL_{24h} Threshold (dB re 1 μPa^2-s)	Distance to Threshold (m) (L1 / L3)	SEL_{24h} Threshold (dB re 1 μPa^2-s)	Distance to Threshold (m) (L1 / L3)
No swim bladder	219	< 10	216	< 10	186	10
Swim bladder not involved in hearing	210	< 10	203	< 10	186	10
Swim bladder involved in hearing	207	< 10	203	< 10	186	10
Fish eggs and fish larvae	210	< 10	n/a	-	n/a	-

The maximum predicted behavioural threshold distances for sonar survey activities were 1.8 km for marine mammals, and 2.45 km for penguin/diving birds (Table 5.11) (WSP 2023b). Given that sea turtles have a frequency hearing range of below approximately 2 kHz, there are no expected behavioural impacts of high frequency sonar sources on these species (Finneran *et al.* 2017, WSP 2023b).

Table 5.11. Predicted distances for modelled Sonar Surveys to the **behavioural thresholds** for continuous noise for marine mammals, and penguins and diving birds. A single distance to threshold number indicates the same predicted result at L1 and L3. Calculation of distance to threshold for penguins/diving birds includes a frequency weighting for OCW (WSP 2023b).

Hearing Group	SPL_{rms} Threshold (dB re 1 μPa)	Distance to Threshold (m) (L1 / L3)
Marine Mammals	160	800 / 1 800
Penguins / Diving Birds	120	1 920 / 2 450

5.4.4 ABOVE SURFACE NOISE

In-air noise associated with the project may result from helicopter use for the transportation of personnel to and from the offshore facilities as required, as well as from equipment above the water surface on the drill rig platform and ships (WSP 2023b). Above surface helicopter noise is considered to be transient, with much of the sound reflected by the surface of the ocean i.e., it will have little impact on the underwater noise soundscape (Richardson *et al.* 1995, WSP 2023b).

6 DRILLING DISCHARGES MODELLING RESULTS

6.1 RATIONALE AND APPROACH

The proposal to drill up to six (6) development and appraisal wells in the western Project Development Area and the drilling of up to four (4) additional exploration wells in the eastern Exploratory Priority Area are expected to result in a discharge of drill cuttings and water-based muds. Water-based muds will be used in the initial stages of well drilling (riserless stage) and in the riser stage of drilling. Drilling muds are used to lubricate the drill bit and to maintain well pressure (Dalmazzone *et al.* 2004, Atkinson 2010). Once complete, as much of the drill fluids as possible are recovered, and the reminder, along with the drill cuttings (to which some drill fluid inevitably remains adhered) and chemical additives of various compositions, is disposed of, either onshore in authorised land fill sites or discharged at sea (Dalmazzone *et al.* 2004, Atkinson 2010). The specific composition of the discharge is dependent on the specific stage of drilling and equipment employed. Releases of drilling fluid can occur at the drilling location near the seabed or at the vessel/platform location near the water surface.

Drilling materials of concern include dissolved and deposited metals and chemicals, heavy metals in barite (Barium sulfate $BaSO_4$), a common weighting material used to formulate high-density drilling fluids), particles in mud and cuttings. These drilling materials impact both water and sediment quality through the introduction of toxic compounds, decreased oxygen levels, deposition of particle matter on the sea floor and changes in sediment grain structure (Ditlevsen 2023) (Table 6.1).

Table 6.1. Drilling discharge environmental stressors summary (Ditlevsen 2023).

Water column stressors
Toxicity from **dissolved** compounds or chemicals. Exposure is represented by the dissolved chemical concentration in the water column. This only includes compounds assumed to dissolve in the water column and thus appear in a bioavailable form (i.e., Pow < 1 000).
Particle stress from **suspended** barite, bentonite and other types of particles present in the water column.
Sediment stressors
Toxicity caused by **deposited metals and chemicals** assumed not to dissolve in the water column but to attach to particles and to be transported to the sediment (i.e., Pow ≥ 1 000). The exposure concentration is represented by the average concentration of chemical compounds in the upper 3 cm of the sediment (assuming equilibrium partitioning between pore water and sediment concentrations). DREAM considers organic chemicals (e.g. as part of the mud formulation) as well as heavy metals (e.g. as impurities in barite). Heavy metals may add to toxicity in the sediment but do not contribute to oxygen depletion as they will not biodegrade.
Oxygen depletion in the sediment layer is caused by the consumption of oxygen by biodegradation of deposited chemicals. The oxygen content in the sediment and is computed over the vertical extent of the active bioturbation layer (default is 10 cm). The exposure to reduced oxygen is represented by the % reduction of oxygen in the oxygenated layer.
Deposition of particle matter on the sea floor (primarily cuttings and clay) might result in burial of benthic fauna as the deposited material will cause an extra layer on the seafloor (accumulation). Bioturbation and resuspension might reduce the thickness of that layer. Exposure is represented by the thickness of the deposited layer.

Sediment stressors
A **change in median sediment grain size** caused by deposited particle matter on the sea floor constitutes a change in benthic habitats and might result in a change of benthic communities. Exposure related to grain size change is defined as the change of the median grain size in the sediment, averaged over the upper three cm of the sediment layer (including the added sediment)

SINTEF Ocean (Ditlevsen 2023) and H-Expertise Services S.A.S (HES 2020a, b) used the DREAM (Dose-related Risk and Effects Assessment Model) model to assess deposition, spreading and potential environmental risk (and the associated Environmental Impact Factor (EIF) values) for the water column and the sediment caused by the planned drilling operations in the western Project Development Area and eastern Exploratory Priority Area respectively (Ditlevsen 2023).

The DREAM model has been used by all oil and gas operators on the Norwegian Continental Shelf as a modelling platform for calculating the Environmental Impact Factors for Produced Water Discharges (EIF_{PW}) as an indicator of environmental risk from produced water discharges (Ditlevsen 2023). The DREAM model has been further updated as a basis for calculation of a similar EIF for drilling discharges (EIF_{DD}) (Ditlevsen 2023). DREAM also includes a sediment module which simulates processes in the sediment to account for stressors like sedimentation processes, burial, oxygen demand from biodegradation in addition to toxicity of the sedimented chemicals (Ditlevsen 2023) (Figure 6-1).

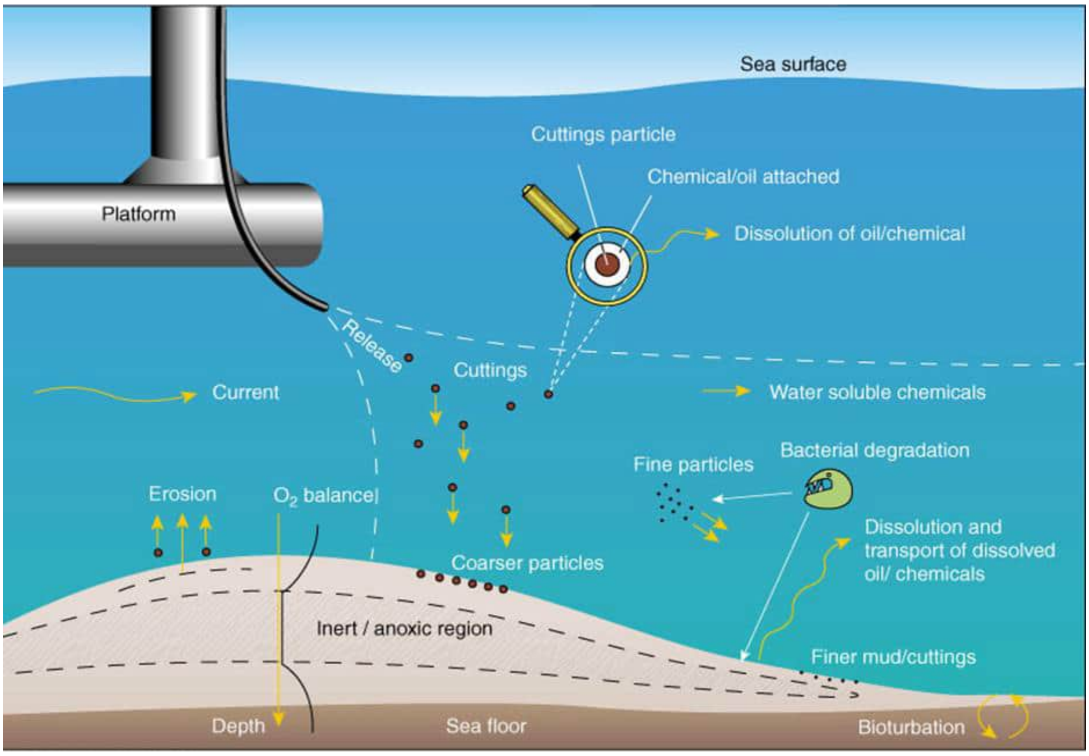


Figure 6-1. Sketch of processes in the DREAM model. In the water column the model accounts for attached chemicals which might dissolve into the water column as well as stress from particles during the simulation period. At the end of the simulation period, the sediment module computes processes in the sediment compartment (HES 2020a, b, Ditlevsen 2023).

Environmental risk in the DREAM system is based on two concepts: the Predicted Environmental Concentration (PEC) and the Predicted No Effect Concentration (PNEC) (from Ditlevsen 2023):

- The **PEC** is the calculated concentration of a chemical in the environment (in this case, the water column) over time and space introduced into the environment via a discharge. DREAM calculates the PEC for dissolved compounds (Pow < 1 000) and for particles that may be present in the discharge, accounting for the influence of ambient currents, vertical and horizontal transport and mixing, evaporation at the sea surface, biodegradation, and adsorption-desorption dynamics, using site specific meteorology and hydrodynamics inputs (the latter is usually imported from outputs generated by 3-dimensional and time-variable hydrodynamic models, or via observed ocean current profiles generated from measurements at a specific location).

  DREAM follows a "particle", or Lagrangian approach. The model generates numerical particles at the discharge point, which are transported with the currents and turbulence in the sea. Different properties, such as the mass of various compounds, densities and sinking velocities, are associated with each particle to represent the characteristics of a discharged compound. Model particles can also represent different states or phases, such as bubbles, droplets, dissolved matter and solid matter. The formulas and calculations for various processes (spreading, fate calculations etc.) are given in Reed & Hetland (2002) and Rye *et al.* (2008) and are mainly based on recommendations from the European Commissions' technical guidance document on environmental risk assessment (EU-TGD) (European Commission 2003).

  In sediments, PEC is represented by the chemical concentration in the porewater, the % oxygen depletion in the oxygenated layer, the layer thickness of the deposited layer and the change in the medium sediment grainsize, respectively. After deposition, the level of exposure to these stresses is calculated by diagenetic equations as described by Rye *et al.* (2006) and Durgut *et al.* (2015). Discharges from a drilling rig to the sea are intermittent, with variable composition and quantity of mud discharged from each drilling section. This causes a corresponding variability in the timing of recipient concentrations as they are discharged.

- The **PNEC** is a measure in toxicity studies that represents the concentration of a chemical compound in either water or sediments below which no adverse effects of exposure in an ecosystem are measured. This PNEC is usually derived from results of laboratory toxicity tests and must be provided for each compound to be considered in the discharge. Guidelines on how the PNEC for water and sediment are derived from laboratory toxicity test results are available from the EU (ECHA 2008). Details on PNECs for added chemicals in the water column and sediments can be found in Johnsen *et al.* (2000) and Altin *et al.* (2015), respectively. There are also non-toxic stressors (i.e., stressors that are due to physical changes in the environment, rather than toxicity effects) with derived species sensitivity distributions from laboratory studies for suspended clays, burial and grainsize change (see Smit *et al.* 2008a).

  Based on this work, the PNEC for burial was set to a deposited layer of 0.65 cm, and the PNEC for the change in oxygen content was set to 20% reduction of oxygen (in terms of mg O_2/m^2 sediment surface) by considering the effect of reduced redox potential on the diversity of the benthic fauna (Ditlevsen 2023). The PNECs for the sediment stressors are included in DREAM's sediment module directly, while PNECs for chemical components follow as input data with these components.

The ratio of PEC / PNEC indicates the likelihood that there will be adverse effects as a result of exposure to a specific chemical. In this way, the DREAM model is a **risk** assessment tool; it determines the risk level (HES 2020a, b). The level of environmental **impacts** on the water column, on the sediments and across the broader marine ecosystem can be compared using a calculated Environmental Impact Factor (EIF) (HES 2020a, b). To calculate an EIF, the exposure concentrations (PEC) are translated to a risk probability. As per Ditlevsen (2023), this risk probability is the "*probability that a randomly selected species in the environment is exposed to concentrations exceeding the No Observed Effect Concentration (NOEC)*" i.e., the highest tested concentration for which there are no statistically significant difference of effect ($p<0.05$) when compared to the control group in long-term ecotoxicity studies. As such, a risk probability of 5% is often used as a cut-off point assuming that risk is unacceptable if more than 5% of the species are exposed above their chronic NOEC (Smit *et al.* 2008). Therefore, it has been suggested that the concentration at which the risk probability is 5% corresponds to the PNEC, implying that when the PEC/PNEC equals 1, the risk probability equals 5% (Karman *et. al*. 1994, HES 2020a, b, Ditlevsen 2023). The larger the PEC/PNEC ratio, the larger the percentage of species that may be potentially impacted (HES 2020a, b). The PNEC is derived from LC_{50} values calculated form toxicity studies (LC_{50}, or Lethal concentration 50, is the amount of a substance required to kill 50% of test animals during a predetermined observation period and are used as a general indicator of a substance's acute toxicity).

The overall risk for the sediment results from all compounds from the drilling discharge that ended up in the sediment and all non-toxic stressors is calculated by the DREAM model in space and time within the model domain. **1 EIF is the unit for the reference water volume or sea floor area where the risk for an effect on the most sensitive species exceeds 5%** (more than 5% of the most sensitive species are at risk). 1 EIF equates to 100x100x10 m^3 in the water column (100 000 m^3), and 1 EIF equates to 100x100 m on the sea floor (10 000 m^2; i.e.,100 EIF = 1 km^2) (Ditlevsen 2023).

The EIF_{DD} for both water and sediment varies over time because wind and current conditions change over time, and because discharges from a drilling rig to the sea are also intermittent and change over time (Ditlevsen 2023). This is accounted for in the DREAM model, and results are presented as the duration of maximum EIF for both water and sediment.

The EIF approach also enables the quantification of the contribution of the various compounds in the discharge (toxicity) and the non-toxic stressors to the overall environmental risk. This enables the identification of the highest risk contributors in the discharge and facilitates the definition and selection of cost-effective risk mitigation measures based on best available technology.

6.2 DISCHARGE CONFIGURATION AND SCENARIOS MODELLED

For the western Project Development Area, two pseudo-well sites (Discharge-4 and Discharge-5, see Figure 6-26.3) were simulated across four seasons, as presented in Table 6.2. The water depth around Discharge-4 is approximately1 200 m, and around 1 800 m for Discharge-5 (Ditlevsen 2023). For more details about the model set up (including discharge volumes and composition), see Ditlevsen (2023).

Table 6.2. Modelled drilling discharge environmental scenarios for the western Project Development Area (Ditlevsen 2023).

Season	Discharge-4	Discharge-5	Simulation duration
	Simulation start times		
SUMMER: Scenario 1 (Dec-Jan-Feb)	2015-12-26 15:00	2015-12-24 03:00	Water = 35 days Sediment = 35 days + 10 years
AUTUMN: Scenario 2 (Mar-Apr-May)	2013-03-12 09:00	2013-03-12 09:00	
WINTER: Scenario 3 (Jun-Jul-Aug)	2016-08-14 09:00	2015-08-12 00:00	
SPRING: Scenario 4 (Sep-Oct-Nov)	2014-10-19 12:00	2015-10-15 03:00	

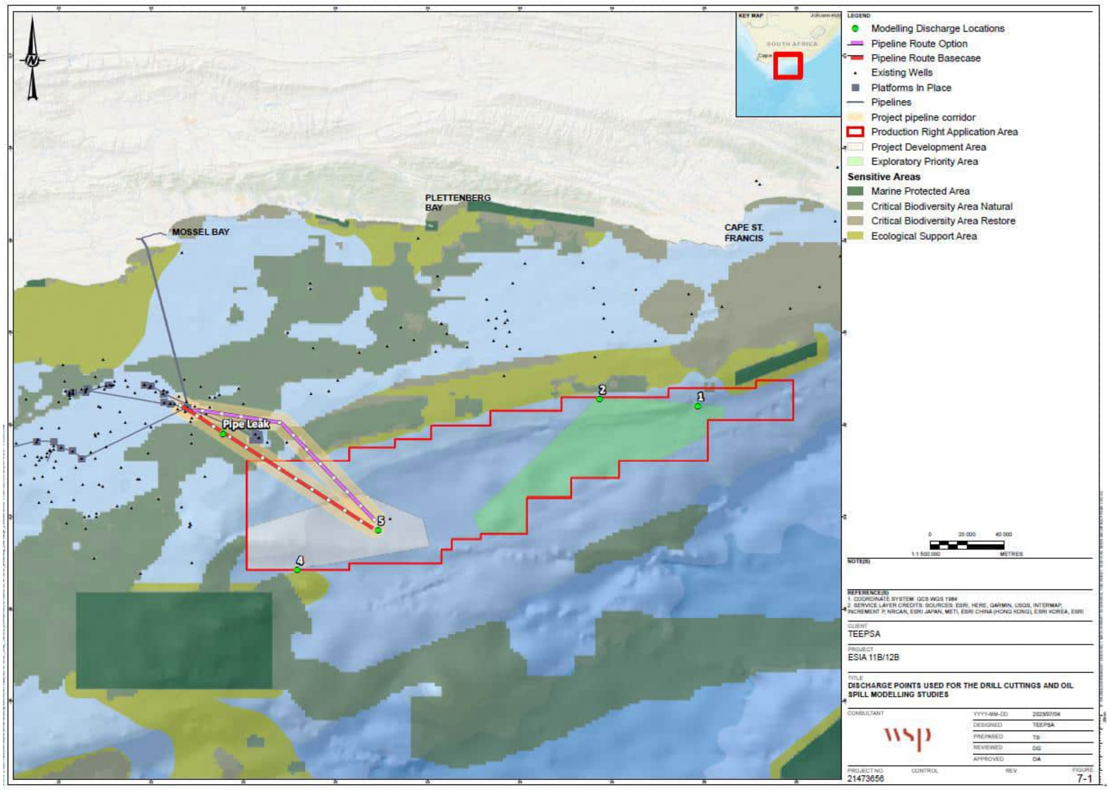


Figure 6-26.3. Location of the drilling Discharge-4 and Discharge-5, within the Block 11B/12B western Project Development Area, and Discharge-1 and Discharge-2 in the eastern Exploratory Priority Area offshore South Africa.

As the exact locations of the wells to be drilled within the area Block 11B/12B eastern Exploratory Priority Area are unknown (and still dependent on exploratory outcomes), drilling modelling studies assessed two pseudo-well sites (Discharge-1 and Discharge-2, see Figure 6-26.3) were simulated across four seasons (four base-case runs, and one optional run), as presented in Table 6.3. Discharge-1 is located at ~1 254 m depth, and Discharge-2 is located at around 690 m (HES 2020a, b). These sites were selected because they were closest to the coast, and close to areas of high sensitivity areas at two different depths.

For more details about the model set up (including discharge volumes and composition), see HES (2023, b) for Discharge-1 and Discharge-2, respectively.

Table 6.3. Modelled drilling discharge environmental scenarios for the eastern Exploratory Priority Area (HES 2020a, b).

Season	Discharge-4	Discharge-5	Simulation duration
	Simulation start times		
SUMMER: Scenario 1 (January 2012)	2012-01-01	2012-01-01	Water = 45 days Sediment = 45 days + 10 years
AUTUMN: Scenario 2 (March 2012)	2012-03-01	2012-03-01	
WINTER: Scenario 3 (June 2012)	2012-06-01	2012-06-01	
SPRING: Scenario 4 (September 2012)	2012-09-01	2012-09-01	
SUMMER: Scenario 5 (January 2012)	2012-01-01	2012-01-01	Water = 62 days Sediment =62 days + 10 years

The drill cuttings DREAM model specifies two types of discharges, dependent on depth and operational requirements:

1. The cuttings of the drilled top-hole sections (i.e., riserless drilled sections at the start of the drilling process, see Figure 6-4) will be discharged directly at the sea floor. The coarser part of the particle content in the discharges will deposit on the sea floor almost immediately, while the finer particles and dissolved chemicals will be transported along the sea floor in the direction of the ambient currents.

2. The discharges from the deeper drilling sections (in the deeper portion of the well, see Figure 6-4) will be made from the drilling rig 10 m below sea surface.

In the model, the discharge is represented by numerical particles, where each numerical particle carries the respective amount of chemicals and particulate material. The numerical particles are transported with the currents and sink due to their density. There are different numerical particle classes for dissolved (chemicals) and particulate matter (undissolved chemicals, mud and cuttings) (Ditlevsen 2023).

The simulation itself is performed with two different modules in DREAM, the first being the transport and fate module, that computes dissolution and degradation in the water column and settling on the sea floor for a period of 35 days. The second module, the sediment module, computes long-term processes on the sea floor and is run for 10 years to assess toxicity, oxygen change, grain size change and burial (notice that the sediment module is run independently of environmental data i.e., it does not simulate the re-suspension and re-distribution of bottom sediments, resulting in very conservative results).

The results from the simulated drilling operations together with their computed Environmental Impact Factor (EIF) are presented below for both the western Project Development Area sites (modelled by Ditlevsen 2023) and the eastern Exploratory Priority Area sites (modelled by HES 2020a, b). Note that EIF = 1 is the area of 100x100 m where the risk for environmental effects exceeds 5%. It is assumed that the concentration at which the risk probability is 5% corresponds to the PNEC, and when PEC/PNEC = 1, the risk probability equals 5%.

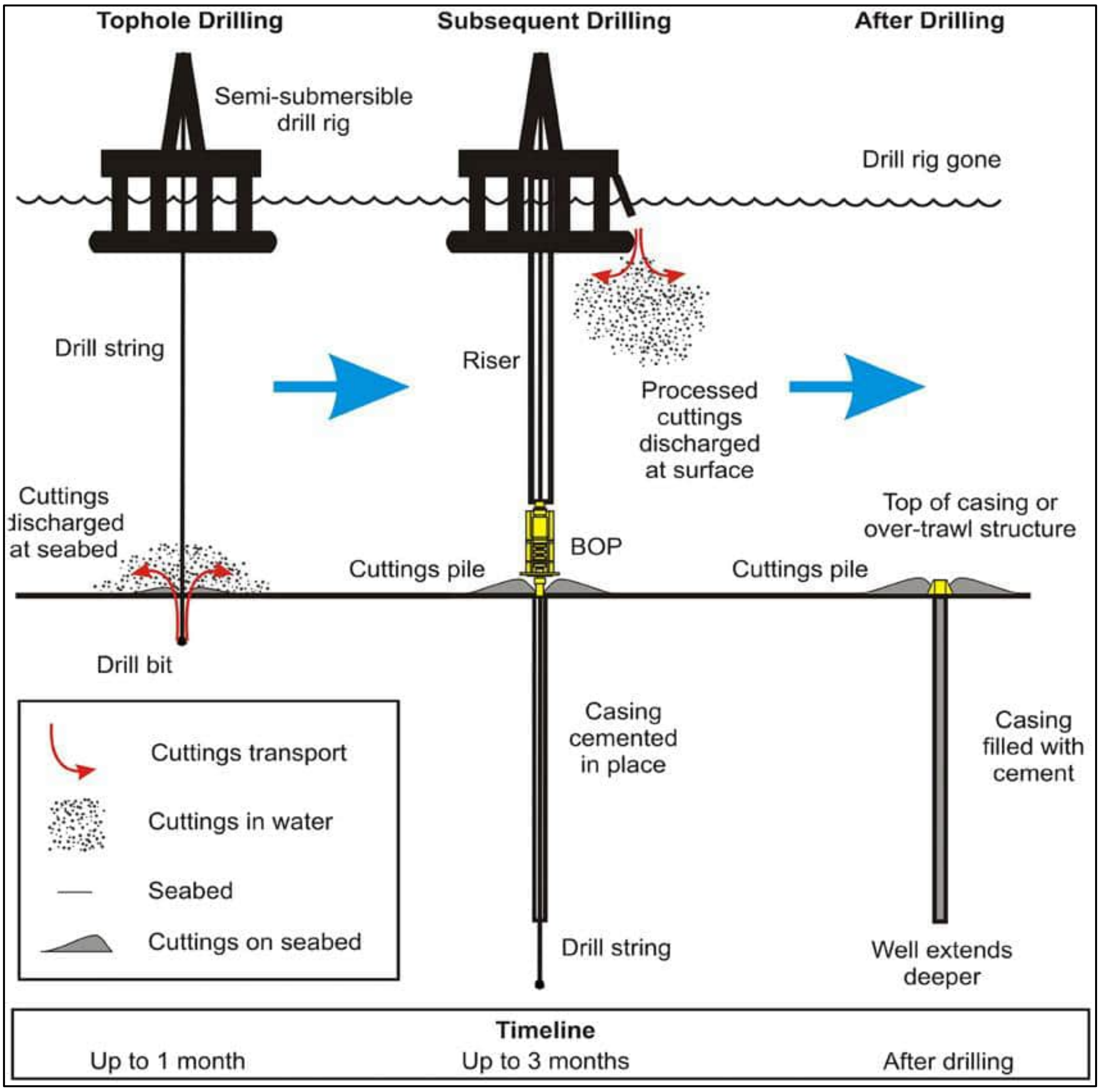


Figure 6-4. Primary sediment discharges resulting from deep-water drilling activities. These effects are nearly identical whether a semi-submersible rig (as shown) or a drillship is used for drilling and are similar for both exploratory and production drilling (Cordes *et al.* 2016).

6.3 Western well modelling results

6.3.1 Modelled effects on the water column

The model results indicate that, for the upper water column (0-100 m depth), the discharge from the rig 10 meters below sea-surface sinks down to about 40 meters depth, with the spatial distribution mostly driven by the predominant S/SW currents (Figure 6-5) (Ditlevsen 2023). In the lower water column (1 100-1 300 m depth for Discharge-4), the finer particle discharge from the drilled top-hole sections remains in suspension and is transported along the seabed in the direction of ambient currents for Discharge-4 (Figure 6-6). For Discharge-5 however, the plume becomes "attached' to the benthos immediately after discharge, and the total extent of the plume is smaller than that of Discharge-4 (Figure 6-6). Note that as the lower water column is also subject to lower ambient current speeds, elevated concentrations persist for longer periods than in the surface waters (Ditlevsen 2023).

Across the modelled seasons, the area of impact (the EIF) for lower water column discharge is greater than that of the upper water column for Discharge-4 (mean EIF = 11 802 and 10 724 respectively), while for Discharge-5, the EIF for the upper water column is greater than that of the lower (mean EIF = 11 802 and 8 681 respectively). This is likely because of the plume attachment to the bottom for the Discharge-5 drilling discharge (as shown in Figure 6-6), which results in a smaller overall area of impact. The greatest extent of environmental impact (i.e., highest EIF) on the upper water column is expected to occur under modelled summer conditions (December to February) for Discharge-4 (max EIF = 12 616) and under modelled spring conditions (September to November) for Discharge-5 (max EIF = 14 536) (Figure 6-5 and Table 6.4). For the lower water column, the greatest impacts are expected to occur in autumn (March to May) for Discharge-4 (max EIF = 12 332), and in winter (June to August) for Discharge-5 (max EIF = 8 773) (Figure 6-6 and Table 6.4). These results indicate that there appears to be no single modelled 'worst-case' season, and that impacts are predominately determined by well location.

Concentrations in the water-column are shown to spread rapidly and dilute with the currents (Ditlevsen 2023). In the upper water column, the maximum EIF of 14 536 occurred at Discharge-5 during spring (conservative estimated area of impact = 126 km^2) and lasted for two days (Table 6.4). This 'peak' impact is associated with the mud discharge at the end of the drilling period (Ditlevsen 2023). Prior to this mud discharge, the EIF values over the stimulated discharge period did not exceed 4 000, lasting around 5 days maximum (Figure 6-7).

In the lower water column, the maximum EIF of 12 332 occurred at Discharge-4 during autumn (conservative estimated area of impact = 64 km^2) and lasted for 2.5 days (Table 6.4). While Discharge-5 has a lower maximum EIF, with an estimated area of impact of 44 km^2, the duration of the impact is longer, with maximum EIF conditions persisting for approximately five days across all seasons (Figure 6-6).

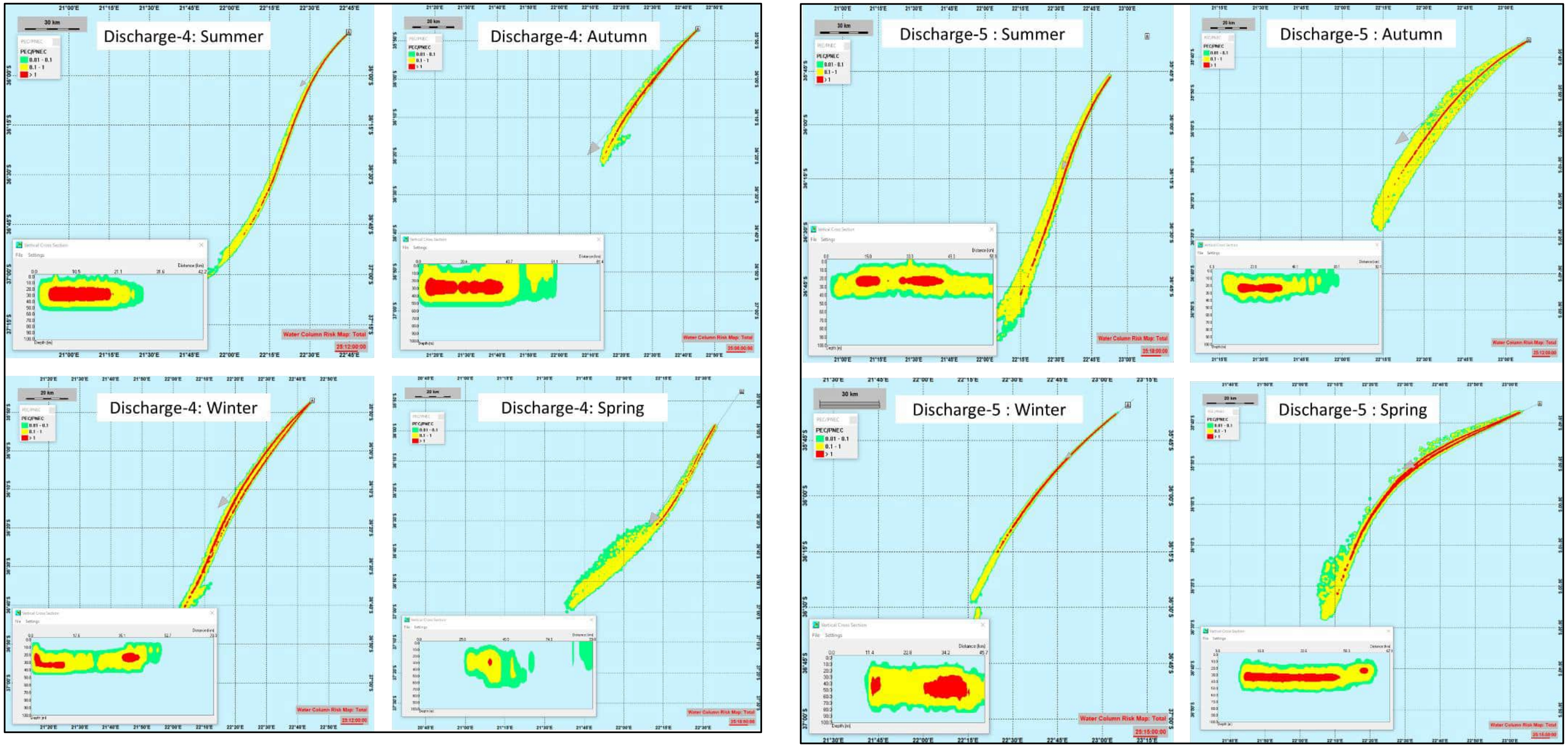


Figure 6-5. Maximum instantaneous (i.e., time instance snapshot) EIF for the upper water column between 0-100 m for all modelled seasons. The snapshot occurs ~25 days after start, when the discharge is released from the rig. The vertical cross section shows the PEC/PNEC ratio in the water column along the grey arrow (Ditlevsen 2023).

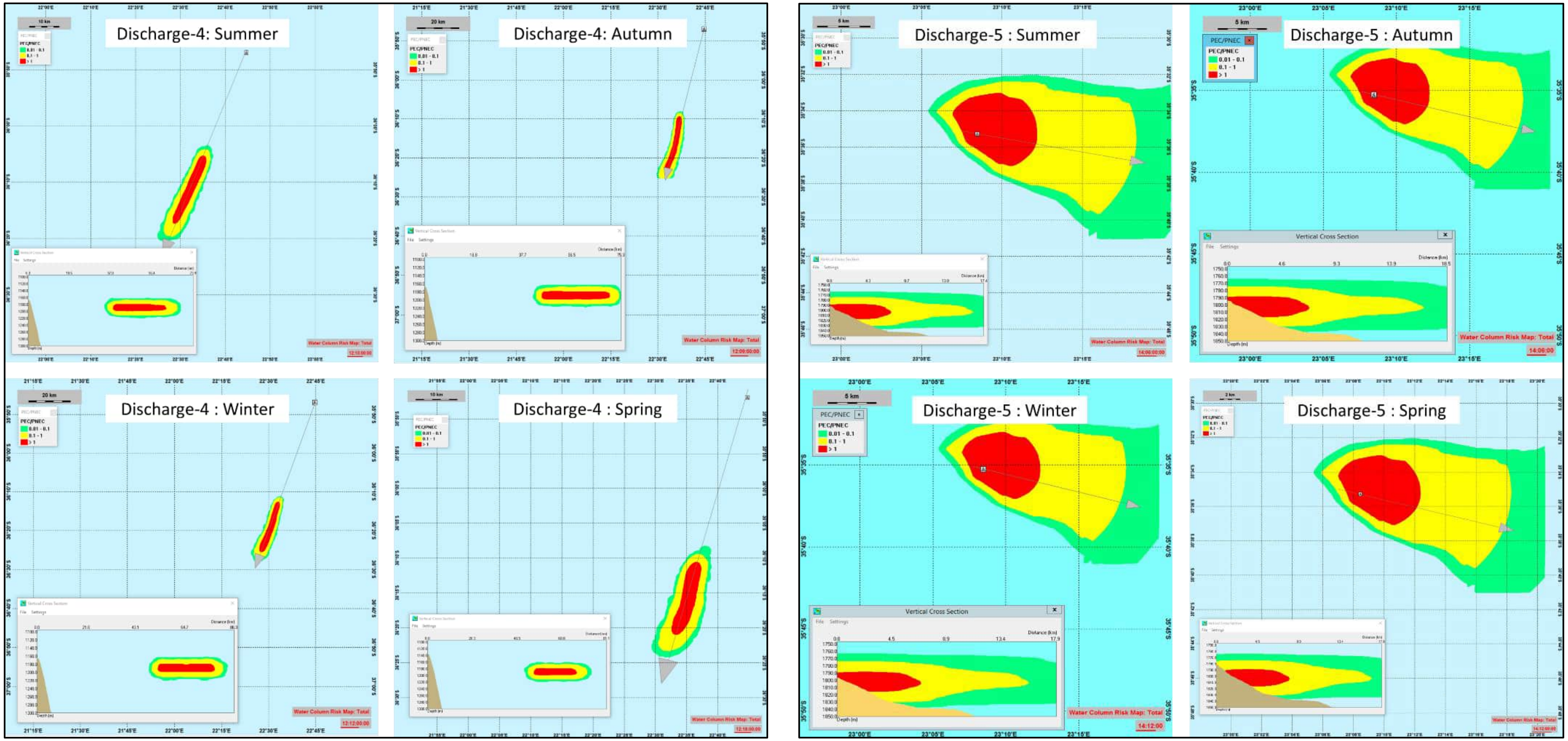


Figure 6-6. Maximum instantaneous (i.e., time instance snapshot) EIF for the <u>lower water column</u> between 1100-1300 m for Discharge-4, and 1750-1850 m for Discharge-5 for all modelled seasons. The snapshot occurs ~12-14, when the discharge is from the top-hole sections on the sea floor. The vertical cross section shows the PEC/PNEC ratio in the water column along the grey arrow (Ditlevsen 2023).

Table 6.4. Summary of upper and lower water column EIF results for Discharge-4 and Discharge-5 (Ditlevsen 2023). The Estimated Area of Impact (km^2) calculates the EIF area of impact using GIS plume analysis.

Season		Maximum instantaneous EIF	Seawater volume of impact (km^3) assuming 1 EIF = 100x100x 10m	Estimated area of impact (km^2)	Duration of max. EIF (for EIF>1)	Dominant risk contributor
Upper water column						
Discharge-4	Summer	12 616	1.2616	63	~ 1.25 days	Barium-sulfate 84%
	Autumn	9 232	0.9232	46	~ 1.25 days	Barium-sulfate 86%
	Winter	12 016	1.2016	116	~ 1.25 days	Barium-sulfate 83%
	Spring	9 032	0.9032	45	~ 1.25 days	Barium-sulfate 85%
Discharge-5	Summer	10 148	1.0148	77	~ 2 days	Barium-sulfate 82%
	Autumn	8 156	0.8156	77	~ 1.25 days	Barium-sulfate 84%
	Winter	14 220	1.422	58	~ 1.5 days	Barium-sulfate 85%
	Spring	14 536	1.4536	126	~ 2 days	Barium-sulfate 83%
Lower water column						
Discharge-4	Summer	11 639	1.1639	65	~ 2.5 days	Barium-sulfate 63% Bentonite 20%
	Autumn	12 332	1.2332	64	~2.5 days	Barium-sulfate 59% Bentonite 23%
	Winter	11 972	1.1972	67	~2.5 days	Barium-sulfate 59% Bentonite 22%
	Spring	11 265	1.1265	64	~2.5 days	Barium-sulfate 66% Bentonite 16%
Discharge-5	Summer	8 605	0.8605	43	~ 5 days	Barium-sulfate 70% Bentonite 14%
	Autumn	8 623	0.8623	44	~5 days	Barium-sulfate 70% Bentonite 14%
	Winter	8 773	0.8773	43	~5 days	Barium-sulfate 71% Bentonite 14%

Season	Maximum instantaneous EIF	Seawater volume of impact (km³) assuming 1 EIF = 100x100x 10m	Estimated area of impact (km²)	Duration of max. EIF (for EIF>1)	Dominant risk contributor
Spring	8 722	0.8722	44	~5 days	Barium-sulfate 68% Bentonite 15%

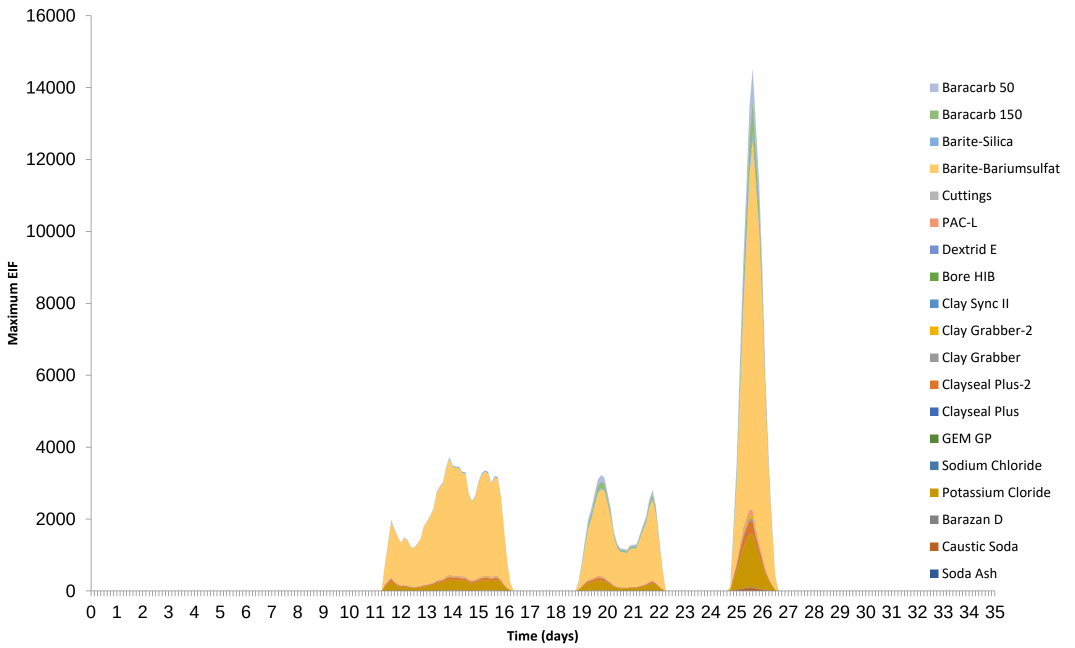


Figure 6-7. Time series development of the EIF for the upper water column, for Discharge-5 season 4 (Spring) (Ditlevsen 2023).

The model results indicate that the primary environmental impacts of drill discharge and cuttings release in the upper water column are linked to the discharge of particulate matter, and in particular, the release of barium sulfate (i.e., barite) (PNEC of 0.115 mg/L), and to both barite and bentonite (PNEC of 0.170 mg/L) in the lower water column (Table 6.4) (Ditlevsen 2023). Barite makes up 70-80% of the WBMs used for drilling during the riserless stage (Neff 2005).

The primary environmental risk from the discharge of drill cuttings is to the benthic environment because of biochemical effects from drilling fluids, smothering, reduced oxygen levels in the sediment and changes in sediment composition. Therefore, bottom water environmental risks of the proposed drilling activities are of particular importance in the assessment of impacts (see Section 8.2.2 and Section 8.2.3 for construction phase drilling). Assuming one well is drilled at a time, no more than ~126 km² of water in the upper water column, and no more than 44 km² of bottom water column will experience elevated concentrations of barite and bentonite for more than 5 days at a time (Table 6.4). Cumulatively, should all six production wells be drilled, the impact will last for a total of 30 days.

Drill discharge modelling results do show that, depending on the well location, potential impacts can extend beyond the confines of the Application Area. Indeed, the modelled maximum cumulative risk throughout the water column at any time for both Discharge-4 and Discharge-5 (for the discharge from the rig at 10 m below sea surface) intersects with the Southwest Indian Seamounts Marine Protected Area to the southwest of Block 11B/12B (Figure 6-8.). The modelled cumulative plume discharge for Discharge-4 overlaps substantially with the MPA in all seasons in both the upper and lower water columns, while for Discharge-5, there is no overlap in the lower water column with the MPA at all (Figure 6-8.).

For Discharge-4, the maximum extent of modelled cumulative overlap with the MPA in the surface waters (for values both above and below the PNEC) is 4 117 km^2, representing an area covering ~92% of the surface waters of the MPA (Table 6.5). For the bottom waters, the maximum extent of modelled EIF overlap with the MPA is 895 km^2 (~20% pf the MPA) (Table 6.5). However, for Discharge-4, the greatest extent of overlap with the MPA where the PNEC > 5 occurs during winter and covers just under 10% of the area of the MPA surface waters (Table 6.5, Figure 6-8.). For the bottom waters, the greatest extent of overlap with the MPA resulting from drilling at Discharge-4 (where the PNEC > 5) occurs during summer and covers ~4.5% of the bottom water area of the MPA (Table 6.5).

Table 6.5. Upper and lower water column maximum cumulative extent of impact and overlap with the Southwest Indian Seamounts MPA for Discharge-4 and Discharge-5 across all seasons (Ditlevsen 2023).

Season		Area (km^2)				**Proportion of overlap area of plume > PNEC with MPA**
		Total area of plume	Total area of plume in MPA	Total area of plume > PNEC	Total area of plume > PNEC in MPA	
Upper water column						
Discharge-4	Summer	6966	953	487	228	5.06
	Autumn	26192	4117	414	313	6.95
	Winter	10727	1212	619	448	9.96
	Spring	15330	1981	393	320	7.10
Discharge-5	Summer	7963	1446	854	167	3.7
	Autumn	13392	2728	722	196	4.4
	Winter	12110	3603	412	67	1.5
	Spring	12797	2324	1337	451	10.0
Lower water column						
Discharge-4	Summer	1707	873	308	204	4.53
	Autumn	2117	895	198	100	2.23
	Winter	1517	270	737	152	3.37
	Spring	2343	585	411	137	3.05

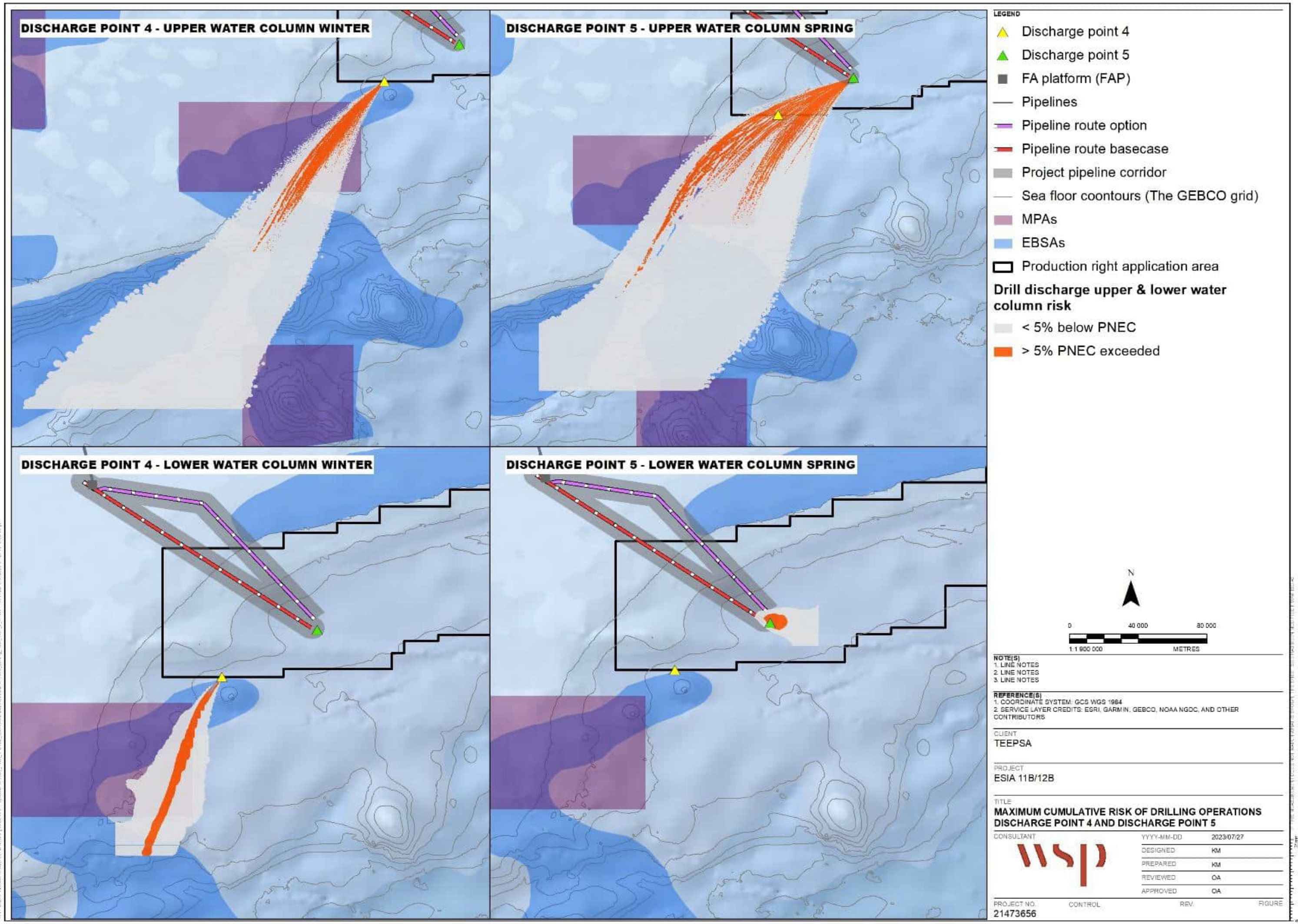


Figure 6-8. Maximum cumulative risk of drilling operations throughout the water column during winter for Discharge-4 and spring for Discharge-5. The maximum potential overlap with the Southwest Indian Seamounts MPA (dark blue) in the surface and bottom waters (Ditlevsen 2023).

For Discharge-5, the maximum extent of modelled cumulative EIF overlap in the upper water column (for values both above and below the PNEC) is 3 603 km², representing an area covering 80% of the MPA (Table 6.5). However, the area of modelled EIF within the MPA that exceeds the 5% threshold (i.e., falls above the PNEC) is 67 km², representing some ~ 1.5% of the area of the MPA (Table 6.5). Model results show that for Discharge-5, the greatest extent of modelled cumulative overlap with the MPA where the PNEC > 5 occurs during spring and covers some 10% of the area of the MPA surface waters (Table 6.5).

6.3.2 MODELLED EFFECTS ON THE SEDIMENT

The model results indicate that deposited material in the sediment will occur within a radius of 250-300 meters from the discharge point, with the thickest areas of deposition areas closest to the well comprising cuttings discharged from the top-hole sections, which, as the cuttings discharges are located on the sea floor, will deposit immediately after discharge (Ditlevsen 2023). The model results indicate that the primary environmental impacts of drill discharge and cuttings release on sediments is burial and grain size change (Table 6.6) (Ditlevsen 2023).

Simulations shows that impact on the sediment caused by discharge from the rig are negligible for all seasons, with EIF < 1 (Ditlevsen 2023). Impacts from top-hole discharge are also low, with low EIF values of between 0.75-1.5 for Discharge-4, and 0.5-0.75 for Discharge-5 —the impacts on the sediment for proposed drilling activities at Discharge-5 are lower than those for Discharge-4 (Table 6.6). The highest EIF occurred in winter for Discharge-4 (EIF = 1.5, for a converted area of impact of 150 m²) (Ditlevsen 2023) (Table 6.6).

Table 6.6. Summary of sediment EIF results for Discharge-4 and Discharge-5 across the four modelled seasons (Ditlevsen 2023).

	Season	Maximum EIF (sea floor area 50x50 m)	Area of impact (m²)	Duration of max. EIF (for EIF>1)	Dominant risk contributor
Sediment (0-100 m depth)					
Discharge-4	Summer	1.5	150	~ 4.3 years	Burial 74%, Grain size change 26%,
	Autumn	0.75	75	~ 4.3 years	Burial 73%, Grain size change 27%
	Winter	1.5	150	~ 4.3 years	Burial 73%, Grain size change 27%
	Spring	1	100	~ 4.3 years	Burial 73%, Grain size change 27%
Discharge-5	Summer	0.75	75	~ 4.5 years	Burial 65%, Grain size change 35%,
	Autumn	0.75	75	~ 4.5 years	Burial 64%, Grain size change 36%
	Winter	0.5	50	~ 4.5 years	Burial 65%, Grain size change 35%
	Spring	0.75	75	~ 4.5 years	Burial 64%, Grain size change 36%

Modelled drilling at Discharge-4, at the end of 10 years (assuming no simulation of sediment redistribution) shows that sediment deposition will occur predominately in a south west pattern, with a worst-case deposition of 30 mm thick in an area of ~5 000 m^2 around the drilling site, and a sediment deposition of 10-30 mm thick covering an area of ~2 500 m^2 (Figure 6-9). The PNEC for burial (6.5 mm) is predicted to cover an area of ~25 000 m^2 (~0.025 km^2) (Figure 6-9).

For Discharge-5, sediment deposition will occur in a more uniform pattern closer to the drill site, resulting in a deposition of 30 mm thick in an area of ~5 000 m^2 around the drilling site at the end of 10 years (Figure 6-9). A sediment deposition of 10-30 mm thick is predicted to cover an area of ~2 500 m^2 (Figure 6-9). PNEC for burial (6.5 mm) is predicted to cover an area of ~175 000 m^2 (~0.175 km^2) (Figure 6-9).

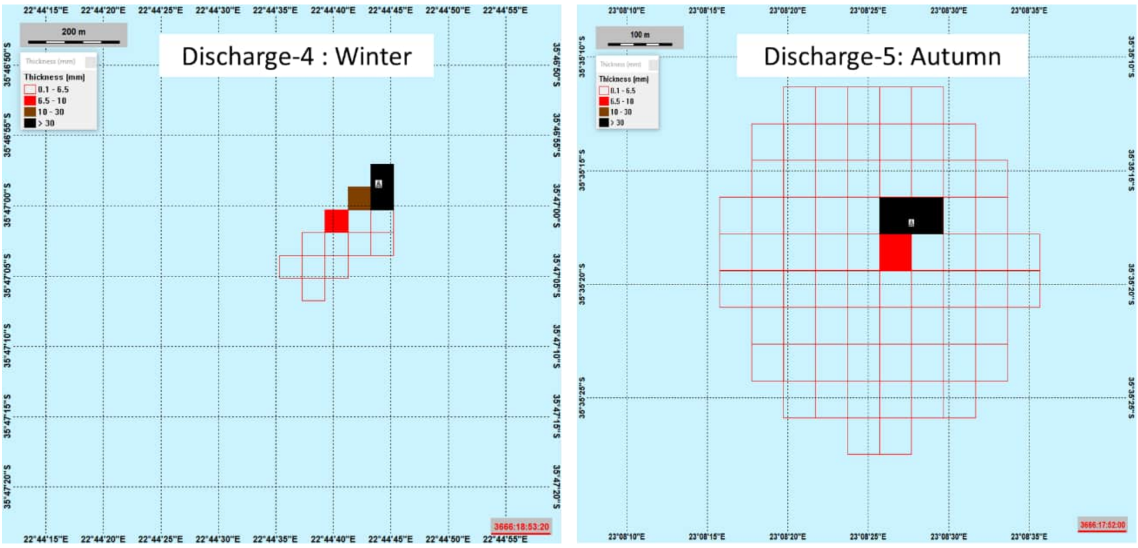


Figure 6-9. Worst-case (largest area of impact) thickness of deposited cuttings for Discharge-4 (in summer) and for Discharge-5 (in autumn) at the end of the simulation period of 10 years. PNEC level for burial = 6.5 mm (Ditlevsen 2023).

The environmental risk on the sea floor and in the sediment is presented as spatial distribution on a map and snapshots in time in Figure 6-10. For Discharge-4, the model results show no risk in the sediment after four years, despite the relatively high EIF value (as per Table 6.6) i.e., it is assumed that the duration of impact on sediment lasts up to four years (Ditlevsen 2023). For Discharge-5 however, a risk of 5-10 % remains in the sediment after four years in an area of 2 500 m^2, with an estimated recovery time of ~4.5 years (Table 6.6).

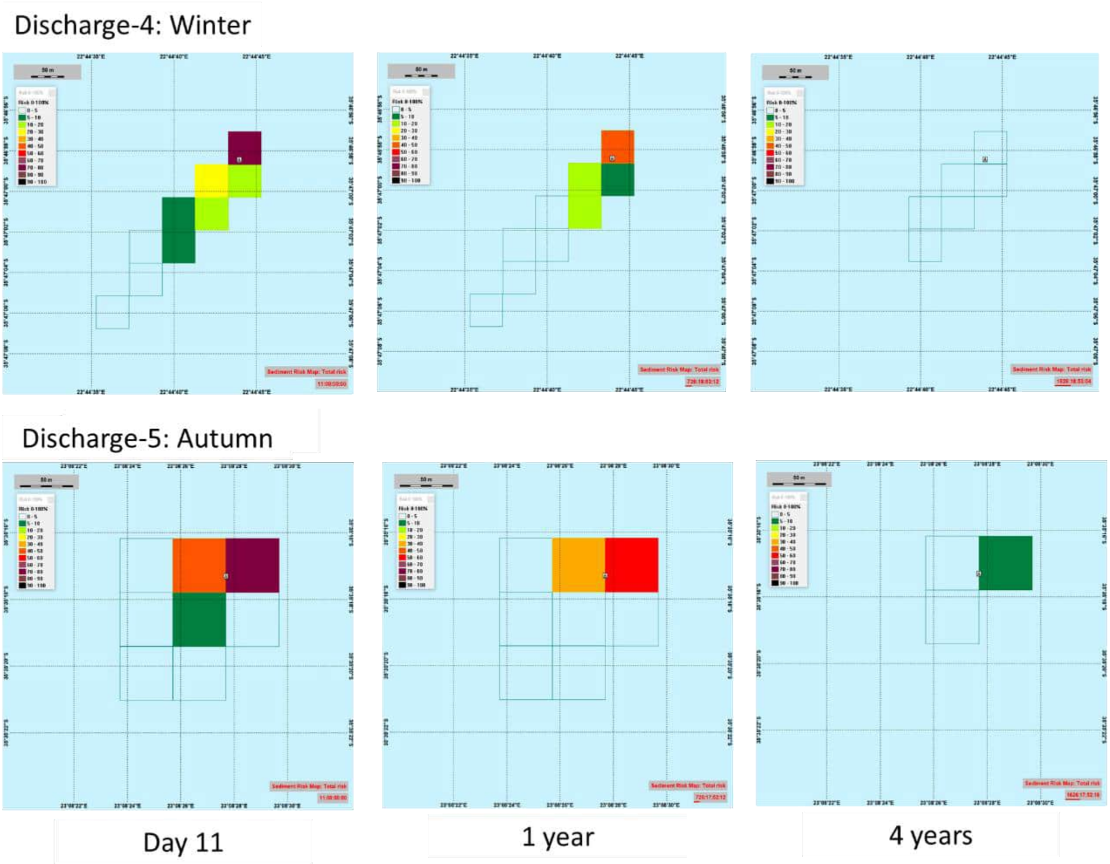


Figure 6-10. Worst-case (largest area of impact) risk % in the sediment for (top) Discharge-4 and (bottom) Discharge-5 after 11 days, one years, and four years. The colour scale is environmental risk in % as the combination of all stressors (toxicity, oxygen depletion, burial, and grain size change). Environmental risk below 5% (not contributing to the EIF) is coloured as outline only. Note that changes to the sediment due to resuspension and transport by currents is not part of the simulation (Ditlevsen 2023).

6.4 Eastern Well Modelling Results

6.4.1 Modelled Effects on the Water Column

The model results indicate that, for Discharge-1, a significant risk in the water column as a result of riserless drilling (the initial stages of the drilling) occurs 8.5-9.5 km away and at depths of 1 200-1 300 m (depending on the season), following the deep-sea current to the west / south-west (Table 6.7, Figure 6-11). The risk is predominantly linked the quantity of Barite to be used in the mud of the riserless sections (HES 2020a). The worst-case EIF occurred in winter (Table 6.7). A significant risk due to the discharge of the sections drilled with a riser (linked to the hydrochloric acid present in the Clayseal Plus to be used in these sections) has also been observed extending 18-34 km away from the discharge point (in winter and autumn, respectively) toward south-west (at 0-100 m depth below sea surface) (Figure 6-11, Table 6.7) (HES 2020a). This risk, while significant, is intermittent, and limited scale (restricted to small patches around the drill site) and duration, persisting for 11.8-13.5 days (when EIF>0) and disappearing completely after operations end (in this case, after 43 days) (Table 6.7) (HES 2020a).

Table 6.7. Summary of water column EIF results for Discharge-1 and Discharge-2 (HES 2020a, b). The Estimated Area of Impact (km^2) could not be calculated, because no GIS data was provided.

Scenario/Season		Maximum instantaneous EIF	Maximum distance at risk around the discharge point (km)	Duration (days) with EIF > 0	Dominant risk contributor
Discharge-1	Scenario 1 (Summer)	11695	8.5 km (lower water column); 25 km (upper water column)	13.5	Barite: 94%
	Scenario 2 (Autumn)	10559	9 km (lower water column); 34 km (upper water column)	12.2	Barite: 95%
	Scenario 3 (Winter)	11350	9.5 km (lower water column); 18 km (upper water column)	11.8	Barite: 94%
	Scenario 4 (Spring)	11119	8.7 km (lower water column); 19 km (upper water column)	12.1	Barite: 94%
	Scenario 5 (Summer, longer duration)	11976	10 km (lower water column); 25 km (upper water column)	25.5	Barite: 92%
Discharge-2	Scenario 1 (Summer)	11016	30 km (lower water column); 24 km (upper water column)	15.9	Barite: 90%
	Scenario 2 (Autumn)	11168	15 km (lower water column); 10 km (upper water column)	4.2	Barite: 93%
	Scenario 3 (Winter)	10136	35 km (lower water column); 21 km (upper water column)	12.2	Barite: 92%
	Scenario 4 (Spring)	12000	12 km west and 5.5 km south-east (lower water column); 11 km (upper water column)	4.7	Barite: 92%
	Scenario 5 (Summer, longer duration)	9504	35 km (lower water column); 12 km (upper water column)	19.2	Barite: 89%

For Discharge-2, significant risk in the water column as a result of riserless drilling (the initial stages of the drilling) occurs up to 35 km away and at depths of 600-700 m (in winter), following the deep-sea current to the west / south-west, while in the spring, this plume extends 12 km west and 5.5 km south-east (Figure 6-12). The risk is predominantly linked the quantity of Barite to be used in the mud of the riserless sections (HES 2020b). The worst-case EIF occurred in spring (Figure 6-12, Table 6.7). A significant risk due to the discharge of the sections drilled with a riser (linked to the hydrochloric acid present in the Clayseal Plus to be used in these sections) has also been observed extending 10-24 km away from the discharge point (in winter and autumn, respectively) toward south-west (at 0-100 m depth below sea surface) (Figure 6-12) (HES 2020b). This risk, while significant, is intermittent, and limited scale (restricted to small patches around the drill site) and duration, persisting (EIF>0) for 4.2-15.9 days and disappearing completely after operations end (after 43 days) (Table 6.7) (HES 2020b).

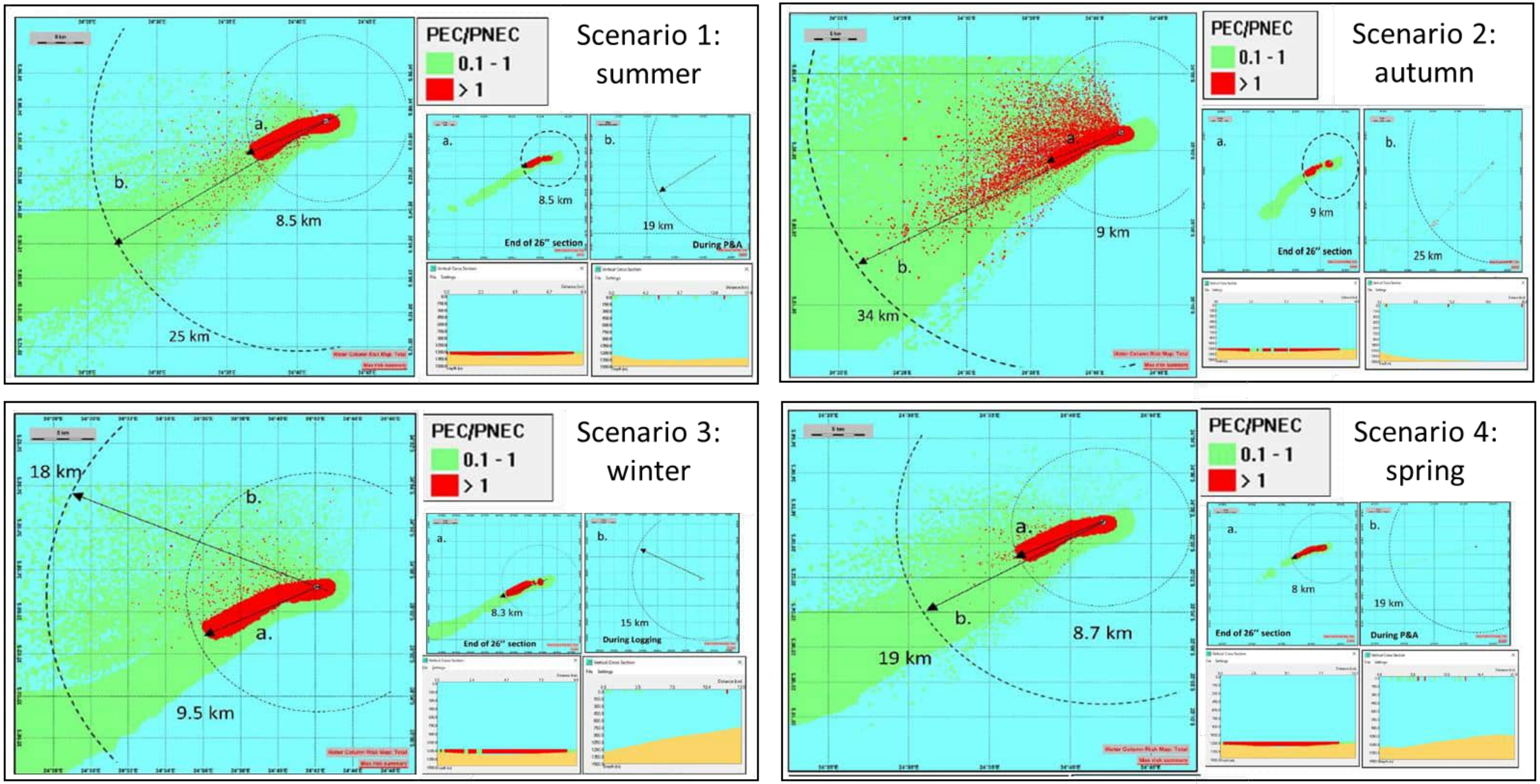


Figure 6-11. Maximum cumulative risk of drilling operations throughout the water column at any time for Discharge-1 across all modelled scenarios/seasons. The vertical cross section shows the PEC/PNEC ratio in the water column along the black arrow in the (a) and (b) inserts, showing instantaneous risk at the end of the bottom (riserless) and surface (riser) discharges (HES 2020a).

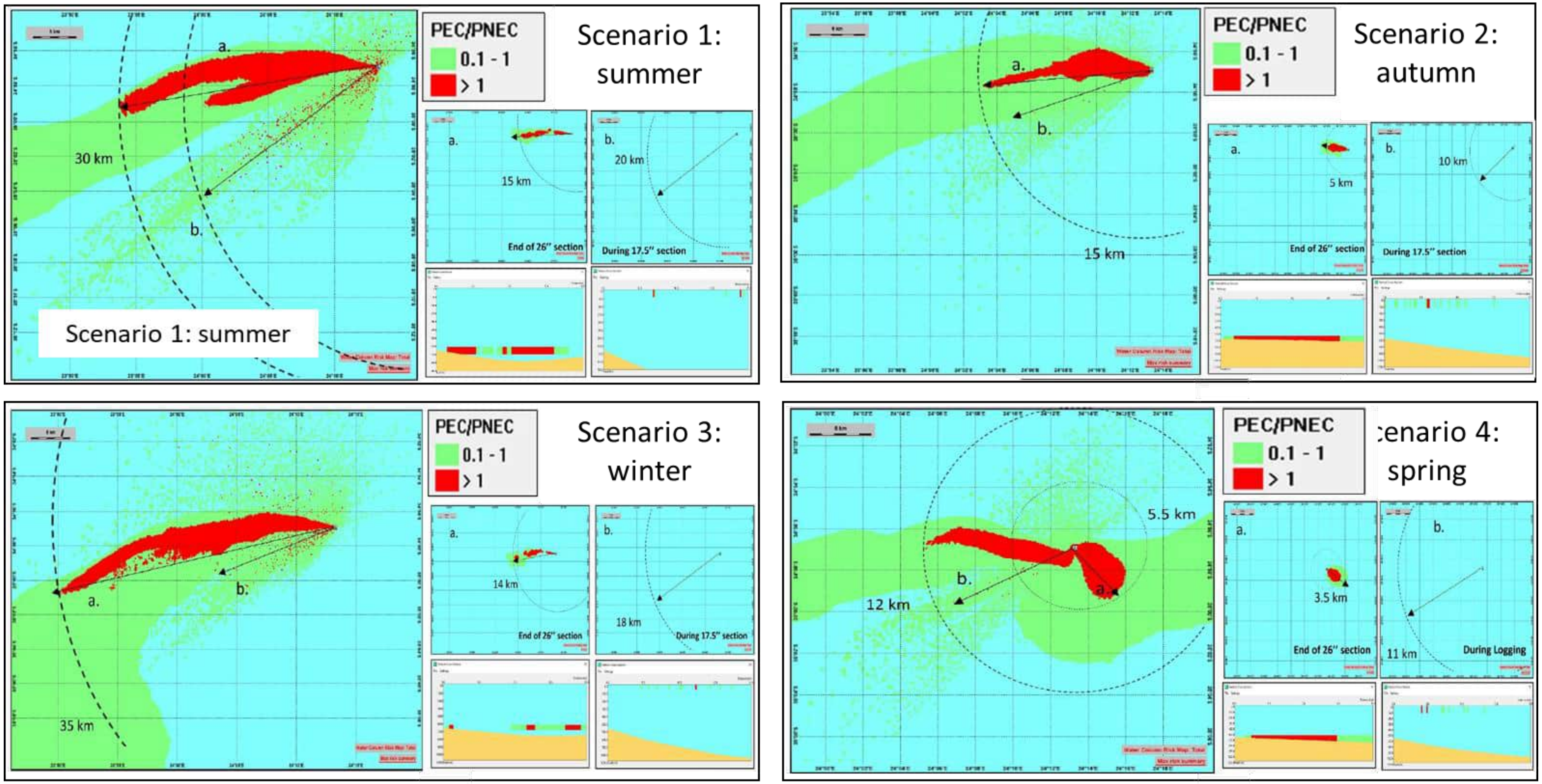


Figure 6-12. Maximum cumulative risk of drilling operations throughout the water column at any time for Discharge-2 across all modelled scenarios/seasons. The vertical cross section shows the PEC/PNEC ratio in the water column along the black arrow in the (a) and (b) inserts, showing instantaneous risk at the end of the bottom (riserless) and surface (riser) discharge (HES 2020b).

Model results show that, under Scenario 5 (longer duration drilling), there are higher EIF values for Discharge-1 (i.e., a larger area of impact) than under the base cases Scenarios (Figure 6-13), and that the duration of the impact is longer (with EIF > 0 for 25.5 days) (Figure 6-13). Again, this risk is predominantly linked the quantity of Barite to be used in the mud of the riserless sections, and with hydrochloric acid present in the Clayseal Plus in the sections drilled with a riser (HES 2020a, b). Model results show that this risk disappears completely after operations end (HES 2020a, b).

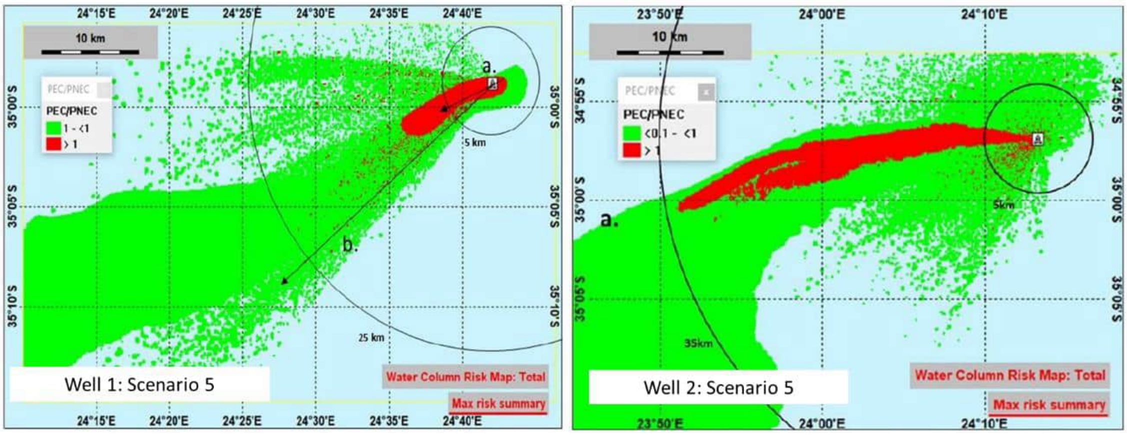


Figure 6-13. Maximum cumulative risk of drilling operations throughout the water column at any time for (left) Discharge-1 and (right) Discharge-2 for Scenario 5. The vertical cross section shows the PEC/PNEC ratio in the water column along the black arrow in the (a) and (b) inserts, showing instantaneous risk at the end of the bottom (riserless) and surface (riser) discharge (HES 2020a, b).

As no GIS-linked outputs were provided, it is difficult to calculate the extent of overlap of these drill discharge modelling results with surrounding areas of sensitivity and significance. Therefore, the report image showing the cumulative effects of risk from drilling operations in summer was georeferenced and overlaid on a base map in GIS (Figure 6-14). For drilling during summer, the maximum area of impact (i.e., PNEC > 5) for drilling at Discharge-1 was estimated as 19.75 km^2, and as 76.64 km^2 for Discharge-2 (Figure 6-14). There is no overlap of the area of modelled impact with the Kingklip Corals EBSA for drilling during summer at either Discharge-1 or Discharge-2 (Figure 6-14).

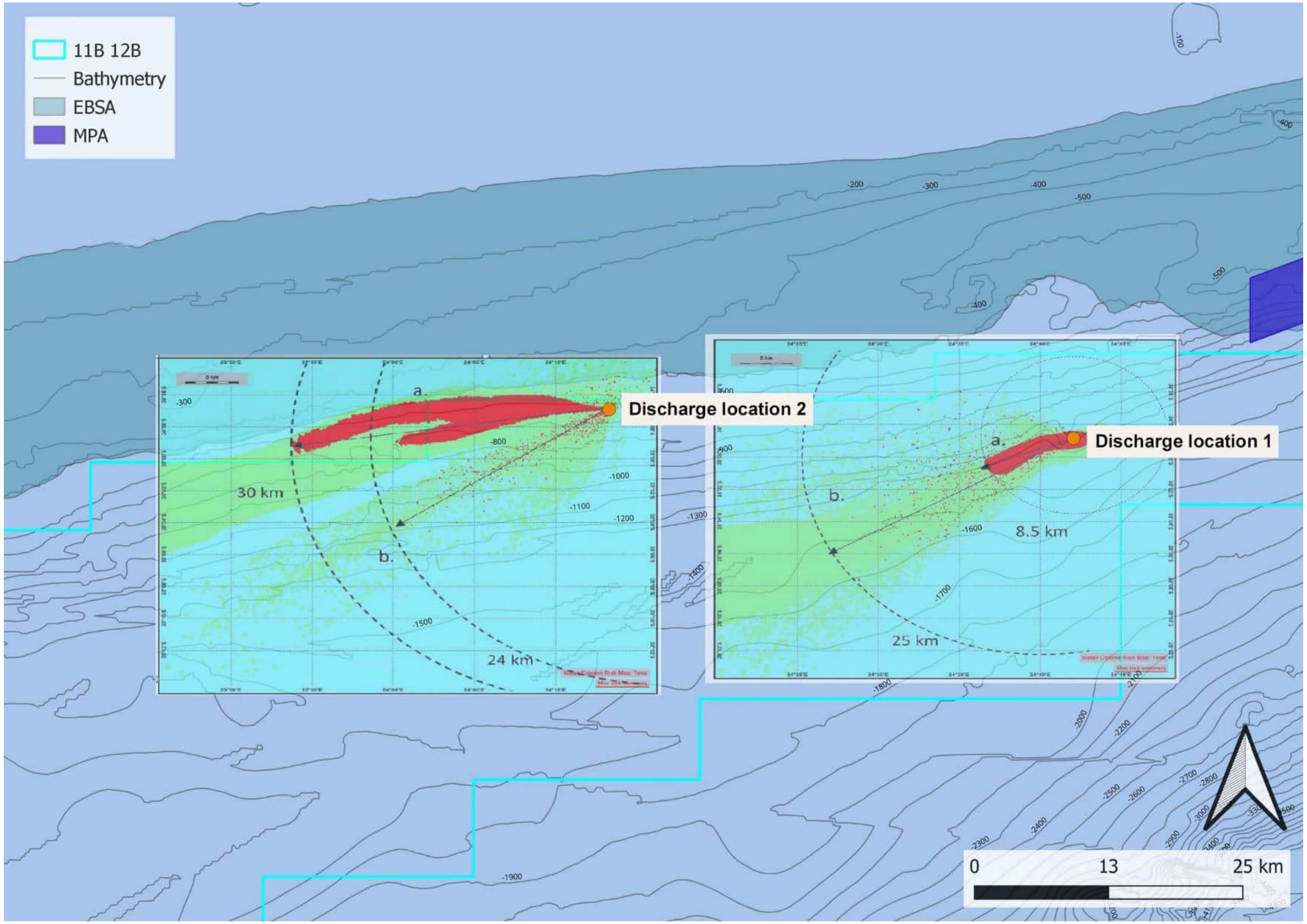


Figure 6-14. Maximum cumulative risk of drilling operations throughout the water column for Discharge-1 and Discharge-2 in summer, indicating potential overlap with the Southwest Port Elizabeth Corals MPA (dark blue) and the Kingklip Corals EBSA (light blue) (HES 2020a, b). Red = > 1 PNEC.

6.4.2 MODELLED EFFECTS ON THE SEDIMENT

Modelled results show that, across all scenarios, oxygen depilation (i.e., anoxia risk) in the sediment is close to zero for both Discharge-1 and 2, because of limited biodegradation of the chemicals in the sediment resulting from the properties of the chemicals used (i.e., no chemicals with log Kow >3 will be discharged) (HES 2020a, b).

The model results again indicate that deposited material in the sediment will occur relatively close the discharge point for Discharge-1 (up to 225 m around the well in the spring) but extend further away for Discharge-2 (400 m to the west/south-west in autumn) (HES 2020a, b). The model results indicate that the primary environmental impacts of drill discharge and cuttings release on sediments is grain size change (Table 6.6) (HES 2020a, b).

Simulations shows that impact on the sediment caused by discharge from rig at the eastern wells are higher than that of the western wells (Discharge-4 and 5) across all seasons, with EIF > 1, and are higher for Discharge-2 (EIF = 2-6 for base case simulations, and 11 for extended drilling) than Discharge-1(EIF = 1-2) (Table 6.6) (HES 2020a, b). The area of risk (where PNEC >5) for sediments is lower for Discharge-1 than Discharge-2, with an area of impact of 2 500-5 000 m^2 for Discharge-1, and 5 000-10 000m2 for Discharge-2 (base case drilling) (Table 6.6). The extended drilling scenario (Scenario 5) results in a much larger area of impact of 27 500 m^2 for Discharge-2 (Table 6.6) (HES 2020a, b).

Table 6.8. Summary of sediment EIF results for Discharge-1 and Discharge-2 across the five modelled scenarios (HES 2020a, b).

Season		Maximum EIF (sea floor area 50x50 m)	Calculated area of impact (m^2)	Distance of significance risk from discharge point (m)		Duration of max. EIF (for EIF>1)	Dominant risk contributor
				Without smoothing	With smoothing		
Discharge-1	Scenario 1 (Summer)	1	2 500	100, to the east	160	~4 years	Grain size change 81% Thickness deposit 19%
	Scenario 2 (Autumn)	1	2 500	125, to the southeast	180	~4 years	Grain size change 82% Thickness deposit 18%
	Scenario 3 (Winter)	2	5 000	200, to the west	165	~4 years	Grain size change 80% Thickness deposit 19%
	Scenario 4 (Spring)	2	5 000	225, around the well	165	~4 years	Grain size change 79% Thickness deposit 21%
	Scenario 5 (Summer, longer duration)	1	2 500	140, around the well	180	~4 years	Grain size change 92% Thickness deposit 8%

Season		Maximum EIF (sea floor area 50x50 m)	Calculated area of impact (m²)	Distance of significance risk from discharge point (m)		Duration of max. EIF (for EIF>1)	Dominant risk contributor
				Without smoothing	With smoothing		
Discharge-2	Scenario 1 (Summer)	2	5000	170 around the well	175	~4 years	Grain size change 76% Thickness deposit 24%
	Scenario 2 (Autumn)	6	15000	400 to the west/south-west	280	~4 years	Grain size change 77% Thickness deposit 23%
	Scenario 3 (Winter)	6	15000	200, around the well	165	~4 years	Grain size change 75% Thickness deposit 25%
	Scenario 4 (Spring)	4	10000	160, around the well	150	~4 years	Grain size change 80% Thickness deposit 20%
	Scenario 5 (Summer, longer duration)	11	27500	720 to the west/south-west	325	~4 years	Grain size change 86% Thickness deposit 14%

For Discharge-1, at the end of four years after the operations (after which there is no more environmental risk in the sediment), model results show that sediment deposition occurs predominately around the drill site, with a worst-case (autumn) deposition within a 150 m radius around the discharge point (without smoothing; 325 m with smoothing, as shown in Figure 6-15) for an area of impact of 0.07 km² (unsmoothed) (HES 2020a). The highest sediment deposit concentrations are localized very close to the discharge point, with most (28 mm) of the accumulation accumulating via the discharge of the top whole sections (42" and 26") drilling (HES 2020a).

For Discharge-2, there are again no more environmental risks predicted in the sediment at the end of four years after the operations, with sediment deposition orientated south-west from discharge point (Figure 6-15). Modelled worst-case deposition also occurred in autumn, within a 105 m radius from the discharge point (without smoothing; 350 m with smoothing, as shown in Figure 6-15) for an area of impact of 0.03 km² (unsmoothed) (HES 2020a). The highest sediment deposit concentrations again were predicted to fall very close to the discharge point and are again accumulated via the discharge of the top-hole sections drilling (HES 2020a).

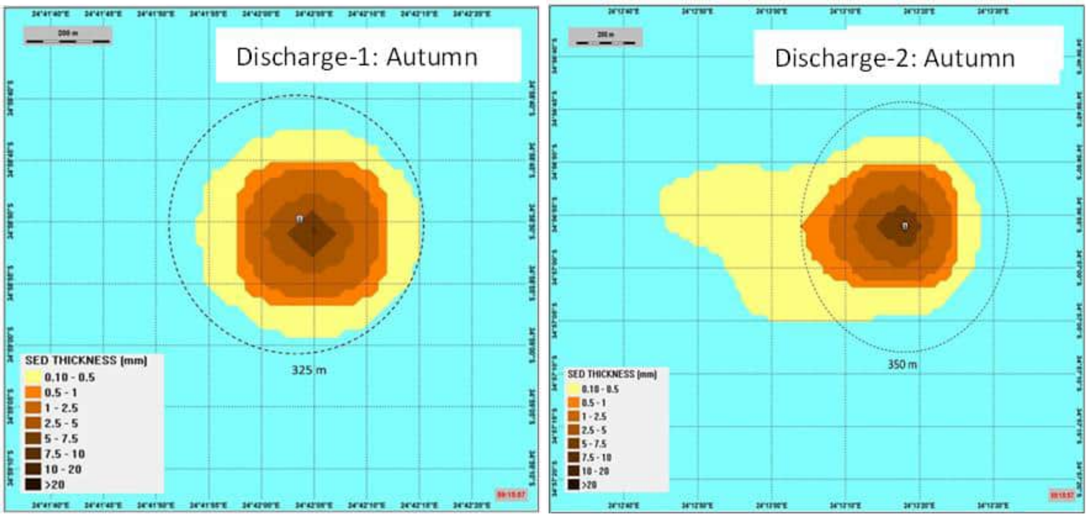


Figure 6-15. Worst-case (largest area of impact) cuttings thickness deposit on sediment at the end of drilling operations for Discharge-1 (in summer) and for Discharge-2 (in autumn) (HES 2020a, b).

7 OFFSHORE SPILL MODELLING RESULTS

7.1 RATIONALE AND APPROACH

Unplanned events or accidents linked to offshore oil and gas production can have potentially significant impacts on the marine environment. The greatest environmental threat from offshore drilling operations is the risk of unplanned hydrocarbon release in the form of a subsea blowout or subsurface pipe rupture (WSP 2023). Although a contingency plan would be prepared and be in place at all times during operations, accidental, or non-routine, discharges of hydrocarbons may also include the accidental loss of fuel during refuelling or from vessel collisions that could occur.

Any release of liquid hydrocarbons has the potential for direct, indirect and cumulative effects on marine fauna (and associated habitats) and the fishing industry in the offshore, nearshore and coastal environment. Spilled hydrocarbons move according to the prevailing weather conditions with the greatest possible impact realised if it makes landfall. Spilled hydrocarbons can have toxic and/or smothering effects on organisms in the path of a spill, with coastlines being particularly vulnerable. These effects include physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton (particularly copepods), pelagic eggs and fish larvae, and habitat loss or contamination (CSIR 1998b, Perry 2005). Spills can also have socio-economic implications if fisheries and coastal tourism (among others) are disrupted.

The quantification of this risk, through an assessment of the extent of potential spill and duration thereof from production activities in the Application Area, is critical to the assessment of impacts on the marine environment. Modelling studies were conducted for wells in both the western Project Development Area and the eastern Exploratory Priority Area:

- For the western Project Development Area, DHI (2023) used SATOCEAN input and the MIKE Oil Spill (OS) module from the MIKE suite to assess predetermined loss of containment (LOC) scenarios associated with gas and condensate well and subsea production system operations. MIKE OS is a particle tracking software that simulates the movements of discrete particles in a fluid flow field. The spilled oil is simulated as a collection of particles, each representing a specified oil mass with associated physical and bio-chemical properties (DHI 2023). The mass and properties of each particle vary as the simulation proceeds to include the effects of weathering. The probability of oil stranding and water re-entry is described as a function of the shoreline characteristics (i.e., rocky, shingle, sandy or muddy beach, seawall or revetment, marshy, etc.). The study assumes that once the oil strands on a coast/beach, it stays on the coast/beach and doesn't return to the sea (DHI 2023).

- For the eastern Exploratory Priority Area, H-Expertise Services S.A.S (HES 2020c, d) used the Oil Spill Contingency and Response (OSCAR) module from MEMW software (v11.0.1) was used to assess the possible fates and trajectories of a crude oil spill (from a subsea blowout discharge). The OSCAR module has capabilities to determine how the slick will drift and how oil components will interact with the marine environment to support decision making. OSCAR computes the fate and weathering of oil, and uses surface spreading, advection, entrainment, emulsification, and volatilization algorithms to determine the transport and fate of the oil on the surface and/or the shoreline (HES 2020c, d). The near-field blowout model applied in OSCAR is Deepblow. The model is based on a Lagrangian model concept, and the oil droplet size distribution is given by a modified Weber number model (HES 2020c, d).

The fate and behaviour of oil spills in the marine environment requires an accurate characterisation of the ambient meteorological and oceanographic (metocean) conditions and environmental data, including wind, waves, currents, salinity, and water temperature (DHI 2023). For the western sites, hydrodynamic conditions were simulated through the combination of surface elevation data from a HYCOM[9] dataset (HYCOM GLBv0.08_expt_56.3 from the Naval Research Laboratory 2014-2021) in combination with the current speed and direction from the SAT-OCEAN dataset[10] (DHI 2023). Wave data was derived from DHI's Global Wave Model[11] and water temperature, and salinity was also sourced from HYCOM (DHI 2023). For the eastern sites, metocean data were purchased from SAT-OCEAN, and covered five years of data (2012-2016) (see more detail in HES 2020c, d).

For the western sites, data on the gas and condensate characteristics (True Boiling Point, density, viscosity at 10, 20 and 40°, content of asphaltenes and wax) were provided by TotalEnergies (DHI 2023). For the eastern sites, modelled oil properties were chosen to simulate oil previously encountered at other sites[12] within Block 11B/12B (HES 2020c, d).

7.2 SCENARIOS MODELLED

For the western Project Development Area wells, two spill scenarios were considered: a deep-sea blowout at a capping stack, and a full rupture of a pipeline in the first year of operation (Table 7.1). To investigate the effect of varying ambient conditions throughout the year and from year to year, several seasonal simulations were conducted for each spill scenario. For each spill scenario, 400 simulations were selected and distributed across the modelling period (2012-2016) and four seasons. The four representative seasons used were: Season 1 (December – February), Season 2 (March – May), Season 3 (June – August) and Season 4 (September – November).

The pipeline rupture will result in 1 610 bbl of condensate being released in the first two hours assumed to be the time required to shut down the well. This will result in a two-hour release of condensate at a rate equivalent to 19 320 bbl/day. It is assumed that the entire volume of 9 755 bbl of condensate remaining in the pipeline then will be released in the 22 hours following the shut-down of the well. This will result in a 22-hour release at a rate equivalent to 10 728 bbl/day.

9 Hybrid Coordinate Ocean Model (HYCOM) is an open-source ocean general circulation modelling system that provides simultaneous analyses of temperature, salinity, geopotential, and vector velocity (DHI 2023).

10 SAT-OCEAN is a source of meteorological and oceanographic (metocean) data for several industries. It provides information on current direction, current speed, wind speed, and wind direction, which are input variables for oil spill modelling. The SAT-OCEAN dataset was provided by TotalEnergies (DHI 2023).

11 DHI Global Wave Model (GWM) serves as an important source of data for many oceanographic and meteorological studies, as it provides valuable information on wave and ice coverage data. This model is validated against both wave and satellite altimetry observations, proving its reliability and effectiveness when applied as boundary conditions for several models around the world (DHI 2023).

12 The closest well which has been drilled and sampled is Brulpadda-1AX. The geological setting and pressure regime of the prospect are expected to be the same as for Brulpadda-1AX, which makes Brulpadda-1AX results good calibration data.

Table 7.1. General characteristics of modelled spill scenarios for the western Project Development Area wells (DHI 2023).

Spill Scenario Characteristics	Scenario 1 Well bow-out	Scenario 2 Pipeline rupture
Event Characteristics	Deepsea blowout at wellhead.	Full rupture of the pipe in first year of production (i.e., highest condensate yield).
	Release assumed to last 20 days until containment is re-established via a capping stack.	Two hours to shut-down the wells (worst-case) i.e., as there is no valve between the Production Manifold in western Project Development Area and FA platform riser in B9.
		Assumption entire volume inside the pipe will be released within one day.
Release Point (WGS84) (Figure 6-26.3)	S 35° 35' 17.3071" E 23° 08' 27.6914"	S 35° 6' 58.41" E 22° 23' 1.66"
Water depth (below MSL)	~1 780 m	~ 146 m
Currents - primary direction (to)	Southwest to West-Southwest	Southwest to West-Southwest
Winds - primary direction (from)	West-Southwest to West-Northwest	West-Southwest to West, East
Duration (days)	20	1
Simulation period (days)	30	30
Discharge rate (bbl/day)	18 350	1-2 hour 19 320 2-24 hour 10 728

For the eastern Exploratory Priority Area, a crude oil spill of 69 000 barrels/day was considered at two sites that represent worst-case scenarios, considering depth (Discharge-1 and 2 are located at 1 254 m and 690 m, respectively), distance from the coast (89 km and 98km from the nearest shore, respectively) and proximity to areas of sensitivity and significance (HES 2020c, d) (Table 7.2). To investigate the effect of varying ambient conditions throughout the year and from year to year, several seasonal simulations were conducted for each spill scenario. For each spill scenario, 90 simulations were selected and distributed across the modelling period (2012-2016) and four seasons. The four representative seasons used were: Season 1 (January – March), Season 2 (April – June), Season 3 (July – September) and Season 4 (October – December).

Table 7.2. General characteristics of modelled spill scenarios for the eastern Exploratory Priority Area wells (HES 2020c, d).

Spill Scenario Characteristics	Discharge-1	Discharge-2
Event Characteristics	Deepsea blowout at wellhead.	Deepsea blowout at wellhead
Release Point (Figure 6-26.3)	S 34° 58' 49,765" E 24° 42' 3,649"	S 34° 56' 56,043" E 24° 13' 18,074"
Water depth (below MSL)	1 254 M	690 M
Currents - main directions	Southeast	Southeast
Winds - main directions	West – East	West – East

Spill Scenario Characteristics	Discharge-1	Discharge-2
Duration (days)	20	20
Simulation period (days)	60	60
Discharge rate (bbl/day)	69 000	69 000

Thresholds used for this study for surface oil thickness, the No Observed Effect Concentration (NOEC) for acute exposure to dispersed oil in the water-column, and shoreline oiling are summarised in Table 7.3.

Table 7.3. Thresholds applied to results of the modelled spill scenarios (adapted from DHI 2023, HES 2020c, d).

Threshold	Threshold value	Rationale
Surface Oil	5 µm	While 10 µm corresponds to the thickness that would impart a lethal dose to an intersecting wildlife individual (French McCay 2009), a more conservative threshold of 5 µm was chosen because it is minimum thickness at which response equipment can skim/remove oil from the surface, surface dispersants are effectively applied, or oil can be boomed/collected. Fresh oil at this thickness corresponds to a slick being a dark brown or metallic sheen (as per the Bonn Agreement Oil Appearance Code).
Water-Column	58 ppb	A NOEC value for acute exposure to dispersed oil of 58 ppb has been proposed, based on the toxicity of chemically dispersed oil to various aquatic species, which showed the 5% effect level is 58 ppb (see details in DHI 2023, HES 2020c, d).
Shoreline Oiling	10 g/m^2	Shoreline oiling was calculated for deterministic scenarios assuming that a certain surface is affected by kilometre of shoreline, depending on the shoreline type. For various shoreline types, a set of maximum oil "holding capacities" is estimated along with a set of removal rates. The holding capacities are intended to reflect both shoreline slope and permeability. The threshold of 10 g/m^2 provides a more conservative screening threshold used for potential ecological effects on shoreline fauna. Assumed as a sublethal effects threshold for birds on the shoreline (see details in DHI 2023, HES 2020c, d).

To obtain a better understanding of worst-case results, several simulations were identified for both western and eastern discharge points, which included the worst case from each season in each spill scenario. The worst case was defined as the simulation that produced the largest impact on the shoreline. The worst-case simulation from stochastic simulations was re-simulated and further analysed to illustrate mass balance as well as evolution of drift. These deterministic simulations provide detailed pictures of the hydrocarbon trajectory during the simulation periods.

7.3 Western Discharge Points Modelling Results

Stochastic and deterministic results are provided for both gas and condensate spill scenarios (well blowout and pipeline rupture). Stochastic simulations are statistical calculations / analyses based on the results from ensemble modelling of the LOC scenario under a wide range of weather and/or seasonal conditions, while deterministic simulations provide detailed pictures of the gas and condensate trajectory during the simulation periods (DHI 2023).

Based on the thresholds presented in Table 7.3, the results of the statistical analysis for the gas and condensate spill scenarios are presented as:

- Surface probability of exposure to a hydrocarbon slick (> 5 µm) [%].
- Probability of shoreline oiling larger than 10 g/m² [%].
- The minimum time (from the start of a spill) to exposure to a hydrocarbon slick [days] 95% percentile.

7.3.1 FATE OF THE SPILLED CONDENSATE

Model results show that, over approximately four months (i.e., one season), evaporation is the most important weathering process for gas and condensate, as evaporation starts immediately after loss of containment (DHI 2023). Indeed, most of the total gas and condensate released evaporates over the modelled time frame while biodegradation, sedimentation and photooxidation contribute less than 10% of the total mass balance of the spill (Figure 7-1) (DHI 2023).

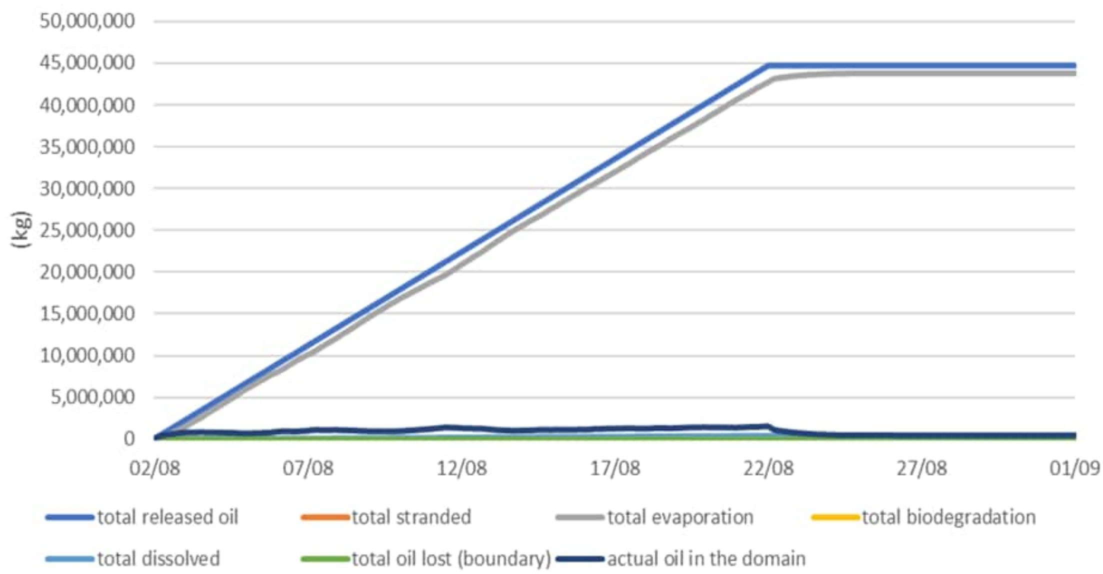


Figure 7-1. Worst-case, all seasons, Scenario 1 model mass balance (i.e., all the processes that influence the fate of the total condensate spilled, and the relative proportion thereof assuming conservation of mass), Note how most of the total condensate released (medium blue line) evaporates over time (grey line) (DHI 2023).

7.3.2 SCENARIO 1: DISCHARGE POINT BLOWOUT

In a discharge point blowout scenario, worst-case model results indicate that there is a 90% probability that a spill will extend 250-290 km from the rupture point to the southwest, depending on season (Figure 7-2). Model results indicate that there is a 1% chance that a spill will extend 490 km west for all seasons, and 750-950 km to the southwest, dependent on season (Figure 7-2). Indeed, these results show that for all seasons, a blowout would result in condensate reaching waters beyond the South African EEZ (i.e., international waters).

Offshore, surface oil (> 5 µm thick) is projected to intersect (>75% probability) with a number of EBSAs and MPAs, including almost the entirety of the Southwest Indian Seamounts MPA and large portions of the Shackleton Seamount Complex EBSA and the Mallory Escarpment and Trough EBSA to the southwest (Figure 7-2). In autumn and winter, the northwestern portion of the Southwest Indian Seamounts MPA is also modelled to overlap with the >75% probability plume (Figure 7-2). In winter, there is also a large overlap with the Kingklip Corals EBSA to the northeast of the blowout site (Figure 7-2). In winter and spring (the worst-case models), the results indicate that the surface condensate is projected to overlap several MPAs, with a 1% probability of overlapping 18.1% of the Browns Bank Corals MPA and 5% of the Port Elizabeth Corals MPA, 1-5% probability of overlapping 91% of the Agulhas Front MPA and 94% of the Southeast Atlantic Seamounts MPA and 1-10% probability of overlapping 49% of the Agulhas Bank Complex.

The model results show that condensate (>10 g/m^2) is expected to reach shore in 2-4 days in every season except summer (December-February, when no condensate is expected to come ashore) (Table 7.4). The highest probability of condensate -shoreline impact after a discharge point blowout occurs in winter (Season 3, June-August), with >10 g/m^2 oil predicted to potentially impact some 64 km of shoreline (Table 7.4). The maximum condensate amount found on shore based on the worst-case scenario (deterministic simulation) is 1.2-2.8 tons, with a probability of 1.1-4.8% (Table 7.4). The probability of condensate reaching shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) is, however, very low (4.8% for the worst-case, and 1.3% across all seasons) (Table 7.4). The impacted shoreline is predicted to comprise Cape St Francis, Oyster Bay, Huisklip Nature Reserve, Thyspunt, Rebelsrus Private Nature Reserve, Wasserna's Beach (Table 7.4, Figure 7-3).

While DHI (2013) reports that the probably of oiling > 10 g/m^2 is 0% at sensitive sites (specifically, Bird Island, the De Hoop MPA, Knysna Lagoon, the Klein Brak Estuary, Stilbaai Estuary, Tsitsikamma MPA and Walker Bay) for all modelled seasons, this is likely the result of the site of measurement (i.e., an observation point was included in the model, and condensate was measured at that specific point). Taking the full area into account (as per Figure 7-3), worst-case model results indicate that, in winter, there is a 1-5% probability that surface oil > 5 µm thick will overlap with the south eastern corner of the Tsitsikamma MPA (an area of 109.1 km^2, or 36.6% of the MPA) and a 1% probability that the surface condensate will overlap with the southern half of the Robberg MPA (an area of 10.4 km^2, or 39.7% of the MPA) (Figure 7-3).

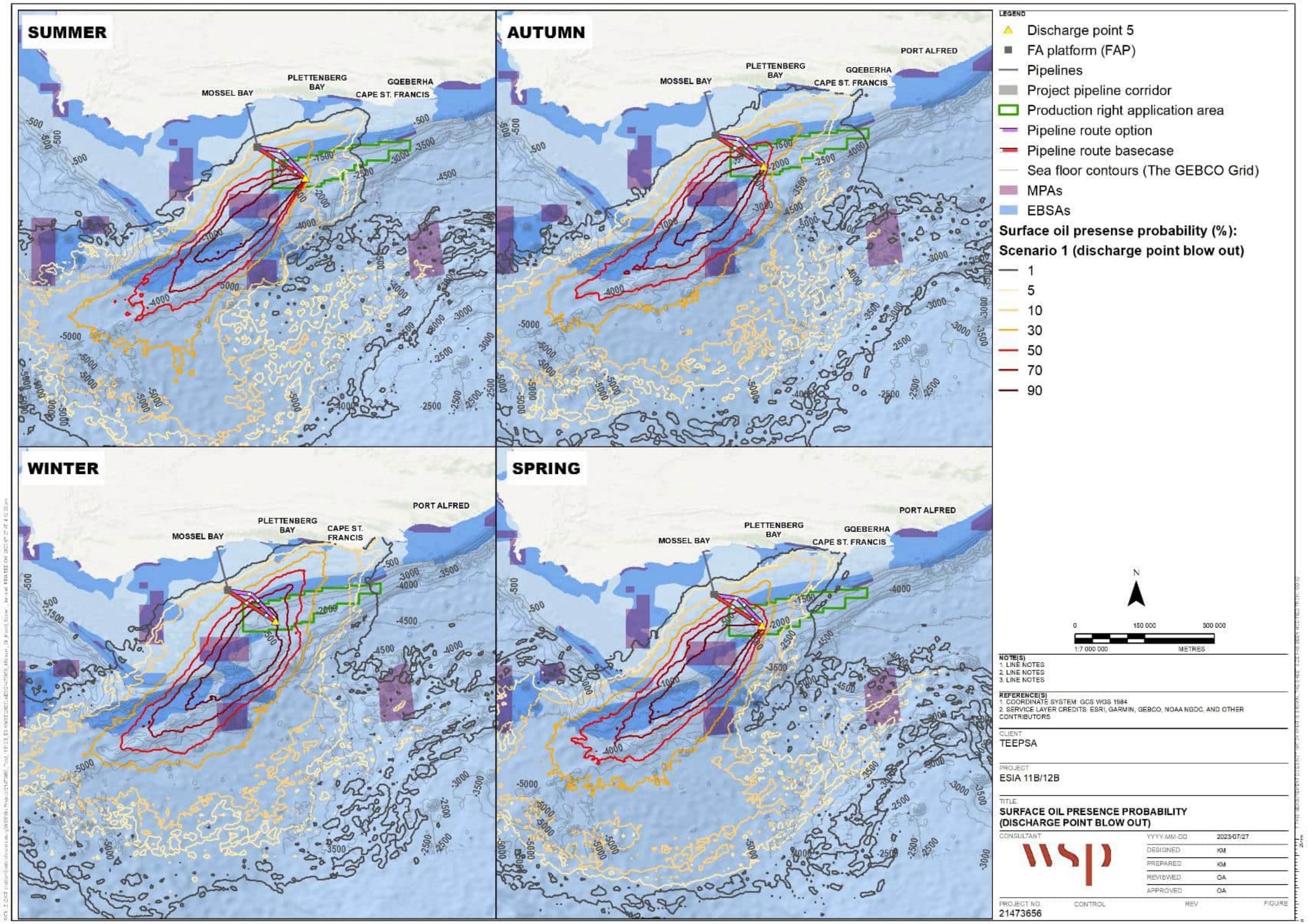


Figure 7-2. Surface condensate presence probability: Scenario 1 (discharge point blowout) model results statistics for all simulations that start in summer, autumn, winter and spring. Note that these maps are an amalgamation of 400 spill simulations under different metocean conditions, not representative of a single spill event (DHI 2023).

Table 7.4. Scenario 1 (discharge point below out) model results summary across all seasons. RP = Release Point (DHI 2023).

Scenario 1: Blowout	All Simulations	Season 1 (Summer Dec-Feb)	Season 2 (Autumn, March-May)	Season 3 (Winter, June-Aug)	Season 4 (Spring, Sep-Nov)
Flow Rate / Amount	Oil: 18350 bbl/d, Gas: 6170000 Sm^3/d				
Main direction of the Spill Drift	Toward SW	Toward SW	Toward SW	Toward SW	Toward SW
MAX. Distance of the 90%-oil-surface-probability contour	250 km SW from RP	275 km SW from RP	230 km SW from RP	240 km SW from RP	290 km SW from RP
MAX. distance of the 1%-oil-surface-probability contour	490 km W & 850 km SW from RP	490 km W and 970 km SW from RP	490 km W and 870 km SW from RP	490 km W and 750 km SW from RP	490 km W and 970 km SW from RP
Offshore surface waters possibly reached by a spill	South African, International Waters	South African, International Waters	South African, International Waters	South African, International Waters	South African, International Waters
Shoreline length that could receive oil >10 g/m^2 (considering all the simulations)	68 km	0 km	4 km	64.3 km	2.5 km
Shoreline Possibly Impacted (by oil >10 g/m2)	Cape St Francis, Oyster Bay, Huisklip Nature Reserve, Thyspunt, Rebelsrus Private Nature Reserve, Wasserna's Beach	-	Huisklip Nature Reserve, Wasserna's Beach	Huisklip Nature Reserve, Thyspunt, Rebelsrus Private Nature Reserve, Wasserna's Beach	Huisklip Nature Reserve, Wasserna's Beach
Deterministic Worst-case Shoreline Length Impacted	20 km	0 km	4 km	20 km	0.8 km
MAX. % Shoreline Impact Probability	1.3%	0%	1.9%	4.8%	1.1%
MAX. oil amount onshore (tons)*	2.5	0.9	2.8	2.5	1.5
Probability of Shoreline Oiling (>10 g/m^2)					
Bird Island	0%	0%	0%	0%	0%
De Hoop MPA	0%	0%	0%	0%	0%
Knysna Lagoon	0%	0%	0%	0%	0%
Klein Brak Estuary	0%	0%	0%	0%	0%
Stilbaai Estuary	0%	0%	0%	0%	0%
Tsitsikamma MPA	0%	0%	0%	0%	0%
Walker Bay	0%	0%	0%	0%	0%
Minimum Shoreline Arrival Time	2-3 days	-	3-4 days	2-3 days	4 days

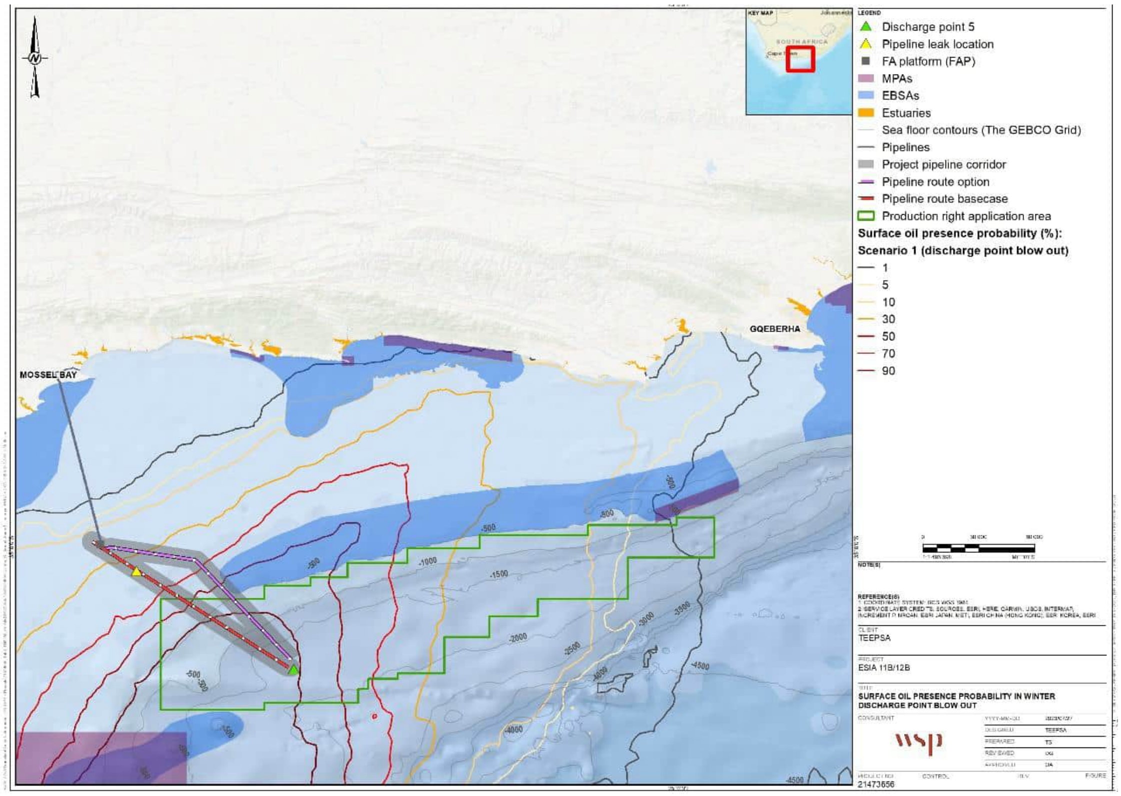


Figure 7-3. Worst-case coastal surface condensate presence probability: Scenario 1 (well blowout) model results statistics for all simulations that start in winter. This map is an amalgamation of 400 spill simulations under different metocean conditions, not representative of a single spill event (DHI 2023).

7.3.3 Scenario 2: Full pipeline rupture

In a pipeline rupture scenario, worst-case model results indicate that there is a 90% probability that a spill will extend 10 km from the rupture point in all seasons (Figure 7-4). Under a Scenario 2 pipeline rupture, there is a 1% chance that a spill will extend 490 km west for all seasons, and 145-230 km to the northeast, and 155-485 km to the southwest, dependent on season (Figure 7-4). Unlike Scenario 1, model results show that for all seasons, condensate from a pipeline rupture spill remains within the South African EEZ.

Offshore, surface condensate (> 5 µm thick) is projected to intersect (30-40% probability) with the Kingklip Corals EBSA to the northeast of the 11B/12B Production Right Application Area (Figure 7-4). In winter and spring (the worst-case models), the results indicate that the surface condensate is projected to overlap two MPAs, with a 1% probability of overlapping 12.1% of the Agulhas Bank Complex MPA and a 1-5% probability of overlapping 17% of the Southwest Indian Seamounts MPA.

The model results show that condensate (>10 g/m^2) is expected to reach shore in 1-1.5 days in winter and spring. The highest probability of condensate-shoreline impact after a pipeline rupture also occurs in winter (Season 3, June-August), with condensate >10 g/m^2 predicted to potentially impact some 20.5 km of shoreline in this season, and 35 km across all seasons (Table 7.5). The probability of condensate reaching shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) is also very low for a pipe rupture (1.9% for the worst-case, and 0.75% across all seasons) (Table 7.5). The maximum condensate amount found on shore based on the worst-case scenario (deterministic simulation) is 0.5-1.3 tons (Table 7.5). The impacted shoreline is predicted to comprise Huisklip Nature Reserve, Robberg Nature Reserve, Kranshoek, Knoetzie Beach and the Knysna Lagoon offshore MPA, with a 1% probability that the oil reaches the Knysna Lagoon should a rupture occur in winter and spring (Table 7.5, Figure 7-4). In winter and spring, worst-case model results indicate that there is a 1% probability that surface condensate > 5 µm thick will overlap with the Tsitsikamma MPA (a maximum area of 162.9 km^2, or 54.7% of the MPA), and Robberg MPA (an area of 13.9 km^2, or 52.7% of the MPA) (Figure 7-5).

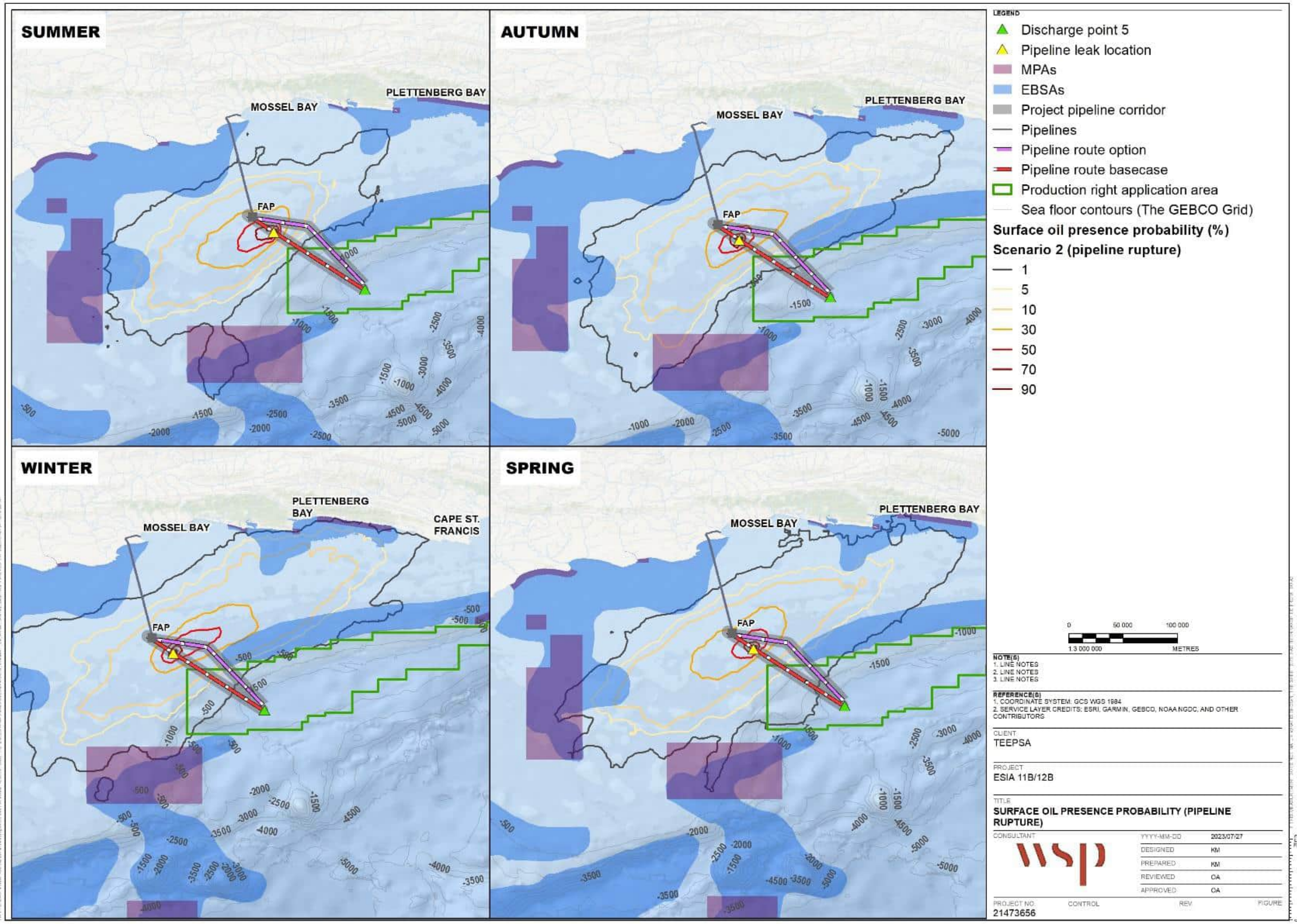


Figure 7-4. Surface condensate presence probability: Scenario 2 (pipeline rupture) model results statistics for all simulations that start in summer, autumn, winter and spring. Note that these maps are an amalgamation of 400 spill simulations under different metocean conditions, not representative of a single spill event (DHI 2023).

Table 7.5. Scenario 2 (pipeline rupture) model results summary across all seasons. RP = Release Point (DHI 2023).

Scenario 2: Pipeline rupture	All Simulations	Season 1 (Summer Dec-Feb)	Season 2 (Autumn, March-May)	Season 3 (Winter, June-Aug)	Season 4 (Spring, Sep-Nov)
Flow Rate / Amount	Qoil: 19320 bbl/d (0-2h), 10728 bbl/d (2-24h), Qgas: 6170000 Sm3/d (0-2h), 1415000 Sm3/d (2-24h),				
Main direction of the Spill Drift	Toward SW or NE	Toward SW or NE	Toward SW or NE	Toward SW or NE	Toward SW or NE
MAX. Distance of the 90%-oil-surface-probability contour	10 km from RP	10 km from RP	10 km from RP	10 km from RP	10 km from RP
MAX. distance of the 1%-oil-surface-probability contour	195 km NE and 165 km SW from RP	145 km NE and 485 km SW from RP	210 km NE and 155 km SW from RP	230 km NE and 140 km SW from RP	205 km NE and 165 km SW from RP
Offshore surface waters possibly reached by a spill	South African	South African	South African	South African	South African
Shoreline length that could receive oil >10 g/m^2 (considering all the simulations)	35 km	0 km	0 km	20.5 km	18.4 km
Shoreline Possibly Impacted (by oil >10 g/m2)	Huisklip Nature Reserve, Nature Valley Beach, Robberg Nature Reserve, Kranshoek, Knoetzie Beach, Knysna Lagoon	-	-	Huisklip Nature Reserve, Robberg Nature Reserve, Kranshoek, Knoetzie Beach, Knysna Lagoon	Nature Valley Beach, Robberg Nature Reserve, Kranshoek, Knoetzie Beach, Knysna Lagoon
Deterministic Worst-case Shoreline Length Impacted	19 km	0 km	0 km	19 km	18 km
MAX. % Shoreline Impact Probability	0.75%	0%	0%	1.9%	1%
MAX. oil amount onshore (tons)*	0.5	0.2	0.5	0.5	1.3
Probability of Shoreline Oiling (>10 g/m^2)					
Bird Island	0%	0%	0%	0%	0%
De Hoop MPA	0%	0%	0%	0%	0%
Knysna Lagoon	0.25-0.5%	0%	0%	1%	1%
Klein Brak Estuary	0%	0%	0%	0%	0%
Stilbaai Estuary	0%	0%	0%	0%	0%
Tsitsikamma MPA	0%	0%	0%	0%	0%
Walker Bay	0%	0%	0%	0%	0%
Minimum Shoreline Arrival Time	1-1.5 days	-	-	1-1.5 days	1-1.5 days

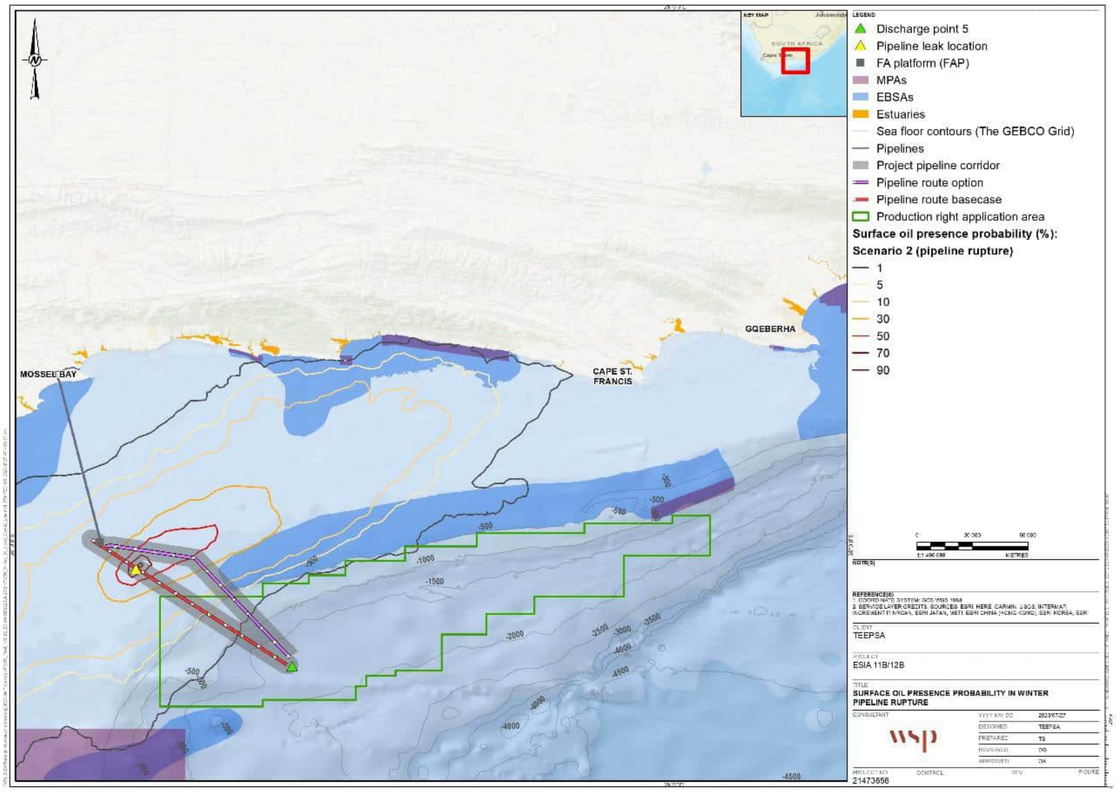


Figure 7-5. Worst-case coastal surface condensate presence probability: Scenario 2 (pipeline rupture) model results statistics for all simulations that start in winter. Note that these maps are an amalgamation of 400 spill simulations under different metocean conditions, not representative of a single spill event (DHI 2023).

7.4 Eastern discharge points modelling results

Stochastic and deterministic results are provided for all oil spill scenarios. Stochastic simulations are statistical calculations / analyses based on the results from ensemble modelling of the LOC scenario under a wide range of weather and/or seasonal conditions, while deterministic simulations provide detailed pictures of the oil trajectory during the simulation periods (HES 2020c, d). The oil spill modelling studies (HES 2020a, b) present data for various spill response strategies, as per the response strategy outlined in Total E&P South Africa BOCP (Blowout Contingency Plan) and TEEPSA OSCP (Oil Spill Contingency Plan).

7.4.1 Scenario 1: Discharge Point 1

In a discharge point blowout scenario, worst-case model results indicate that there is a 40-50% probability that a spill will extend up to 460 km from the rupture point to the southwest, entering international waters, depending on season (Figure 7-6). There is a 90-100% probably that the surface slick will spread up to 340 km to the southwest across all seasons. Summer represents the worst-case season (Figure 7-6). Offshore, surface oil (> 5 µm thick) is projected to intersect with a number of EBSAs and MPAs, including almost the entirety of the Southwest Indian Seamounts MPA and large portions of the Shackleton Seamount Complex EBSA and the Mallory Escarpment and Trough EBSA to the southwest (Figure 7-6). In summer, there is a >70% probability that the plume overlaps with 53% of the Southwest Indian Seamounts MPA, with an overlap of 44% in spring (Figure 7-6).

In autumn, there is a 50-70% chance of the modelled plume overlapping with Port Elizabeth Corals, with this spill projected to cover 90% of the EBSA (Figure 7-6). There are slightly lower probability of overlap (5-10%) with over sensitive areas, including the Agulhas Bank Complex MPA (90.6% of area covered in summer) and the Browns Bank Corals MPA (23% of area covered in summer) (Figure 7-6).

The model results show that oil (>10 g/m^2) is expected to reach shore in 1-3 days (minimum) and 10-15 days average (winter is the worst case, with oil expected to come ashore in the Gqeberha after approximately 1 day) (Table 7.6). The highest probability of oil-shoreline impact after a discharge point blowout occurs in autumn (Season 2, April-Jun) and winter (Season 3, Jul-Sept), with a maximum shoreline impact probability of 87% in the Oyster Bay and St. Francis Bay areas, from Plettenberg Bay to Gqeberha (Table 7.6, Figure 7-7). In spring (Season 4, Oct-Dec), there is a 42% probability of the oil reaching shore from Knysna to St. Francis Bay area (Table 7.6, Figure 7-7).

In winter (the worst-case model), the Discharge Point 1 results indicate that the surface oil > 5 µm thick is projected to overlap three major coastal MPAs. There is a probability of 30-50% that the spill will overlap with the Addo Elephant National Park MPA (maximum area of 439.3 km^{2,} representing 39.6% of the MPA), 58.6% of the Tsitsikamma MPA (maximum area of 170.8 km^2) and a 10-30% probability of overlapping 95% of the Goukamma MPA (maximum area of 30.5 km^2) (Figure 7-8).

Table 7.6. Discharge Point 1 blowout model results summary across all seasons. RP = Release Point (Lavidas 2020c).

Scenario 1: Blowout	**Season 1 (Summer Jan-Mar)**	**Season 2 (Autumn, Apr-Jun)**	**Season 3 (Winter, Jul-Sep)**	**Season 4 (Spring, Oct-Dec)**
Flow Rate / Amount	Oil: 69 000 bbl/d			
Main direction of the Spill Drift	Toward SW	Toward SW	Toward SW	Toward SW
MAX. Distance of the 90%-oil-surface-probability contour	400 km from RP	170 km from RP	175 km from RP	340 km from RP
Secondary draft		60% to the SW	75% to the N	
Offshore surface waters possibly reached by a spill	International			
MAX. % shoreline impact probability	22% observed from George to St. Francis Bay area	87% observed in the Oyster Bay and St. Francis Bay areas, from Plettenberg Bay to Gqeberha	87% observed in the Oyster Bay and St. Francis Bay areas, from Plettenberg Bay to Gqeberha	42% observed from Knysna to St. Francis Bay area
Minimum Shoreline Arrival Time	St. Francis Bay, approximately 3 days after start of the release	East of the St. Francis Bay area, West to Gqeberha, 2 days after start of the release	Gqeberha area, approximately 1 day after start of the release	West of Oyster Bay area, approximately 2 days after start of the release
Average Shoreline Arrival Time	14 days	11 days	10 days	15 days
Deterministic Worst-Case Oil Onshore with capping only	12000 g/m^2 is observed along approximately 270 km between	12000 g/m^2 is observed along approximately 470 km between	12000 g/m^2 are observed along approximately 190 km between	12000 g/m^2 is observed along approximately 235 km between

Scenario 1: Blowout	Season 1 (Summer Jan-Mar)	Season 2 (Autumn, Apr-Jun)	Season 3 (Winter, Jul-Sep)	Season 4 (Spring, Oct-Dec)
	Woodlands (west to St. Francis Bay) and Cannon Rocks (East of Algoa Bay)	George and Port Alfred towns	George and Oyster Bay	Woodlands George coastline and St. Francis Bay

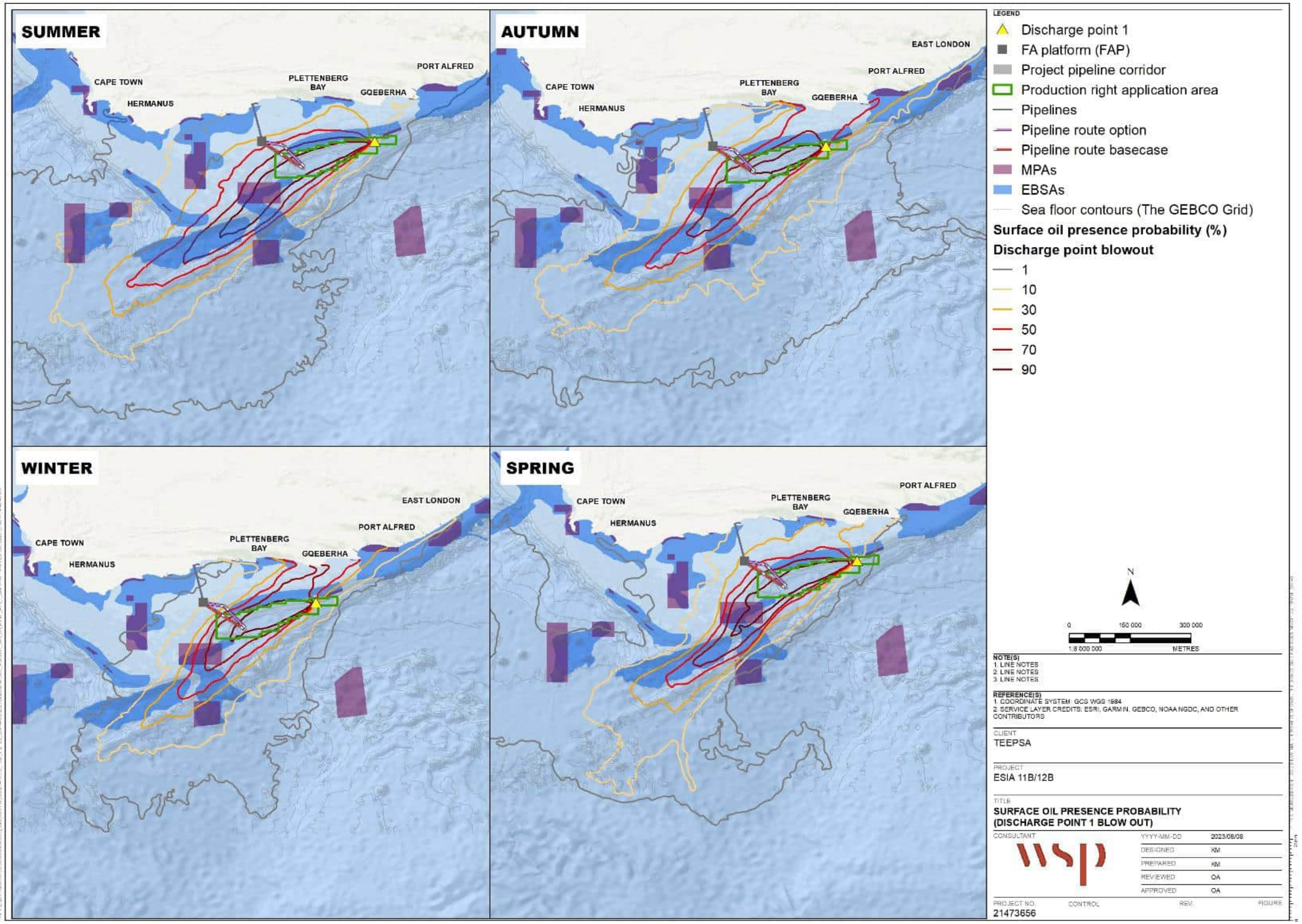


Figure 7-6. Surface oil presence probability: Discharge Point 1 blowout model results statistics for all simulations in summer, autumn, winter and spring. Note that these maps are an amalgamation of 90 spill simulations under different metocean conditions, not representative of a single spill event (HES 2020c).

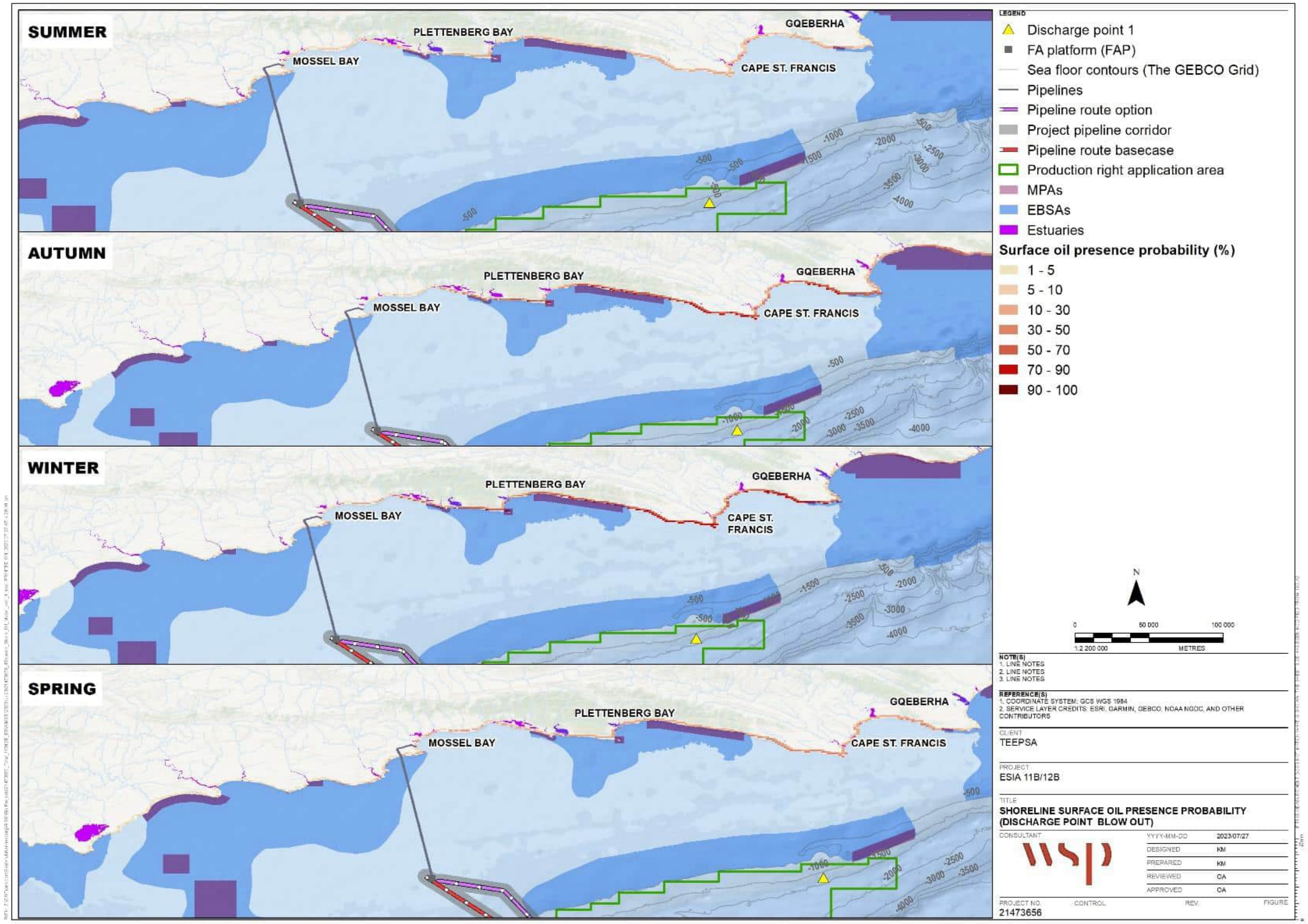


Figure 7-7. Worst-case shoreline oiling probability above threshold (>10 g/m^2): Discharge Point 1 blowout model results statistics for all simulations in summer, autumn, winter and spring. Note that these results do not represent a single spill but the combination of statistical results of the 90 individual trajectories composing the various Stochastic scenarios (seasons) (HES 2020c).

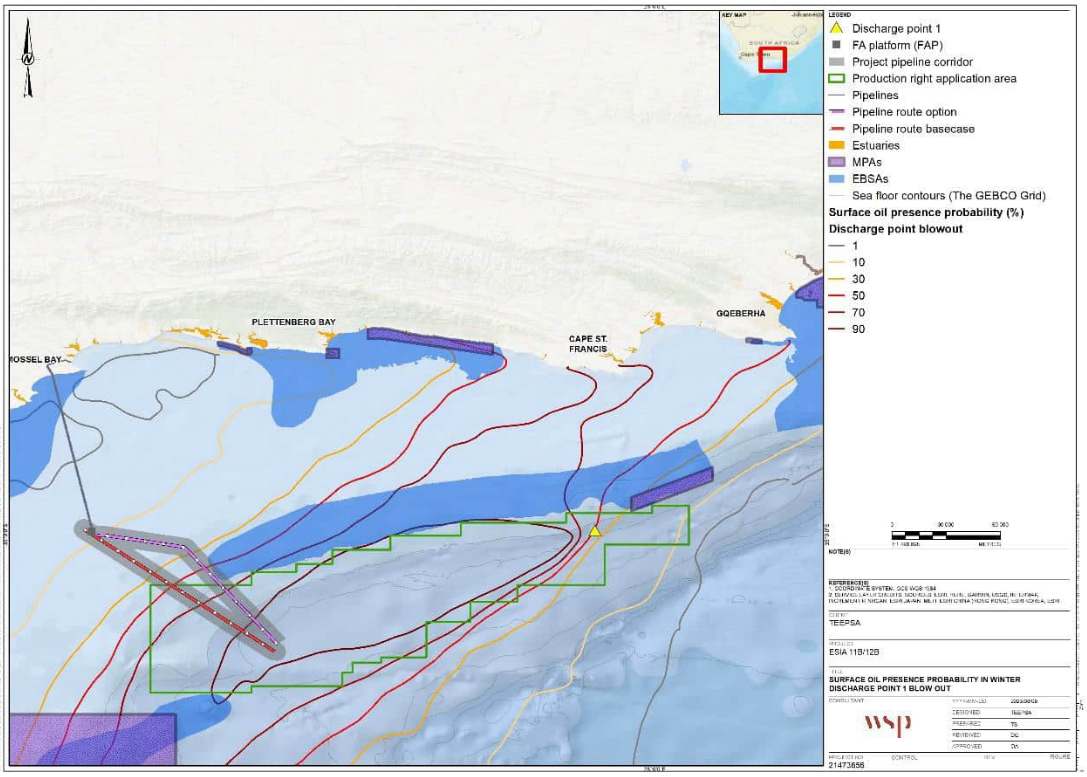


Figure 7-8. Worst- case surface oil presence probability: Discharge Point 1 blowout model results statistics for all winter, focussing on coastal MPAs. Note that these maps are an amalgamation of 90 spill simulations under different metocean conditions, not representative of a single spill event (HES 2020d). Marine Protected Areas are overlaid.

7.4.2 Scenario 2: Discharge Point 2

In a discharge point blowout scenario, worst-case model results indicate that there is a 37% probability that a spill will extend up to 500 km from the rupture point to the southwest, entering international waters during the summer, whilst in winter, there is a 17% probability of the spill extending 435 km south west (Figure 7-9). There is a 90-100% probably that the surface slick will spread 135-310 km from the rupture point to the southwest across all seasons (Figure 7-9, Table 7.7). There is also a 90-100% probably that the surface slick will spread 138 km to the north/north east in winter, a 70% probability of the spill moving north east towards Gqeberha in summer, an a 80% probability of a autumn spill moving north/north east towards the east coast of South Africa (Figure 7-9, Table 7.7). Summer represents the worst-case season for surface oil spread (Figure 7-9). Offshore, surface oil (> 5 µm thick) is again projected to intersect with a number of EBSAs and MPAs, including almost the entirety of the Southwest Indian Seamounts MPA and large portions of the Shackleton Seamount Complex EBSA and the Mallory Escarpment and Trough EBSA to the southwest (Figure 7-9).

In summer, there is a >70% probability that the plume overlaps with 47% of the Southwest Indian Seamounts MPA, with an overlap of 40% in spring (Figure 7-9). In autumn, there is a 10-30% chance of the modelled plume overlapping with Port Elizabeth Corals, with this spill projected to cover ~90% of the EBSA (Figure 7-9). There is a 10-30% probability of the spill covering ~96% of the Agulhas Bank Complex MPA in spring, and a 1-5% probability that 77% of the Browns Bank Corals MPA will be covered in winter (Figure 7-9).

The model results show that oil (>10 g/m^2) is expected to reach shore in 1-2 days (minimum) and 11-14 days average (winter is again the worst case, with oil expected to come ashore in the Gqeberha area after approximately 1 day) (Table 7.7). Model results indicate that shoreline oiling annual probability is 83%, with the highest probability of oil-shoreline impact after a well blowout occurring in autumn (Season 3, July-Sept) with a maximum shoreline impact probability of 100% from George to Gqeberha (Table 7.7, Figure 7-10). In spring (Season 4, Oct-Dec), 63% of shoreline impacts are observed on the Tsitsikamma National Park coastline area, while in autumn (Season 2, Apr-Jun), 98% of impacts are modelled to occur between Knysna and Gqeberha (Table 7.7, Figure 7-10). The period of the year identified as the worst in the event of a blowout (i.e., with maximum oil amount onshore coupled with the maximum probability) is again the third quarter (spill starting in August).

In winter (the worst-case model), the Discharge Point 2 results indicate that the surface oil > 5 µm thick is projected to overlap three major coastal MPAs. The overlap is projected to occur with a 50-70% probability of overlapping 28.8% of the Addo Elephant National Park MPA (maximum of 319km^2). There is also a 70-90% probability of overlap with the Tsitsikamma MPA (representing 84.61% of the MPA, with a maximum area of 246 km^2) and 40.47% of the Goukamma MPA (13.75 km^2) (Figure 7-11).

Table 7.7. Discharge Point 2 blowout model results summary across all seasons. RP = Release Point (Lavidas 2020d).

Scenario 1: Blowout	Season 1 (Summer Jan-Mar)	Season 2 (Autumn, Apr-Jun)	Season 3 (Winter, Jul-Sep)	Season 4 (Spring, Oct-Dec)
Flow Rate / Amount	Oil: 69 000 bbl/d			
Main direction of the Spill Drift	Toward SW	Toward SW	Toward SW; N/NE	Toward SW
MAX. Distance of the 90%-oil-surface-probability contour	310 km from RP	135 km from RP	160 km SW from RP 138 km N/NE from RP	290 km from RP
Secondary draft	70% NE towards Gqeberha	80% on N/NE		
Offshore surface waters possibly reached by a spill	International			
MAX. % shoreline impact probability	72% observed on Plettenberg Bay area	98% observed between Knysna and Gqeberha	100% observed from George to Gqeberha	63% observed on the Tsitsikamma National Park coastline area
Minimum Shoreline Arrival Time	St. Francis Bay after ~2 days	St. Francis Bay area, West to Gqeberha after 2 days	West of St. Francis Bay area after ~1 day	Cape Saint Francis area after ~2 days
Average Shoreline Arrival Time	14 days	11 days	11 days	12 days
Deterministic Worst-Case Oil Onshore with capping only	12 000 g/m^2 along ~230 km between Knysna and Gqeberha	12 500 g/m^2 along ~480 km between George and east of Gqeberha	12 000 g/m^2 from George to Gqeberha	12 000 g/m^2 along ~460 km between Uiterstepunt coastline and St. Francis Bay

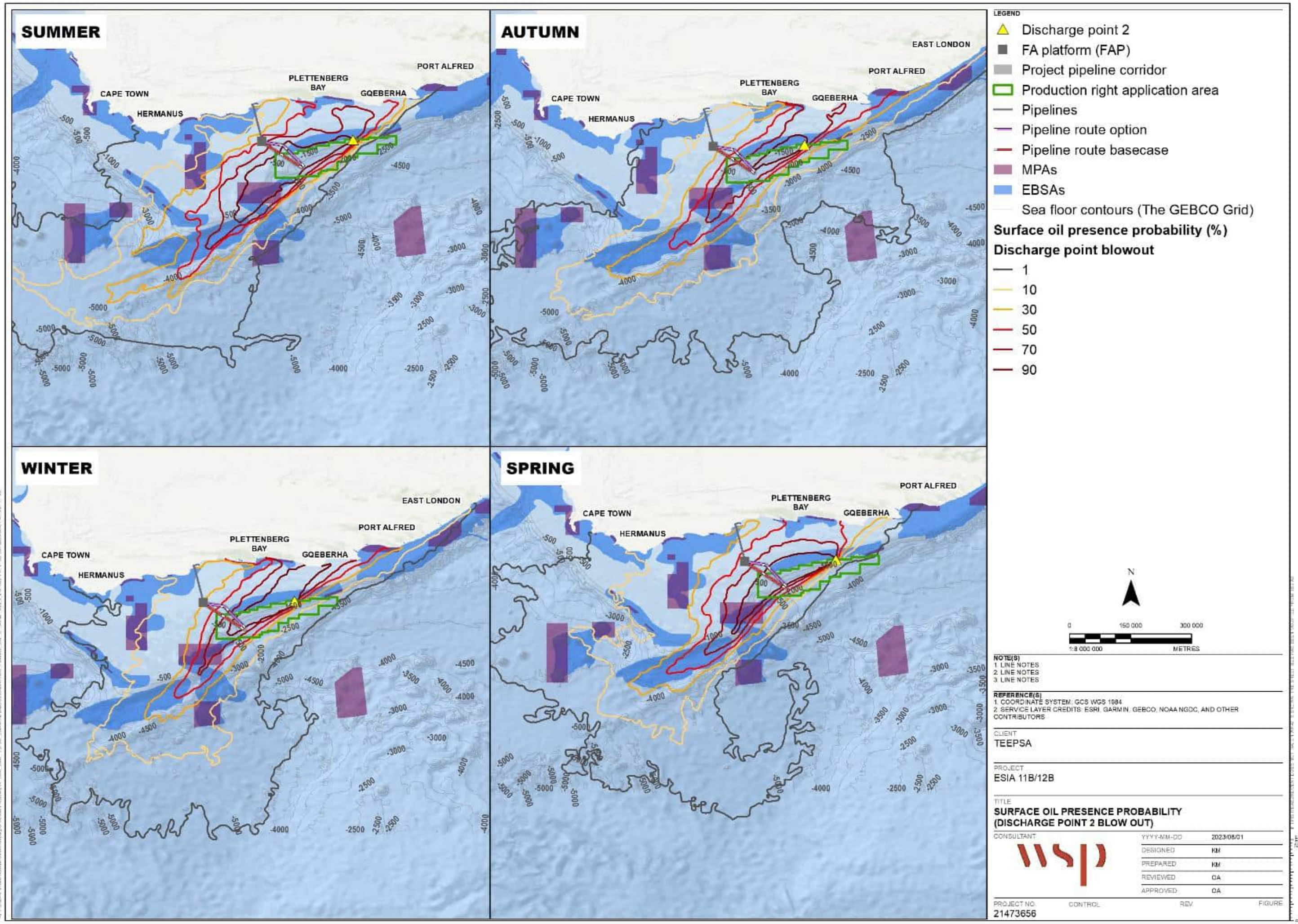


Figure 7-9. Surface oil presence probability: Discharge Point 2 blowout model results statistics for all simulations in summer, autumn, winter and spring. Note that these maps are an amalgamation of 90 spill simulations under different metocean conditions, not representative of a single spill event (HES 2020d).

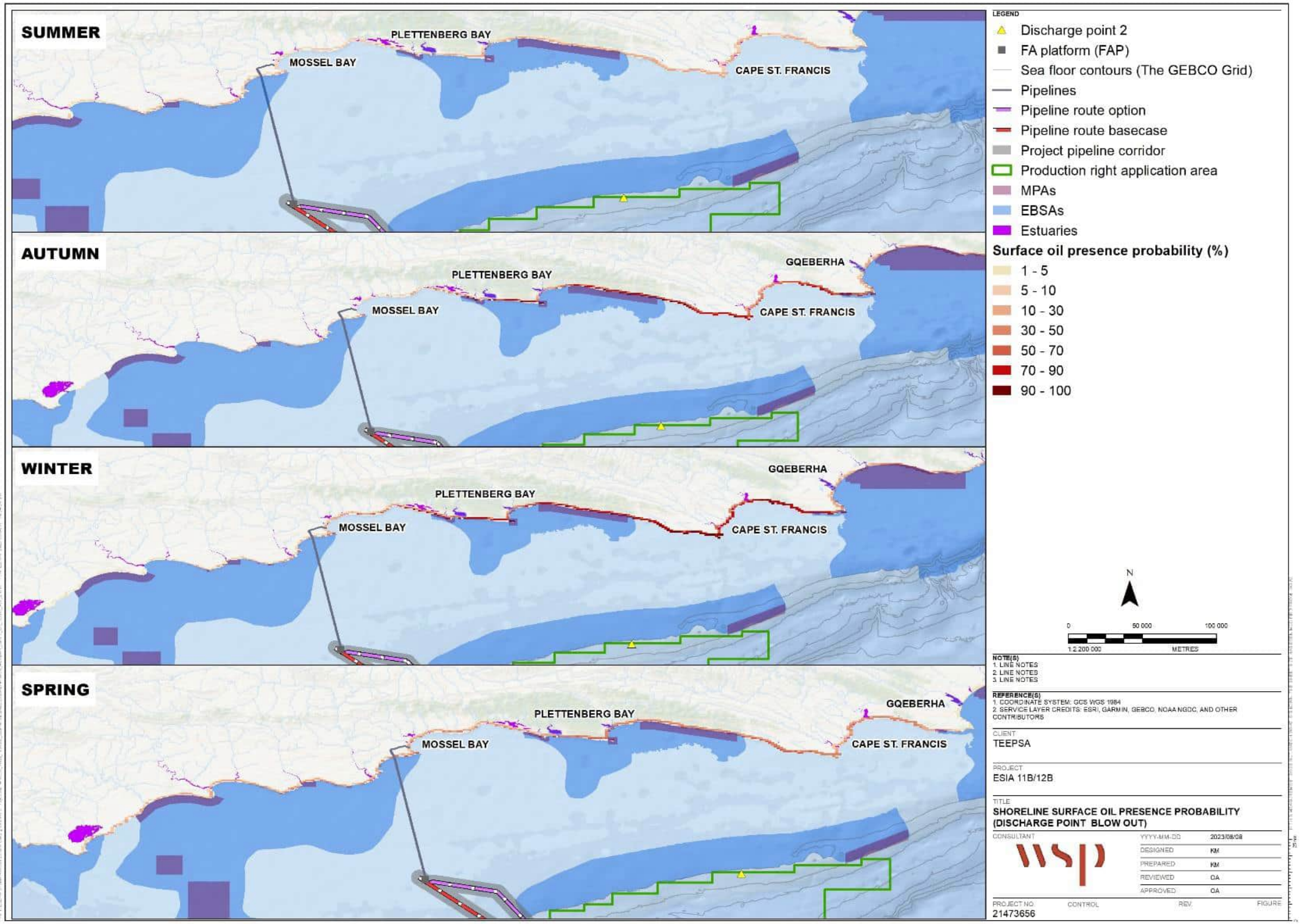


Figure 7-10. Worst-case shoreline oiling probability above threshold (>10 g/m^2): Discharge Point 2 blowout model results statistics for all simulations in summer, autumn, winter and spring. Note that these results do not represent a single spill but the combination of statistical results of the 90 individual trajectories composing the various Stochastic scenarios (seasons) (HES 2020d).

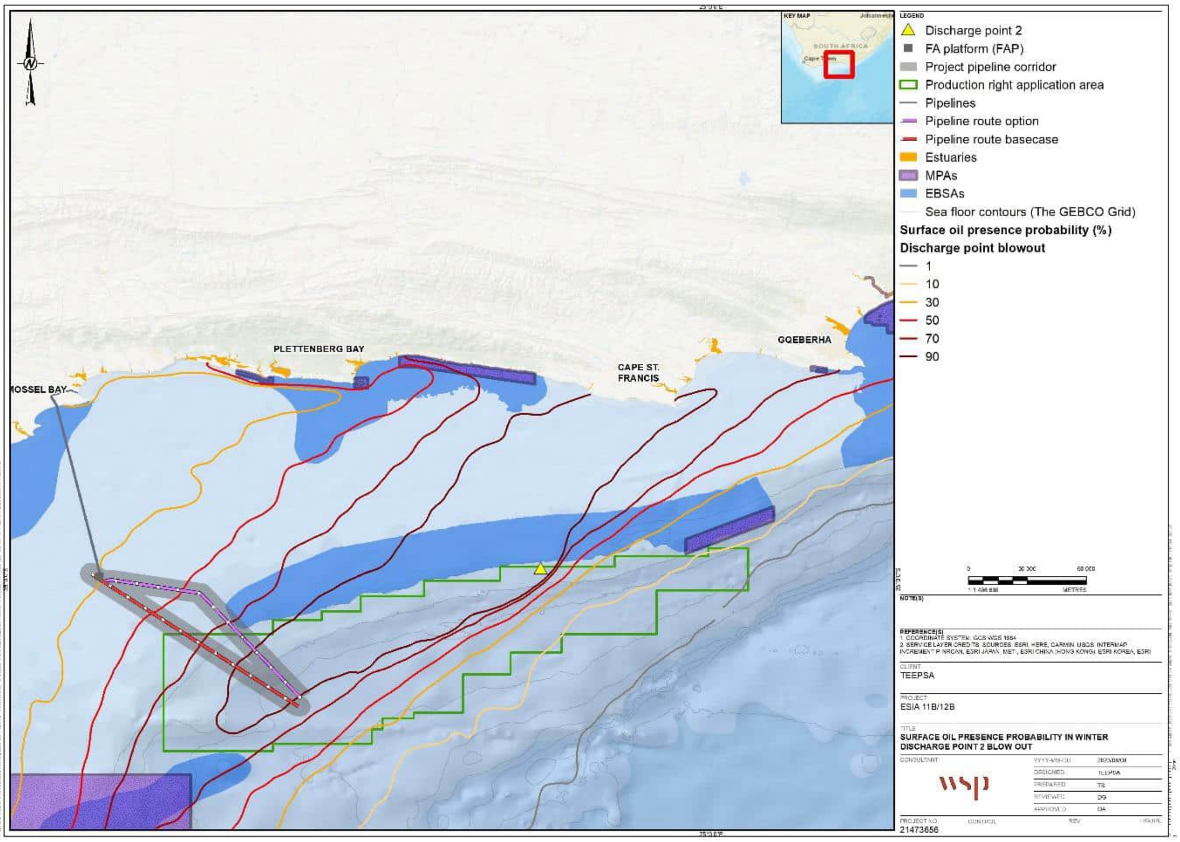


Figure 7-11. Worst- case surface oil presence probability: Discharge Point 2 blowout model results statistics for all winter, focussing on coastal MPAs. Note that these maps are an amalgamation of 90 spill simulations under different metocean conditions, not representative of a single spill event (HES 2020d). Marine Protected Areas are overlaid.

8 POTENTIAL IMPACTS

8.1 BACKGROUND

Potential impacts to the marine environment as a result of exploration, prospecting, installation and operation of production platforms and associated pipelines and decommissioning of these production facilities offshore South Africa have been assessed in a large number of studies (see for example Grunlingh *et al.* 2006, Pulfrich 2015, 2016, Blood 2015 and Mason 2017).

In the marine environment a disturbance can be relatively short-lived (e.g., accidental spill which is diluted in the water column below threshold limits within hours) but the effect of such a disturbance may have a much longer lifetime (e.g., attachment of pollutants to sediment which may be disturbed frequently). The assessment and rating procedure described in the ESIA methodology addresses the effects and consequences (i.e., the impact) on the environment rather than the cause or initial disturbance alone. To reduce negative impacts, precautions referred to as 'mitigation measures' are set, and attainable mitigation actions are recommended. In this report, the 'construction footprint' is defined as the total area of new infrastructure as determined by design engineers.

Both 'worst case' impacts and cumulative impacts are assessed in this report. The assessment is presented as impacts under normal operations (Section 8.2 to Section 8.4), and impacts under unplanned events (Section 8.5). Negative impacts associated with the activities described in Section 1.2.2 fall into four main categories:

- Construction phase impacts, including water quality impacts related to the discharge of drilling muds and cuttings, impacts of noise and light impacts on marine fauna, well testing/flaring[13], the direct loss of habitat by placement of infrastructure, as well as the risk of invasive species introduction.
- Production phase impacts, which include impacts on water as a result of operational discharges to the marine environment and the impacts of artificial light at night.
- Exploration phase impacts, many of which are similar those in the Construction Phase, but which also includes the impacts of well testing/flaring and noise impacts as a result of exploratory vertical seismic profiling.
- Activities that fall across all project phases, which are specifically related to bathymetry and sonar surveys, seafloor sampling surveys and metocean surveys.

Each of these impacts is likely to affect the associated biota in different ways and at varying intensities depending on the nature of the affected habitat and the sensitivity of the biota.

[13] TEEPSA has signed up the WB Zero Routine Flaring by 2030 initiative a policy to reduce flaring from operations; essentially zero flaring from gas but an allowance has been made in the Air Quality and Greenhouse Gas studies for flaring if required for maintained or unplanned events or in an emergency. There will be flaring for the production wells; however, not all exploration wells will be flared.

Results of each assessment are presented in Table 8.1 to Table 8.35 and are summarised in Table 8.37.

The proposed mitigation measures are based on the mitigation hierarchy which allows for consideration of five different levels, which include avoid/prevent, minimise, rehabilitate/restore, offset and no-go in that order (see the ESIA methodology). When project impacts are considered, the first option should be to avoid or prevent the impacts from occurring in the first place if possible. If such avoidance is not attainable, the impacts must be minimised as far as possible by the implementation of suitable mitigation measures. The next goal is to rehabilitate or restore the areas impacted back to their original form after project completion. Offsets are then considered if all the other measures described above fail to remedy high/significant residual negative impacts. If no offsets can be achieved on a potential impact, which results in full destruction of any ecosystem for example, the no-go option is considered so that another activity or location is considered in place of the original plan.

Mitigation is separated out as Project Controls (i.e., measures that will be implemented/undertaken by TEEPSA as part of industry best practise, Best Available Techniques (BAT) or legislative requirements) and mitigation specific to the proposed activities in this specific environment with the specific identified receptors and sensitivities. Note that the unmitigated impact is assessed as prior to the implementation of any Project Controls or mitigation measures.

8.2 Construction Phase Impacts

The construction phase is expected to include the following activities:

- The installation of infrastructure for the subsea structures including Flowline End Terminations (FLET) and a production manifold at the end of the pipeline to allow the connection of the wells;
- The laying of the 18” rigid production pipeline to be connected from the subsea manifold to the F-A Platform;
- The drilling and completion of up to six development and appraisal wells, including biochemical and toxicity impacts, smothering and noise impacts;
- Commissioning activities; and,
- The use of supply and support vessels, specialised vessels and helicopters to support preparation, construction, and installation activities.

The impacts are therefore expected to include water quality, noise and light impacts on marine fauna as a result of general construction activities (support vessels etc.), impacts of accidental hazardous substance spillage and litter, as well as the direct loss of habitat by placement of infrastructure.

8.2.1 Direct Loss of Benthic Habitat and Physical Disturbance/Mortality of Benthic Fauna

This impact involves the physical disturbance of the seabed and/or destruction of associated benthic biota by anchors and chains utilised in construction and the installation of various pipelines and subsea production systems, direct disturbance and/or loss of benthic fauna in the pipeline’s structural footprint and as a result of physical disturbance of the seabed during pipeline installation (note that impacts associated with discharge of drilling fluids and cuttings is addressed separately in Section 8.2.2 and Section 8.2.3).

The physical disturbance of the seabed from anchoring of the subsea structures including the FLET and a production manifold and pipeline installation may result in a range of effects at various spatial and temporal scales. Setting of anchors will result in direct mortality of some benthic epifauna and infauna, should tensioning of the anchor chains and dragging of the anchors for subsea infrastructure placement occur. The affected area of seabed varies with the number of anchors used, the proportion of anchor chain that lies on the seabed, the forces applied and the substrate type (Pulfrich 2015). Generally, the impacts resulting from these activities include the displacement of seabed materials, and the generation of impact depressions and "anchor scars" (as anchors are set, they are dragged along the seabed, damaging benthic organisms) (Cordes *et al.* 2016). The spatial extent of anchor impacts on the seabed varies but chain lengths are generally up to 2.5 times the water depth (Vryhof Anchors BV 2010, in Cordes *et al.* 2016). Atkinson (2010) reports that, during drilling operations conducted in 350-450 m depth, the area disturbed per (10 tonne) anchor was estimated to be 5 m wide by 200 m long, with an additional disturbance area of 2 m wide by up to 300 m long from each section of anchor chain. A 100 m wide corridor of influence is estimated by Ulfsnes *et al.* (2013).

The duration of impact depressions and sediment displacement mounds vary and are dependent upon the nature of the sediments, the durability of the cohesive masses at the seabed surface and the location of the disturbed area (Dunaway & Schroeder 1998, Biccard *et al.* 2018). Observations of anchor scars and mounds in the northern North Sea suggest that under those conditions, anchor disturbance may persist for 2-10 years (Jennings & Kaiser 1998). In an investigation of natural recovery off Namaqualand after mining activities, anchor scars did not persist for more than two years in unconsolidated sediments (Penney & Pulfrich 2004, Roos 2005). Natural sedimentation rates also influence recovery time, with areas of high natural sedimentation rates (such as offshore of large rivers) showing an accelerated rate of benthos recovery post-mining (Biccard *et al.* 2018).

The physical presence of a pipeline on the seabed is expected to reduce the area of unconsolidated seabed habitat available for colonisation by infaunal communities but will provide alternative hard substratum for colonising by benthic communities (including alien species), fish and mobile invertebrates. Changes in benthic community structure are likely to occur with the loss of immobile, sedentary soft-bodied species and survival of more robust taxa such as molluscs and crustaceans (Savage *et al.* 2001, Sciberras *et al.* 2018, Biccard *et al.* 2018).

While too far offshore to be directly influenced by sediment deposition from rivers, the unmitigated impacts of anchoring on and laying of pipelines (for either routing option) across **soft, unconsolidated sediment** on benthic infauna is considered to be of low significance, as the affected area will be localised (small area), occur with an extent that is virtually negligible in comparison to similar available habitat in the area. However, the duration for pipeline infrastructure will be long term, as pipeline construction essentially transforms the habitat from soft sediment to hard substrate (although the pipes may be buried by sediment over time). The impact is therefore considered to be of low significance prior to mitigation for both pipeline routing options (Table 8.1). Mitigation reduces the impact to very low significance (Table 8.1).

In contrast, anchoring and laying of infrastructure over **hard ground or boulder fields** will result in physical damage to rock outcrops or the inversion of boulders on the seabed. Construction of pipelines (for either routing option) across **subtidal reefs** will require permanently attaching the structure to the substratum in a manner that is sufficiently strong to resist the action of the sea. The use of concrete to cement pipelines in place is the most feasible option. This would result in the direct loss of epifauna living on these hard substrata along the pipeline path or in the areas where concrete is placed. Indeed, Cordes *et al.* (2016) state that, "*the impact of anchors in the deep-sea is of greatest concern in biogenic habitats, such as those formed by corals and sponges, which are fragile and have low resilience to physical forces*". Some of the impacted biota may be long-lived and fragile. While recovery of disturbed deep-sea coral communities can take up to 30 years, the replacement of entire colonies is estimated to take centuries, based on estimated growth rates and polyp recruitment (Doughty *et al.* 2014, Schwing *et al.* 2020, see Section 3.3.2). A number of potential Vulnerable Marine Systems (VMEs) have been identified through the in situ epifauna ROV survey campaign in the vicinity of both proposed pipeline routing options (see Section 3.3.2 and Section 4.4) (BSL 2023). These potential VMEs were identified through the presence of VME indicator species, most of which are present in rocky habitat. The VME indicator species noted in the area of proposed construction activities (specifically pipeline construction on both route options) include right angled corals (*Cladopsammia* and *Eguchipsammia* sp.), the sabre bryozoan (*Adeonella* sp.), zigzag coral (*Enallopsammia rostrata*) and large overhanging lace coral (*Stylasteridae*) (Table 3.2) (Dawson *et al.* 20203, in BSL 2023). The unmitigated impacts of construction anchorage and laying of pipelines across hard ground is therefore considered to be of high significance (for either routing option) (Table 8.2).

This potential impact cannot be eliminated because it is essential to the proposed activities — there is no alternative routing that avoids CBA Natural Areas, given the location of the FA platform relative to the resource (Figure 4-2). Routing options must therefore account for areas of high sensitivity, and those areas should be avoided. Pre-installation site ROV and sampling surveys must be untaken to ensure construction activities do not disturb or destroy sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops). These surveys must make use of suitable expertise to identify areas of particular sensitivity on site (Table 8.2). Further mitigation includes ensuring that the installation of pipelines and manifolds locations are not located within a one km radius of any species, areas (such as MPAs or EBSAs), habitats or structures.

Work assessing TSS concentrations in the water column as a result of smaller trenching activities (in this case, 1 m wide trenching for subsea cable removal on Roberts Bank, British Columbia), showed that while maximum TSS concentrations of 31 000 mg/L occurred in the immediate vicinity of the trenching activities in the lower water column, and 1 200 mg/L at the surface, these high concentrations are limited to 10 m from the activity (Jiang *et al.* 2007). Indeed, TSS concentrations of 25 mg/L were modelled occur over an area of 0.11 km^2 (two hour after removal), while area of TSS above 75 mg/L cover <0.07 km^2 during the removal operation (Jiang *et al.* 2007). Based on the total subsea area of impact (102 416 m^2, as per Table 1.3), a conservative linear width of elevated TSS can be extrapolated as up to 800 m from trenching activities. Therefore, a one km buffer zone should be sufficient, especially given the limited duration of the expected turbidity plumes.

Project Controls include:

- Contractors will also ensure that the proposed drilling campaign is undertaken in a manner consistent with good international industry practice and Best Available

Techniques. This will include limiting the footprint of activities on the seabed to the minimum area necessary.

- Based on pre-drilling ROV survey(s), the well(s) will specifically be sited to avoid sensitive hardgrounds, as the preference will be to have a level surface area to facilitate spudding and installation of the wellhead.

These mitigation measures reduce the impact to medium significance, because CBA Natural areas will still be impacted (Table 8.2). Therefore, as complete avoidance mitigation is not possible, an offset or a compensatory mechanism needs to be developed as part of a Biodiversity Action Plan (BAP) (see Section 9.2.1).

Table 8.1. Impact 1a: Loss of benthic habitat and disturbance/mortality of infauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Long term	Medium	Low	**LOW**	- 've	High
Essential mitigation measures — avoid at source • Technical studies must be undertaken to inform the pipe laying method to inform if trenching will be required and if so, to minimise the amount of trenching required. This will minimise the unavoidable impacts of increased suspended sediment and sedimentation rates in the vicinity of pipelaying activities.								
With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	- 've	High

Table 8.2. Impact 1b: Loss of benthic habitat and disturbance/mortality of epifauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	High	Local	Permanent	High	High	**HIGH**	- 've	High
Essential mitigation measures — avoid at source • Pre-installation site EBS ROV surveys must be undertaken to identify sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops) within the proposed are of interest. These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform construction plans with the aim to provide a one km radius buffer to any sensitive communities, habitats or structures. • Ensure installation of pipelines and manifolds locations are not located within a one km radius of MPAs or EBSAs. • Pipeline routing must be optimised to minimise the unavoidable impacts of increased suspended sediment and sedimentation rates in the vicinity of pipelaying activities. **Essential mitigation measures — abate at source** • Anchors and chains should be laid prior to rig arrival to minimize risk of impact to sensitive benthic components by increasing accuracy of positioning in accordance with the anchor-spread and mooring analysis, as optimal placement is ensured by monitoring anchor handling operations by ROV (DNV 2013, cited in Oak 2020). • Anchor chains should be given buoyancy by partly replacing chains with fibre (nylon) wire and attaching buoys to reduce the risk of damage to fragile species by extending the point of anchor chain touchdown and reducing the potential horizontal footprint (as sideways movement decreases further from the rig) (DNV 2013, cited in Oak 2020). • The impact is regarded as permanent but may be mitigated to some extent by the choice of pipeline material, as some sessile rocky shore and reef organisms are predicted to recolonize the concrete and pipeline surface in time. Further mitigation measures include minimising the surface area impacted by cementing. Alternatively bolting the pipeline directly to the rocky substratum or to concrete bases would minimize the area impacted. • Cement spillage to the marine environment must be minimised. **Essential mitigation measures — compensate/offset** • If complete avoidance mitigation is not possible, an offset/compensatory mechanism needs to be developed as part of a Biodiversity Action Plan (BAP) is required (see Section 9.2.1).								

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
With mitigation – without offset/com-pensation	Medium	Local	Permanent	Medium	High	**MEDIUM**	- 've	High
With mitigation – with offset/com-pensation	Low	Local	Permanent	Low	High	**LOW**	- 've	High

8.2.2 BIOCHEMICAL AND TOXICITY WATER COLUMN AND BENTHIC IMPACTS RELATED TO THE DISCHARGE OF DRILLING FLUID AND CUTTINGS

Drilling of the production wells will use of drilling muds to lubricate the drill bit and to maintain well pressure (Dalmazzone *et al.* 2004, Atkinson 2010). Once complete, the drill fluids are recovered as far as possible, and the reminder, along with the cuttings (to which some drill fluid inevitably remains adhered) is disposed of, either onshore in authorised land fill sites or discharged to sea (Dalmazzone *et al.* 2004, Atkinson 2010).

It is expected that drilling will be undertaken using Water Based Muds (WBMs). The primary impacts include direct toxicity and bioaccumulation. The effects may be of significance in terms of:

- Chronic accumulation of persistent contaminants in the marine environment;
- Acute or chronic effects on biota and within the human food-chain (i.e., indirect effects on human health and commercial interests); and,
- Acute or chronic effects on other biota (i.e., indirect effects on biodiversity).

Some laboratory testing results of WBMs suggest that they constitute a low risk of chemical toxicity to marine communities and are not considered to be acutely lethal (96h LC_{50}) to a wide array of marine animals (see Cranford *et al.* 1999). Indeed, impacts of WBM discharge on the benthos derive mainly from sedimentation impacts (assessed in Section 8.2.3) (Ellis *et al.* 2012, Paine *et al.* 2014, Blood 2015). However, some High Performance WBMs, particularly those containing glycols or organic long chain screen blinding polymers, have also been found to cause temporary organic enrichment of sediments, resulting in a reduction in abundance, biomass and diversity of sensitive macrofaunal species, although enrichment effects on tolerant species have also been reported (Schaanning *et al.* 2008, Trannum *et al.* 2010, 2011, Paine *et al.* 2014). Modelling results show that the primary environmental impacts of drill discharge and cuttings release during the proposed drilling in the western Project Development Area of 11B/12B are linked to the discharge of particle matter, and in particular, the release of barite (PNEC of 0.115 mg/L) and bentonite (PNEC of 0.170 mg/L), and of barite in the eastern Exploratory Priority Area (Ditlevsen 2023, HES 202a,b, see Section 6). Barite makes up 70-80% of the WBMs used for drilling during the riserless stage (Neff 2005).

Particulate barite is almost insoluble and non-biodegradable. While the toxicological effects of barium on faunal communities have not been accurately quantified, dilute suspensions of barite have been shown to inhibit food ingestion rates leading to reduced growth rates and increased mortality in the scallop *Placopecten magellanicus* (Muschenheim & Milligan 1996, from Atkinson 2010). This sensitivity appears to be related to the suspended particulate barite (as the least soluble inorganic salt of barium, see Neff 2002), which physically affects filter feeding structures (in this case, gills) rather than direct toxic effects (Atkinson 2010). More recent studies have identified that responses of benthic communities to high concentrations of barite may be due to factors other than just physical disturbance (Trannum *et al.* 2010). Other studies have shown no deleterious effects of barite on a single polychaetae species *Mediomastus ambiseta* (Starczak *et al.* 1992), and that the effects of barite are more likely to be detected at a community level than at individual species levels (Olsgard & Gray 1995, in Atkinson 2010).

For the proposed production wells in the Project Development Area, no more than 44 km^2 of bottom water column will experience elevated concentrations of barite and bentonite for more than 5 days at a time (assuming one well is drilled at a time) (Section 6). Cumulatively, should all six production wells be drilled, the impact will last for a total of up to 30 days. Impacts in the surface water are modelled to affect a larger area of up to 126 km^2, lasting two days (Section 6). Depending on the drill site, the area of impact on the surface waters may extend into highly sensitive areas like the Southwest Indian Seamounts Marine Protected Area to the southwest of the 11B/12B Production Right Application Area (Section 6). The extent of overlap of environmental risk (i.e., where more than 5% of the species are exposed above their chronic No Observed Effect Concentration) covers at maximum 10% of surface water area of the area of the MPA (in spring, for Discharge-5, see Section 6). Impacts in the bottom water are modelled to affect an area of up to 204 km^2 (~4.5% of the MPA) and persist for about 5 days (Section 6).

For the proposed eastern Exploratory Priority Area wells (Discharge-1), significant risk in the water column was modelled to occur 8.5-9.5 km (at 1 200-1 300 m depth), and 18-34 km away from the discharge point (at 0-100 m depth below sea surface) toward west/south-west (Section 6). For Discharge-2, the worst-case EIF occurred in spring, with significant risk in the water column modelled to occur up to 35 km away (at 600-700 m depth), and 18-34 km away from the discharge point (at 0-100 m depth below sea surface) toward west/south-west (in the spring, this plume extends 12 km west and 5.5 km south-east) (Section 6). While this risk is significant, it is intermittent and of limited scale (restricted to small patches around the drill site) and duration, persisting for 11.8-13.5 days and 4.2-15.9 days respectively (when EIF>0) and disappearing completely after operations end (in both cases, after 43 days) (Section 6).

Another biochemical effect of the proposed well drilling and resultant cuttings discharge is that hypoxic or anoxic (i.e., low oxygen) conditions on the seafloor may potentially develop as a result of drill discharge cuttings (Trannum *et al.* 2010). This is thought to be the result of low bottom current speeds (Atkinson 2010 reported bottom water current speeds of ~ 0.128 m/s in the Block 11B/12B Production Right Application Area) in combination with direct mortality of benthic fauna in the cuttings discharge site, subsequent organic enrichment and decomposition thereof (Biccard *et al.* 2018). These processes in turn can affect the chemical properties of the upper sediment layers by generating potentially toxic concentrations of sulphide and ammonia. While mobile species can actively avoid hypoxia which may render them more vulnerable to predation, hypoxia poses a greater risk to immobile or sedentary benthic species, which can die as a result of exposure to drilling muds thereby changing the species composition of the community (Biccard *et al.* 2018). It must be noted however, that benthic communities on the southern coast of South Africa are well adapted to 'natural', productivity driven low-oxygen events, and are characterised by species that are either tolerant to hypoxic conditions or are fast-growing and rapidly able to recruit into areas that have suffered oxygen depletion.

The dispersion modelling results show the worst-case biochemical impacts on the sediment for proposed drilling activities for wells in the western Project Development Area occurs over an area of 150 m^2, which was assessed as posing a low risk of anoxic conditions developing beneath deposited cuttings. Indeed, for the western Project Development Area wells, the primary environmental impacts of drill discharge and cuttings release on sediments is burial, and grain size change, while the latter is the most important factor for the eastern Exploratory Priority Area wells (Section 6, assessed in more detail in Section 8.2.3 below). Should anoxic conditions develop as a result of these smothering effects, these are limited to within the footprint of the WBMs depositional area, where they would have an impact of medium consequence on benthic macrofauna (Atkinson 2010, Blood 2015). However, model results for Discharge-1 and 2 show that there is little to no risk of oxygen depletion in the sediment as a result of the well drilling and discharges, because of limited biodegradation of the chemicals in the sediment resulting from the physical and chemical properties of the chemicals used (HES 2020a, b) (Section 6.4.2).

Cementing of the drill well will be undertaken to form a cement sheath that can provide structural support for the casings, to seal off different areas, and protect the casing from corrosive fluids (Newlove *et al.* 1984, Adjei & Elkatatny 2020). Typically, cement and cement additives are not discharged from drilling units. However, during the initial cementing operation, excess cement emerges out of the top of the well and onto the seafloor to ensure the conductor pipe is cemented all the way to the seafloor (Biccard *et al.* 2018). Well cementing offshore is generally undertaken using Portland cements, which are "defined as pulverised clinkers consisting of hydrated calcium silicates and usually containing one or more forms of calcium sulfate. The raw materials used are lime, silica, alumina and ferric oxide" (Pisces 2014b). Various chemical additives are used in the cementing programme to control its properties, including setting retarders (natural lignosulfonates, cellulose and sugars derivatives) and accelerators (most commonly Calcium Chloride), extenders (such as bentonite or sodium silicate), surfactants (most commonly Polypropylene glycols), and defoamers (silicones), with the formulations adapted to meet the requirements of a particular well (Broni-Bediako *et al.* 2016). It has been reported that these additives constitute less than 10% of the overall cement used and have a low toxicity to marine life (Pisces 2014b, Blood 2015). Therefore, the impact related to the discharge of the excess cement around the wellbore and leaching of the additives into the surrounding water column is considered to be extremely localised, the duration short term and the intensity very low (Table 8.3).

Assuming that the WBMs to be used in drilling the initial section of the well do not contain spotting fluids or lubricating hydrocarbons, the unmitigated impacts of discharges of these drilling fluids to both the water column and the sediments are considered of low significance (Table 8.3). The area affected by discharged drilling fluids/cuttings would be relatively localised with impacts that can extend up to 35 km in the lower water column (for the eastern sites), depending on the site of the well (Section 6). Given the importance of the area in general for VME indicator species (both within and outside of the MPAs and EBSAs), the benthic sensitivity of the proposed drilling area is considered to be high (Section 3.3.2).

Project Controls include the following:

- Should the WBMs not be able to provide the necessary characteristics for effective drilling during the risered phase, a low toxicity non-aqueous drilling fluid (NADF) will be used. In this instance, a zero-discharge strategy will be implemented (i.e., cuttings with NADF will be shipped to shore for disposal).

- Risered cuttings will be discharged via a caisson at greater than 5 m below surface.
- Monitoring and management measures must be implemented in accordance with standard well control practices to assist in detection and control of uncontrolled releases.
- Every effort should be made to prevent the generation of excess cement and cement additives and disposal of these elements should be minimal.
- Maintain a full register of Material Safety Data Sheets (MSDSs) for all chemicals used, as well as a precise log file of their use and discharge.
- A Waste and Discharge Management Plan must be developed for all wastes generated at the various sites and a Chemical Management Plan must be developed to detail the storage and handling of chemicals, as well as measures to minimise potential pollution.

This potential impact cannot be eliminated due to the nature of the drilling approach and the necessity for the use of WBM # in the drilling process. The proposed mitigation measures would reduce the intensity of the impacts of the discharge of drilling fluid and cuttings from medium (for WBMs) to low (Table 8.3).

Table 8.3. Impact 2: Biochemical and toxicity risks associated with the discharge of drilling fluid and cuttings.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation – WBMs	Medium	Local	Medium term	Low	High	**LOW**	-'ve	High
Without mitigation – cement	Very Low	Site	Medium term	Very Low	High	**LOW**	-'ve	High
Essential mitigation measures — avoid/abate at source • Pre-installation site EBS ROV surveys must be undertaken to identify sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops) within the proposed are of interest. These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform construction plans with the aim to provide a one km radius buffer to any sensitive communities, habitats or structures • While the final position of the proposed wells has not been finalised, these modelling studies focused on worst-case scenarios. However, should the drilling methodology change from what has been modelled in these studies, additional modelling will need to be conducted prior to the commencement drilling to assess whether the impact plume (PEC/PNEC > 1) in the bottom water column is expected to intersect with any sensitive species (VME indicators), areas (such as MPAs or EBSAs), habitats or structures. • Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected. • All process areas on board operational vessels should be bunded to ensure drainage water flows into the closed drainage system. • Drip trays should be used to collect run-off from equipment that is not contained within bunded areas, and the contents routed to the closed drainage system. **Essential mitigation measures — abate at source** • Ensure only low-toxicity, low bioaccumulation potential and partially biodegradable additives are used in drilling fluid and cement. • Avoid excess cement usage by using a ROV to monitor discharges to the seafloor around the drill casing. • Low-toxicity biodegradable detergents should be used in the cleaning of deck spillages.								
With mitigation	Medium	Local	Medium term	Low	High	**LOW**	-'ve	High

8.2.3 TURBIDITY AND SMOTHERING IMPACTS ASSOCIATED WITH THE DISCHARGE OF DRILLING MUDS AND CUTTINGS

Discharge of drilling muds, fluids and cuttings have a potentially adverse impact on the environment, in that their discharge directly onto the seafloor adjacent to the wellbore where they would primarily have a smothering impact on sedentary benthic species.

The cuttings of a single well drilled as per the proposed project activities (Section 1.2.2) is estimated to produce a maximum total cuttings weight of 694 metric tonnes discharged at the surface, and 421 tonnes discharged directly to the seafloor (as modelled by Ditlevsen 2023, see Figure 6-4). The hypothetical dispersion and fates of cuttings following discharge to the ocean are shown in Figure 8-1.

The unmitigated impacts of smothering are both direct (mortality and clogging of feeding mechanisms) and indirect (loss of benthic prey to predators, possible disturbance to spawning and/or recruitment). In addition, increased turbidity can also impact light penetration, particularly in shallow marine waters. The cuttings form a highly localised cone-shaped spoil mound around the wellbore, which gets thinner towards the periphery (Section 6). The magnitude of the unmitigated impact on benthic fauna is dictated by the amount of sediment (i.e., depth of burial), the life-history derived tolerances of species to smothering (i.e., filter feeders are more sensitive that deposit feeders), the duration of impact, and the nature of the depositing sediments (SRL 2021). In areas where natural sedimentation rates are high (e.g., in proximity to river mouths or wave-disturbed shallow waters), the ability of taxa to migrate through deposited sediments is likely to be high. On the other hand, relatively immobile species occurring in areas where sedimentation rates are naturally low would be more susceptible to smothering such as in the deeper waters of the Application Area below the 200 m isobath (Blood 2015).

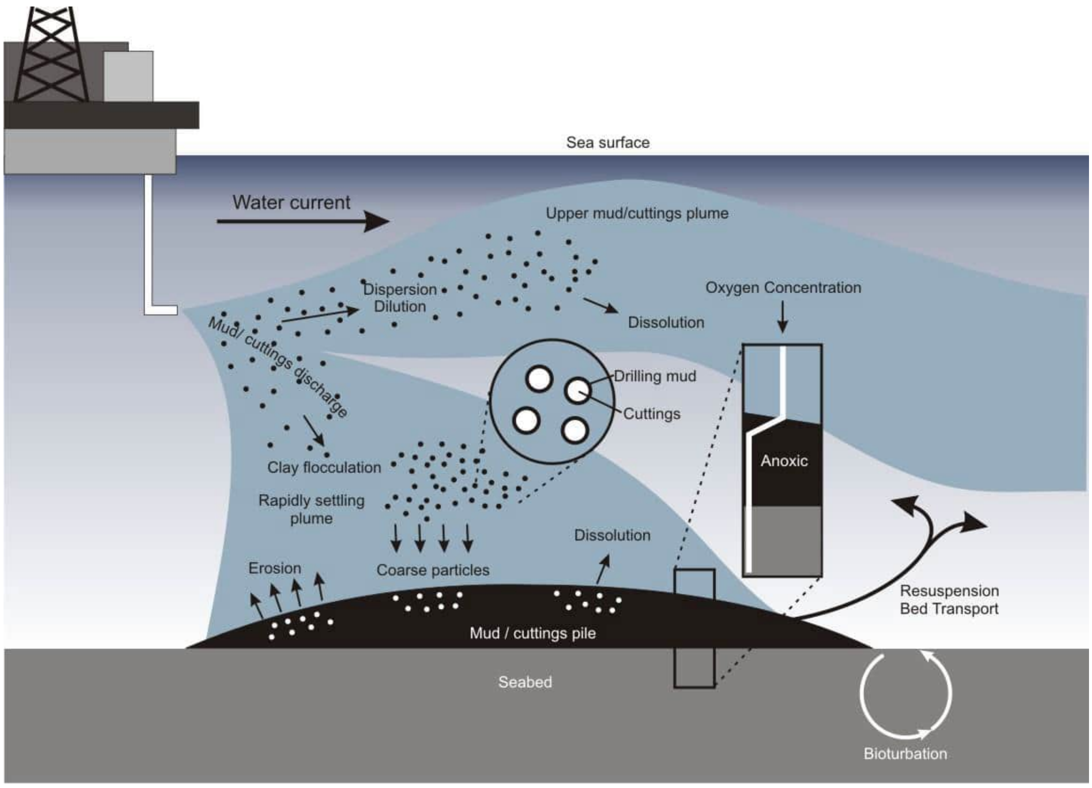


Figure 8-1. The fate of drill cuttings (adapted from Neff 2005).

It is noted that turbidity plumes arising from the drilling of wells and discharge of cuttings would cease to exist on completion of drilling activities. No further increased turbidity would be expected during extraction of the resource, unlike offshore diamond or phosphate mining where resource extraction continually produces turbidity plumes (Biccard *et al.* 2018). Increased turbidity of near-bottom waters through disposal of cuttings at the wellbore and sea surface may place transient stress on sessile and mobile benthic organisms, by negatively affecting filter-feeding efficiency of suspension feeders or through disorientation due to reduced visibility (Blood 2015). However, in most cases, sub-lethal or lethal responses occur only at concentrations well in excess of those anticipated at the wellbore.

The dispersion modelling results show the primary environmental impacts of drill discharge and cuttings release on sediments is linked to burial and grain size change (Section 6). Modelled impacts on sediment deposition thickness after 10 years (assuming no simulation of sediment redistribution) shows that sediment deposition will either occur predominately in a southwest pattern, or in a more uniform pattern closer to the drill site, depending on site selection (Section 6). Sediment deposition is modelled to cover a relatively small area of seabed for each drilled well — for Discharge-4 and Discharge-5, under the worst-case scenario, deposition of 30 mm thick will be present in an area of approximately 0.005 km^2 around the drilling site after 10-years, with a deposition of 6.5 mm (i.e., the defined PNEC for burial) covering an area of approximately 0.175 km^2 (Section 6). For Discharge-1 and Discharge-2, the area of deposition (0.1->20 mm thick) occurs over an (unsmoothed) area of 0.07 km^2 and 0.03 km^2, respectively (Section 6).

For Discharge-1 and 2, there is no predicted environmental risk in the sediments four years after operations (Section 6). Deposited material in the sediment is modelled to occur relatively close the discharge point for Discharge-1 (up to 225 m around the well in the spring) but extend further away for Discharge-2 (400 m to the west/south-west in autumn), with grain size change assessed to be the primary environmental impact. Simulations show that impact on the sediment caused by discharge from the rig at the eastern wells are higher than that of the western wells (Discharge-4 and 5) across all seasons, with EIF > 1 and are higher for Discharge-2 than Discharge-1 (Section 6). The area of risk (where PNEC >5) for sediments is lower for Discharge-1 than Discharge-2, with an area of impact of 2 500-5 000 m^2 for Discharge-1, and 5 000-10 000 m^2 for Discharge-2 (base case drilling) (Section 6). The extended drilling scenario (Scenario 5) results in a much larger area of impact of 27 500 m^2 for Discharge-2 (Section 6).

The unmitigated impact of smothering as a result of drilling and tailings discharge is highly dependent on the community composition of the site. Changes in abundance and diversity of **infaunal**, benthic communities in response to deposited cuttings are typically detected within a few hundred metres of the discharge, with recovery of the benthos observed to take from several months to several years after drilling operations had ceased (Thiel & Schriever 1990, Bluhm *et al.* 1995, Jennings & Kaiser 1998, Atkinson 2010, Biccard *et al.* 2018). The impact is localised, and recovery is expected within five years (Section 6); therefore, given the relatively small impact footprint, it is expected that the benthic macrofaunal community would recover to a point within the range of natural variability (i.e., where the effects of the impact(s) are no longer discernible) relatively quickly after the cessation of drilling. The smothering effects resulting from the discharge of drilling solids at the wellbore is therefore assessed to have an unmitigated impact of medium intensity on the infauna of unconsolidated sediments in the cuttings footprint, whereas discharges from the drilling unit would have a low intensity impact (Table 8.5). As such, the unmitigated impact on infaunal communities is therefore assessed as of low significance (Table 8.4).

The relatively short duration of the turbidity plumes and their small spatial extent is expected to have negligible potential negative impacts on the **pelagic system communities** (namely on phytoplankton and ichthyoplankton production, fish, cetacean and turtle migration routes and spawning areas). The impact of increased turbidity in the water column and elevated suspended sediment concentrations on pelagic communities are considered to be localised, short term (days), of slight consequence and ultimately of very low significance with mitigation (Table 8.5). Considering the depth of the proposed drilling activities (approximately 200 m) there is rarely any significant light penetration at these depths (NOAA 2023) and therefore unmitigated impacts of turbidity increases on light availability at this depth are considered negligible (Table 8.7).

However, the impacts of the by-products of oil exploitation, including drill cuttings, drill mud, and wastewater discharge, can smother and ultimately negatively impact sensitive deep water **epifaunal** communities as described in Section 3.3.2, including cold water coral (Roberts & Cairns 2014). For example, exposure to fine sediments and drill cuttings has been shown to slow skeletal growth in coral species *Lophelia pertusa*, which are relatively well adapted to an environment with active near-bed sediment fluxes (Larsson *et al.* 2013) (note, however, that in this study, the corals were exposed to exposed to suspended particles (<63 µm) for 12 weeks). Modelling results indicate that environmental effects in the lower water column are expected to ensure for a very short duration, up to 2.5 days maximum. However, benthic effects are modelled to endure for up to five years (Section 6). Therefore, should the cuttings footprint overlap with vulnerable communities on hard ground, the smothering effects could potentially have an impact of substantial consequence, and recovery would only be expected over the medium to long-term (>10 years) due to their long generation times. Prior to mitigation, this impact is considered to be of high significance (Table 8.6).

Project Controls include the following:

- Risered cuttings will be discharged via a caisson at greater than 5 m below surface.
- Monitoring and management measures must be implemented in accordance with standard well control practices to assist in detection and control of uncontrolled releases.

Mitigation includes undertaking pre-installation site EBS ROV surveys to ensure that the drilling locations are not located within a one km radius of any sensitive species, areas (such as MPAs or EBSAs), habitats or structures (given the drill modelling results presented in Section 6) (Table 8.4). With the implementation of these mitigation measures, the impacts on infauna can be reduced to low significance (Table 8.4), to very low significance for pelagic fauna (Table 8.5) and low for benthic epifauna, provided that pre-drilling site ROV surveys are untaken to ensure drilling activities do not disturb or destroy sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops) and that drilling/drill discharge do not take place within a one km radius of any sensitive species, areas (such as MPAs or EBSAs), habitats or structures.) (Table 8.6).

Table 8.4. Impact 3a: Benthic impacts associated with the discharge of drilling muds and cuttings on infauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Medium term	Low	Medium	**LOW**	- 've	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Essential mitigation measures — avoid at source • Pre-installation site EBS ROV surveys must be undertaken to identify sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops) within the proposed are of interest. These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform construction plans with the aim to provide a one km radius buffer to any sensitive communities, habitats or structures. **Essential mitigation measures — abate at source** • Innovative technologies and operational procedures for drilling solids discharges should be considered to minimise the impacts when drilling tophole sections to limit the extent of dispersion.								
With mitigation	Medium	Local	Medium term	Low	Medium	**LOW**	- 've	High

Table 8.5. Impact 3b: Impacts of elevated turbidity on pelagic marina biota.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Short term	Very Low	Medium	**VERY LOW**	- 've	High
Essential mitigation measures — abate at source • Innovative technologies and operational procedures for drilling solids discharges should be considered to minimise the impacts when drilling tophole sections to limit the extent of dispersion.								
With mitigation	Low	Local	Short term	Very Low	Medium	**VERY LOW**	- 've	High

Table 8.6. Impact 3c: Benthic impacts associated with the discharge of drilling muds and cuttings on epifauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	High	Local	Long term	High	High	**HIGH**	- 've	High
Essential mitigation measures — avoid at source • Pre-installation site EBS ROV surveys must be undertaken to identify sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops) within the proposed are of interest. These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform construction plans with the aim to provide a one km radius buffer to any sensitive communities, habitats or structures. **Essential mitigation measures — abate at source** • Innovative technologies and operational procedures for drilling solids discharges should be considered to minimise the impacts when drilling tophole sections to limit the extent of dispersion. **Essential mitigation measures — compensate/offset** • If complete avoidance mitigation is not possible, an offset/compensatory mechanism needs to be developed as part of a Biodiversity Action Plan (BAP) is required (see Section 9.2.1).								
With mitigation – without offset/com-pensation	Medium	Local	Long term	Medium	High	**MEDIUM**	- 've	High
With mitigation – with offset/com-pensation	Low	Local	Long term	Low	High	**LOW**	- 've	Medium

Table 8.7. Impact 3d: Impacts of elevated turbidity on light penetration

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Short term	Very Low	Low	**NEGLIGIBLE**	- 've	High
Essential mitigation measures — abate at source • Innovative technologies and operational procedures for drilling solids discharges should be considered to minimise the impacts when drilling tophole sections to limit the extent of dispersion.								
With mitigation	Low	Local	Short term	Very Low	Low	**NEGLIGIBLE**	- 've	High

8.2.4 THE IMPACTS OF DRILLING NOISE ON MARINE MEGAFAUNA, FISH, TURTLES AND AVIFAUNA

The drilling of up to six development wells is proposed for the Project Development Area using a semi-submersible drilling unit, supported by one or two tugboats and supply vessels (WSP 2023b). The source of noise related impacts associated with this activity include operation of the drill unit itself, as well as support tugs and supply vessels. As outlined in Section 5, anthropogenic noise can have both direct and indirect negative impacts on marine fauna, by causing direct physical injury to hearing or other organs, (including permanent or temporary threshold shifts), causing disturbance resulting in behavioural changes or displacement from important feeding, breeding or spawning areas, and through masking or interfering with other biologically important sounds (e.g. communication, echolocation, signals and sounds produced by predators or prey).

To address these impacts, an underwater noise modelling study was undertaken by WSP (2023b). Two scenarios were modelled: 1) a worst-case scenario, where an animal would be exposed to drilling noise for the entire 24 hours, and 2) an exposure to drilling noise of 30-minute period, assuming the likelihood that an animal would move away from the source of the noise (Section 5.4.1). The study considered these scenarios at two sites, both close to the coast and sensitive areas (see Figure 5-1). The model results indicate that the peak pressure levels generated by the drilling units are sufficient to cause permanent (permanent threshold shifts) and temporary direct physical injury (temporary threshold shifts) to hearing in marine mammals and sea turtles, as well as death or injury to fish (Table 5.3 and Table 5.4).

Based on the worst-case 24-hour exposure noise modelling results, baleen whales (southern right whale *Eubalaena australis*, humpback whale *Megaptera novaeangliae*) and other Very High-Frequency Cetaceans (pygmy sperm whale *Kogia breviceps*, dwarf sperm whale *K. sima*) are likely to be impacted the most with temporary impacts modelled to occur at 9 km and 8.6 km respectively, and permanent injury thresholds predicted to occur at distances of about 250 m and 50 m respectively (Table 5.3). The impacts on High Frequency Cetaceans (common dolphin *Delphinus delphis*, killer whale *Orcinus orca*, Atlantic bottlenose dolphin *Tursiops truncatus*, short-finned pilot whale *Globicephala macrorhynchus*) is much smaller, with temporary impacts anticipated at distances of less than 400 m, and permanent injury thresholds predicted to occur at distances of about 10 m (Table 5.3). For turtles, permanent injury is predicted to occur at 10 m from the source of noise, while temporary impacts are expected within 330 m (Table 5.3). For fish with a swim bladder, TTS impacts (i.e., a temporary loss of hearing sensitivity) is predicted to occur only very close to the drilling activity (within 160 m) (Table 5.4).

Temporary effects (TTS) and permanent effects (PTS) are much smaller for the 30-minute exposure scenarios. The maximum 30-minute exposure TTS distance was modelled as 790 m for very high-frequency cetaceans, and 380 m for frequency cetaceans, while the maximum 30-

minute exposure PTS distance was modelled as 20 m for low frequency cetaceans and very high-frequency cetaceans (Table 5.3).

It is considered likely that most of these highly mobile pelagic species would move away once noise activities commence, with species likely leaving the area. However, this has a cost, and as such, behavioural effects of noise were also considered as part of the modelling study, which includes impacts on individual health and fitness, foraging efficiency, avoidance of predation, swimming energetics and reproductive behaviour (Popper & Hawkins 2016). The maximum thresholds of behavioural disturbance from the drilling source were shown to be 66 km for marine mammals in all hearing groups, 11.8 km for penguins / diving birds, and 10 m for turtles (Table 5.5, Figure 5-5). The implications thereof are described below:

- The maximum impacted area for behavioural disturbance at any point in time will equate to some 13 684 km^2 for whales (Figure 8-2). Assuming drilling occurs at the closet landward boundary of the Block 11B/12B preferred production area, there is an overlap of impact of some 3 582 km^2 with the Southern Coastal and Shelf Waters IMMA, representing an overlap of <3% of the IMMA. Based on occurrence probability data presented in Section 3.3.7, the species at highest risk of behavioural impacts include humpback whales in the summer (slightly less so in the winter), sperm whales year around, killer whales and Risso's dolphin (Figure 3-22 and Figure 3-23). MMO observational data indicates that species likely to be impacted include killer whale, striped dolphin, sperm whale (Vulnerable), long-beaked common dolphin, common bottlenose dolphin, pilot whale, False killer whale (Near Threatened) and Risso's dolphin along with humpback whales and Sei whales (Endangered) (CapMarine 2020a, b, BSL & CapMarine 2023). While Southern right whales are the most abundant baleen whales off the coast of South Africa, they were not recorded in the Block during the 2019-2020, or 2022 MMO surveys (CapMarine 2020a, b, BSL & CapMarine 2023).

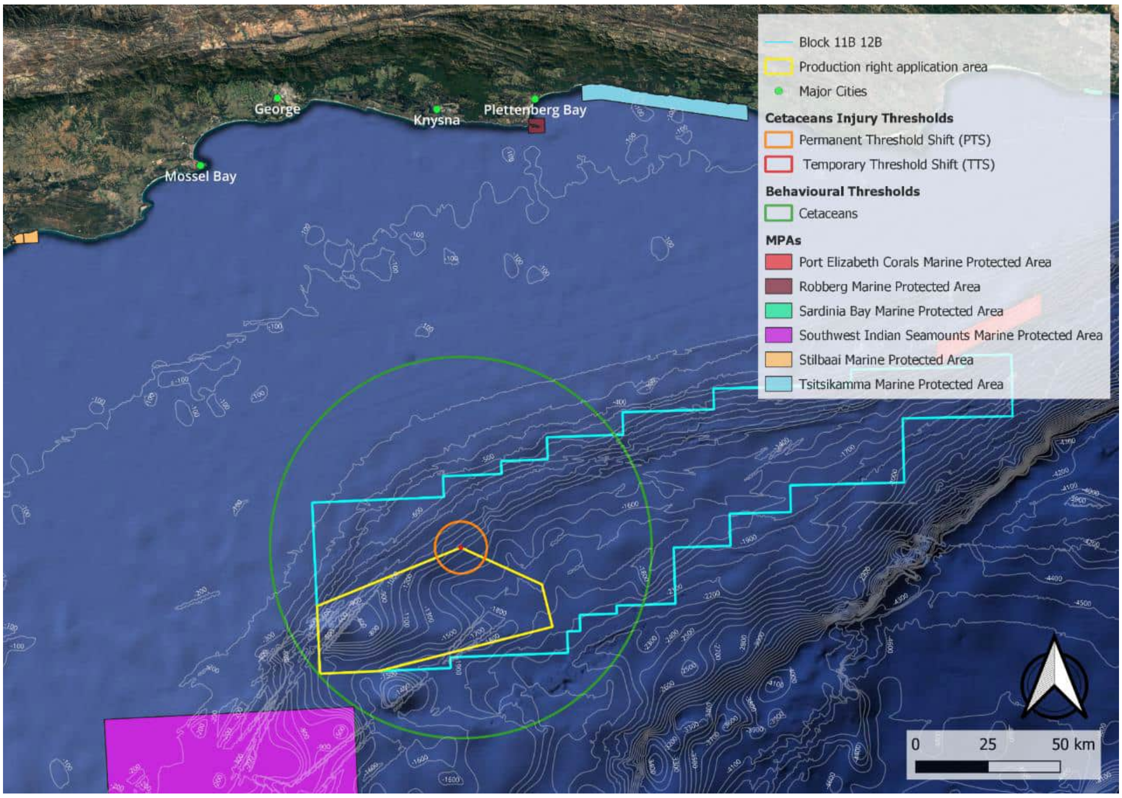


Figure 8-2. Noise modelling study predicted zone impact on cetaceans by proposed drilling activities (worst-case, 24-hour exposure). The area of predicted behavioural impacts is indicated by the green circle, the areas of Temporary Threshold Shifts (TTS) is shown in orange and Permanent Threshold Shifts (PTS) in red.

- The maximum impacted area for behavioural disturbance at any point in time will equate to some 437 km^2 for penguins / diving birds. While Algoa Bay penguins have been recorded as far as 60 km offshore following pelagic shoaling fish species within the 200 m isobath (Section 3.3.5), the closet landward boundary of the Block 11B/12B preferred production area lies more than 140 km offshore below the 200 m contour, and more than 190 km from the De Hoop penguin colony. As such, penguin behaviour is unlikely to be directly impacted by drilling activities within the Production Right Application Area (Figure 8-3). Cape gannets have been reported 100 km offshore in Block 11B/12B, and Cape cormorants have been reported up to 80 km from their colonies (Section 3.3.5). Other bird species of concern that may occur in the Block 11B/12B Production Right Application Area which may be affected behaviourally by underwater noise impacts include the Shy albatross (Near Threatened, regular surface diving species), the Indian yellow-nosed albatross and Atlantic yellow-nosed albatross (both Endangered surface diving and occasional surface plunging species), the White chinned petrel and Spectacled petrel (both Vulnerable, surface diving, species) and the Sooty shearwater (a Near Threatened surface diving, pursuit-diving, surface plunging species) (Table 3.6). These birds may be impacted when submerged during feeding. However, most birds are submerged for a very short period of time, and given relatively small area of predicted behavioural impact compared to the total habitat availability (Figure 8-3), these species are unlikely to be impacted behaviourally by drilling activities within the preferred production area to a degree that impacts broader population dynamics especially if sufficient mitigation is implemented.

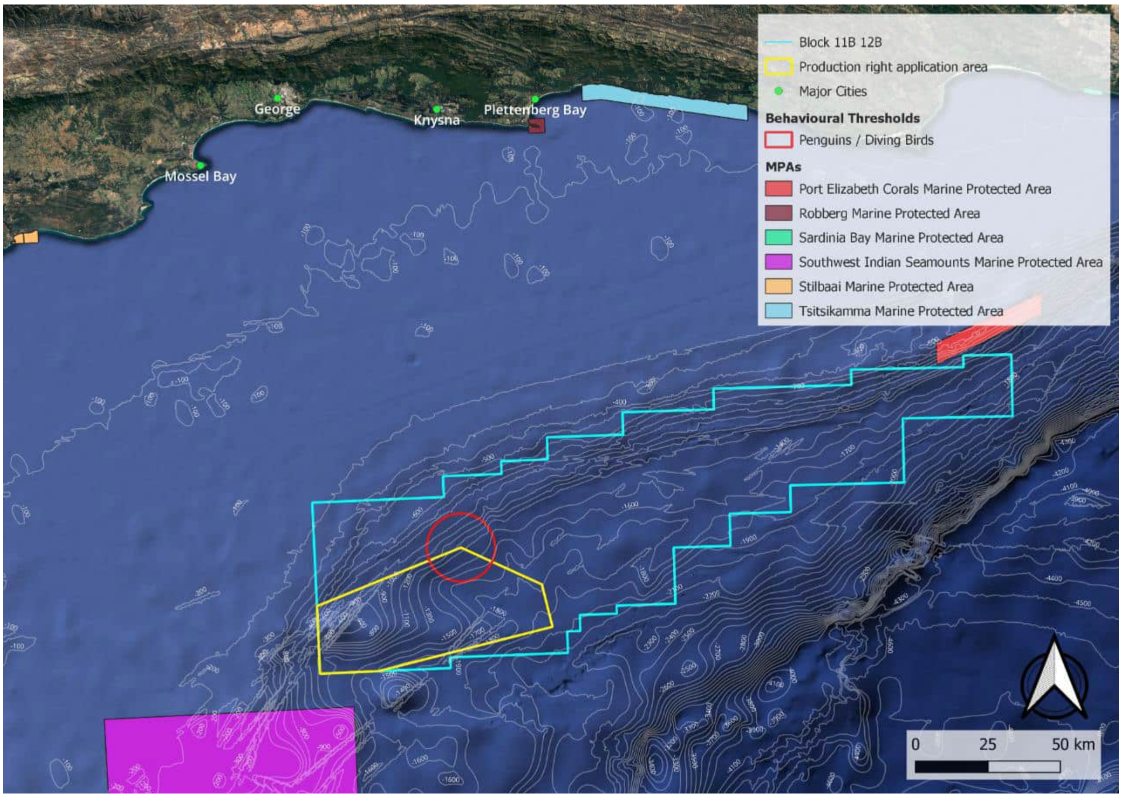


Figure 8-3. Noise modelling study predicted zone impact of proposed drilling activities on penguins / diving birds. The area of predicted behavioural impacts is indicated by the red circle.

While the area impacted is small relative to the available habitat, it does intersect with major cetacean migratory routes, and while drilling activities are unlikely to cause a significant, irreversible change in habitat use of these species, receptor sensitivity is assessed as high. It is expected that the type of noise pollution resulting from proposed drilling activities will affect species that may be present/migrating through the 11/12B Production Right Application Area that includes Endangered and Critically Endangered species of turtles, seabirds, cetaceans, large fish, and sharks, which have the potential to be directly harmed by the drilling noise sources. The impact duration is assessed to be of short-term duration (Table 8.8). While impacts have the potential to be permanent (in the case of PTS), model results show that species have to be within 10-400 m of the noise source (for 24-hour exposure) and within <10-20 m (for 30-minute exposure) for permanent threshold shifts/injury to occur.

This is considered to be highly improbable, considering the greater size of the area of behavioural impacts and because most pelagic species likely to be encountered within the licence area are highly mobile, and would be expected to move away from the sound source before trauma could occur.

Given the sensitivity of the area, the recorded occurrence of a number of sensitive species within the site, and the uncertainty surrounding the implication of behavioural impacts over the long term, the intensity of the impact is assessed as medium over 24-hours (Table 8.8). Based on the current proposed well development time frame (see Section 1.2.2), it takes around four months to drill and plug a well, and the total duration of production drilling is expected to last eight months in Year 0, four months in Year 1 and eight months in Year 10, amounting to 20 months of proposed drilling activities i.e., over the medium term.

The impact for 24-hour exposure is therefore assessed to be of medium significance prior to mitigation (Table 8.8). The smaller spatial scale of impact associated with the 30-minute exposure (see Section 5.4.1) means that fewer species are likely to be impacted (reducing the intensity of the impact to low), but the overall unmitigated impact is still assessed to be of low significance (Table 8.8).

Project Controls induce the following:

- TEEPSA and the drilling contractor will ensure that the proposed drilling activities are undertaken in a manner consistent with good international industry practice and BAT.
- All whales and dolphins are given protection under South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel.

Table 8.8. Impact 4: Drilling noise impacts on marine fauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation – 24-hour	Medium	Local	Medium term	Low	High	**LOW**	-'ve	High
Without mitigation – 30-minutes	Low	Local	Medium term	Very Low	High	**LOW**	-'ve	High
Essential mitigation measures — abate at source • An independent Marine Mammal Observer must accompany the pre-drilling survey to undertake validation of cetacean migration/distribution models. • In the unlikely event of a cetacean sighting within the Permanent Threshold Shift (PTS) threshold distance for the most sensitive species (400 m) immediately prior to drilling commencement, drilling may not commence until an independent Marine Mammal Observer confirms that no cetaceans are present within this PTS radius.								
With mitigation	Medium	Local	Medium term	Low	High	**LOW**	-'ve	High

8.2.5 THE IMPACTS OF NOISE ASSOCIATED WITH GENERAL CONSTRUCTION ACTIVITIES ON MARINE MEGAFAUNA AND AVIFAUNA

This noise will include sound produced by helicopters and construction vessels. These elevated noise levels may disturb faunal species resulting in behavioural changes or displacement from important feeding or breeding areas (direct negative impact).

HELICOPTER NOISE IMPACTS

It is assumed that helicopter transport is the preferred method of transfer from shore to site and that helicopters can also be used for medical evacuations from the drilling unit to shore (at day- or night-time). While the area of construction is lies 80-100 km offshore, the closest commercial airport is in George, and the aircraft will therefore cross over offshore and coastal MPAs, including some sensitive coastal receptors (such as key faunal breeding/feeding areas, bird or seal colonies and nursery areas for commercial fish stocks). In addition, migratory pelagic species transiting through the survey area may also be directly affected.

Offshore taxa most vulnerable to disturbance by helicopter noise are pelagic seabirds, turtles and cetaceans. Although species listed as globally Endangered or Critically Endangered may potentially occur within the proposed area of construction and the helicopter flight path (see Section 3), their numbers are expected to be low. Onshore, roosting and nesting seabirds and seals are most likely to be impacted by routine helicopter operations across the coastal zone during the construction phase. Some of the seabirds roosting and nesting along the coast are listed by the IUCN as Endangered and include the African Penguin, Bank Cormorant, Cape Cormorant and Cape Gannet.

Low altitude flights over bird breeding colonies could result in temporary abandonment of nests and exposure of eggs and chicks leading to increased predation risk. However, sensitivity of birds to aircraft disturbance is species specific, and is generally lessened with increasing distance or if the flight path is off to the side and downwind. Seals may also experience both visual and acoustic disturbance from low flying aircraft, given that the frequency of aircraft engine noise emissions also overlaps with the hearing ranges of seals (Croft and Li 2017). Although any observed response is usually short-lived, disturbance of breeding seals can lead to pup mortalities through abandonment or injury by fleeing, frightened adults. However, there are no seabird or seal colonies directly below or within 5 km of the potential flight paths between the George airport and the area of offshore construction activities (Figure 8-4). The nearest seabird colonies to George airport are on the Robberg Peninsula at Plettenberg Bay (some 85 km away), with further colonies to the east on the Algoa Bay Islands off Gqeberha, (some 100 km from the closest direct flight path) (Figure 8-4). Breeding and non-breeding sites for seals on the mainland include Seal Island in Mossel Bay (25 km to the west of the direct flight path), on the northern shore of the Robberg Peninsula in Plettenberg Bay and at Black Rocks (Bird Island group) in Algoa Bay (Figure 8-4) (Huisamen *et al.* 2011).

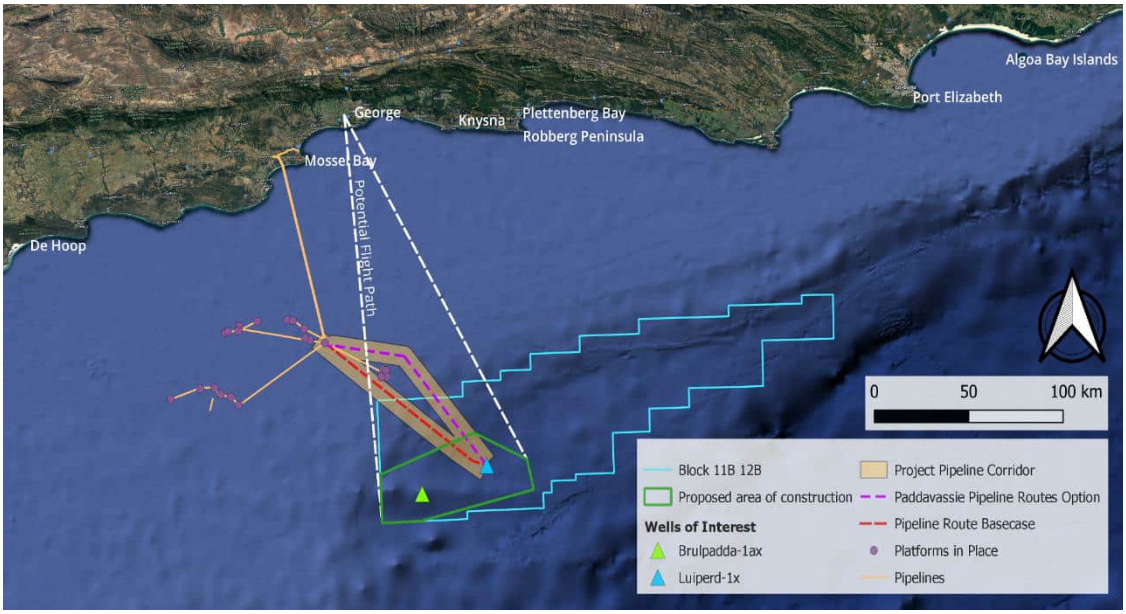


Figure 8-4. Area of potential flight paths (within dashed white lines) from George Airport to the proposed area of construction (green polygon).

Available data indicate that the expected frequency range and dominant tones of sound produced by helicopters overlap with the hearing capabilities of most cetaceans, both odontocetes and mysticetes (Richardson *et al.* 1995; Ketten 1998). Low altitude flights (especially near the coast) can have a significant disturbance impact on cetaceans during their breeding and mating season (Pisces 2020). The level of disturbance will depend on the distance and altitude of the aircraft from the animals (particularly the angle of incidence to the water surface) and the prevailing sea conditions. Of particular concern are the potential overlaps in flight paths with migrating Humpback whales and Southern Right whales inshore of the Application Area (the former April to December, with calving season from July to October, peaking in early August, and the latter June and November) (Best 2007). Southern Right whales utilise the sheltered bays of the South Coast to breed and calve, with winter concentrations recorded all along the southern and eastern coasts of South Africa, with the most significant concentration currently on the South Coast between Cape Town and Gqeberha. As per Section 3.3.7, it is highly likely that several hundred right whales can be expected to pass directly through the Application Area between May and June and then again November to January. Southern Right calving and nursing activities off the Mossel Bay coast would thus fall within the direct flight path. Smaller cetaceans in the area include the Indo-Pacific Humpback dolphin, which occurs as a localised population concentrated around shallow reefs in the Plettenberg Bay- Algoa Bay region. Other species of concern that are likely to be encountered frequently in the Application Area include the Vulnerable Bryde's whales (throughout the year, with peak encounter rates occurring in late summer and autumn), the Endangered Sei whale (peaking in abundance on the East Coast in June and September), and the Vulnerable Sperm whale (high probability throughout the year, increasing in winter). Note that, as per South African legislation, no vessel or aircraft may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft (Section 4.6.1).

For the development well drilling operations and laying of subsea infrastructure, worst-case estimates assume two trips per day, for a total of 480 trips in Year 0, 240 trips in Year 1 and 480 trips in Year 10 (total exposure of 720 days, or ~23 months). Exposure will however be limited in duration, only occurring for a short period twice per day, and of a temporary nature while the helicopter passes overhead (although regional in extent), indiscriminate or direct low altitude flying over seabird and seal colonies, or breeding cetaceans could impact fauna behaviour and breeding success. The level of impact will depend on the distance and altitude of the aircraft from the animals and the prevailing sea conditions at the time, the significance of the unmitigated impact is considered to be low with appropriate mitigation (Table 8.9).

The majority of the transient noise from helicopters will be reflected by the surface of the ocean, with helicopter noise documented to be detectible for less than one minute under water (Richardson *et al.* 1995, WSP 2023b). Therefore, underwater noise impacts from helicopter noise are expected to be much less than those from other project activities.

Project Controls include the following:

- The drilling contractor will ensure that the proposed project is undertaken in a manner consistent with good international industry practice and Best Available Techniques (BAT).
- All whales and dolphins are given protection under South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed , killed or fished. No vessel or aircraft may approach closer than 300 m to any whale and a vessel or aircraft should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m.

- The proposed project must be undertaken in a manner consistent with good international industry practice and Best Available Techniques. The operation of helicopters aircraft is governed by the Civil Aviation Act, 2016 (No. 6 of 2016) and associated regulations.

The generation of noise from helicopters cannot be eliminated if helicopters are required for crew changes. The proposed mitigation, specifically maintaining the regulation altitude over the coastal zone and flying perpendicular to the coast would reduce the intensity of the impact to very low, but the impact will remain of low significance (Table 8.9).

Table 8.9. Impact 5a: General construction noise impacts on marine fauna — helicopters.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Low	Regional	Short-term	Low	High	**LOW**	-'ve	High
Essential mitigation measures — avoid/abate at source • Ensure that all flight paths avoid the Mossel Bay (Seal Island seal colony) and Robberg Peninsula (seabird and seal colonies). • Maintain a flight altitude of at least 1 000 m during flight, except when taking off and landing or in a medical emergency. • Avoid extensive low altitude (<762 m or 2 500 ft) coastal flights by ensuring that the flight path is perpendicular to the coast, as far as possible. • Brief of all pilots on the ecological risks associated with flying at a low altitude along the coast or above marine mammals. • No hovering or circling over whales, dolphins, sharks, turtles or aggregations of sea birds.								
With mitigation	Very Low	Regional	Short-term	Very Low	High	**LOW**	-'ve	High

CONSTRUCTION VESSEL NOISE IMPACTS

Of all human-generated sound sources, the most prevalent in the ocean is the noise of shipping. An overview of the noise levels produced by various natural and anthropogenic sources, relative to typical background or ambient noise levels in the ocean is provided in Section 5.3. It is not anticipated that any blasting will be required during the construction phase, and the impacts of this on marine biota was thus not assessed. Drilling noise impacts are assessed separately in Section 5.

Vessel noise would primarily take place in the area of construction such as the installation of pipelines and the subsea production system, the production drill area and along the route taken by the support vessels between the drilling unit and port. The area of construction is located approximately 80-100 km offshore and is far removed from coastal MPAs and any sensitive coastal receptors (Section 4.2). The proposed pipeline Option route does however pass through the southwestern corner of the Kingklip Corals EBSA (Figure 4-2).

Migratory pelagic species transiting through the construction drill areas may be directly affected. The taxa most vulnerable to disturbance by underwater noise are turtles, large migratory pelagic fish and marine mammals. Some of the species potentially occurring in the Application Area are considered regionally or globally 'Critically Endangered' (e.g. Southern bluefin tuna, leatherback turtle and blue whale), 'Endangered' (e.g. Whale Shark, Shortfin Mako Shark, Fin and Sei whales), 'Vulnerable' (e.g. bigeye tuna, blue marlin, loggerhead turtle, oceanic whitetip shark, dusky shark, great white shark, longfin mako and sperm whale, Bryde's and humpback whales) or 'near threatened' (e.g. striped marlin, blue shark, longfin auna/albacore and yellowfin tuna). Although species listed as globally Endangered or Critically Endangered may potentially occur in the area, the proposed project areas are located in a main marine traffic route, already experiencing elevated marine traffic and vessel noise. Thus, the sensitivity of receptors to vessel noise is considered to be medium (Table 8.10).

The sound levels radiating from vessels in transit and surveying range from 160 to 220 dB re 1 μPa at 1 m at frequencies of 5 to 500 Hz, depending on size and speed (NRC 2003). As Block 11B/12B is located in a main traffic route that passes around southern Africa (see Figure 5-3), the shipping noise component of the ambient noise environment is expected to be significant within and around the licence Block. There is significant local shipping traffic and relatively strong metocean conditions in the Application Area, and so the ambient noise levels are expected to be in the range 90-130 dB re 1 μPa for the frequency range 10 Hz – 10 kHz. Note that underwater noise from vessels in transit is not considered to be of sufficient amplitude to cause direct physical injury to marine life, even at close range (see Section 5.4.4).

Due to their extensive distributions, the numbers of pelagic species (large pelagic fish, turtles and cetaceans) encountered during the proposed surveys and drilling campaign is expected to be low and considering they are highly mobile and able to move away from the sound source before trauma could occur, the intensity of potential injury or behavioural disturbance as a result of drilling and vessel noise is rated low. Furthermore, the survey and drill areas are located in a main marine traffic route and thus is in an area already experiencing increased marine traffic and vessel noise. The duration of the unmitigated impact would be limited to the short-term, and extend regionally (behavioural disturbances would be expected up to 100 km from the drill site, as well as vessel movement between logistics base and drilling unit). The potential physiological injury or behavioural disturbance as a result of construction vessel noise would thus be of low magnitude, and low significance prior to mitigation (Table 8.10). The generation of noise from drilling and project vessels cannot be eliminated. With mitigation, the intensity of the impact is reduced to low, and the impact is rated as of very low significance with mitigation, with very minor effects on receptors (Table 8.10).

Table 8.10. Impact 5b: General construction noise impacts on marine fauna — vessels.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Regional	Short term	Low	Medium	**LOW**	-'ve	High
Essential mitigation measures — avoid/abate at source • Implement a maintenance plan to ensure all diesel motors and generators receive adequate maintenance to minimise noise emissions. • Ensure vessel transit speed between the survey / drill area and port is a maximum of 12 knots (22 km/hr), except within 25 km of the coast where it is reduced further to 10 knots (18 km/hr). • All the noise abatement measures shall be taken to ensure an adequate acoustical insulation of the engines, compressors, turbines (enclose engines) and gas flow lines and valves (lagging, in-line silencers, etc.).								
With mitigation	Low	Regional	Short term	Very Low	Medium	**VERY LOW**	-'ve	High

8.2.6 Light and Water Pollution Impacts of Well (Flow) Testing/Flaring

Well (flow) testing is undertaken to determine the economic potential of any discovery before the well is temporarily or permanently abandoned. As a worst-case scenario, one test would be undertaken per exploration well if a resource is discovered. Testing may take 3-4 days to complete and involves burning hydrocarbons at the well site (WSP 2023). A high-efficiency flare is used to maximise combustion of the hydrocarbons. If produced water arises during well flow testing (typically in small quantities), it would be treated on-board to separate the hydrocarbons from seawater (WSP 2023). TotalEnergies has signed up the WB Zero Routine Flaring by 2030 initiative; a policy to reduce flaring from operations. However, an allowance has been made here for flaring if required for maintenance or unplanned events or in an emergency.

The intense light from flaring at night will increase the ambient light offshore. This increased lighting may disturb and disorientate pelagic seabirds (Section 8.3.4) and may result in behavioural and physiological effects on fish and cephalopods causing them to be drawn towards the lights where they become easy prey for seabirds and other fish. Although species listed as globally Endangered or Critically Endangered may potentially occur in the area, the drill area is located in a busy marine traffic route and thus is in an area already experiencing increased marine traffic and operational lighting. Sensitivity of receptors is considered of medium significance (Table 8.11).

While the effects of operational lights can be mitigated (e.g., by pointing them downwards rather than out to sea, use of red filters etc.), the effect of the very bright light emitted by flaring cannot be mitigated and this is likely to overwhelm the operational lighting. Indeed, the intense light from flaring at night will increase ambient lighting in offshore areas. However, the light from flaring would be in addition to the other lights on the drilling unit and thus not as intense if it were the sole light source (refer to Section 8.2.6 for impact relating to operational lighting). The extent of the unmitigated impact is local, and the duration will be short-term (10 days per well). Thus, the magnitude and significance of the impact are both considered to be very low (Table 8.11).

Hydrocarbon ‘drop-out’ during flaring may cause a visible slick of oil on the ocean surface. Hydrocarbon ‘drop-out’ occurs when inefficient combustion of hydrocarbons during flaring causes unburnt hydrocarbons to drop onto the sea surface. This may have toxic effects on marine fauna. Due to the location of the proposed drilling, it is expected that any hydrocarbon ‘drop-out’ will be diluted and dispersed rapidly. Given the prevailing wind and current directions, it will likely disperse in a south-westerly direction, away from the coastline. It is likely that the species that may be affected by this are pelagic species of fish, birds, turtles and cetaceans, due to the distance offshore. These receptors include species of conservation concern, but they are unlikely to respond to what are expected to be relatively minor changes in water quality. If water from the reservoir encounters hydrocarbons during the well test, the hydrocarbon component will be separated and flared. The unmitigated impact of hydrocarbon ‘drop-out’ during flaring is therefore of medium intensity and limited to the drilling location (Table 8.11).

Hydrocarbons may also be introduced into the surrounding environment through the discharge of produced water. “Produced water” is a term used in the oil and gas industry to describe the water that is brought to the surface along with oil and gas during the extraction process. It is also known as "oilfield produced water" or "formation water." Produced water contains a variety of contaminants, including oil, grease, heavy metals, and naturally occurring radioactive materials (Neff, Sauer & Maciolek, 2011). Produced water contains hydrocarbons at varying concentrations and when discharged into the marine environment can result in toxic effects, possibly leading to increased mortality rates of marine fauna. Additionally, the toxicity may affect the faunal health (e.g., respiratory damage). Although species listed as globally Endangered or Critically Endangered may potentially occur in the area, treatment of produced water will ensure reduced hydrocarbon concentrations in the discharges and reduced sensitivity of marine fauna to these discharges (Table 8.11). In addition, the drill area is located in a main marine traffic route and thus is in an area already experiencing increased marine traffic and operational discharges.

Projects Controls will require that contractors ensure that the proposed exploration campaign is undertaken in a manner consistent with good international industry practice and BAT. For example, produced water will be treated onboard before being discharged or transported to shore. Following the onboard treatment process, if the hydrocarbon content is below 30 mg/L, the produced water may be discharged into the marine environment, if the hydrocarbon content exceeds 30 mg/L, the produced water will either be treated again or be transported to shore to be treated. As with the hydrocarbon 'drop-out', it is expected that any hydrocarbons discharged into the marine environment will disperse rapidly due to the prevailing winds and currents at the drilling site. Thus, the overall sensitivity of receptors to produced water with low concentration of hydrocarbons is considered to be medium, and the unmitigated impact is assessed as of very low significance (Table 8.11).

Given the existing onboard treatment requirements for hydrocarbons resulting from well testing, the impact is rated as of very low significance post-mitigation (Table 8.11).

Table 8.11. Impact 6: Impacts of well testing and flaring.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation Flaring lighting	Medium	Local	Short term	Low	Medium	**VERY LOW**	-'ve	High
Hydrocarbon 'drop-out'	Medium	Local	Medium term	Low	Medium	**LOW**	-ve	High
Produced water discharge	Low	Site	Medium term	Very Low	Medium	**VERY LOW**	-ve	High
Essential mitigation measures — avoid/abate at source • Optimise well test programme to reduce flaring as much as possible during the test. • As far as possible, conduct flaring during daylight hours. • If disorientated, but otherwise unharmed seabirds are found/caught, they must be kept in a dark space and be released during daylight hours. • Use a high-efficiency burner for flaring to maximise combustion of the hydrocarbons and minimise hydrocarbon 'drop-out' during well testing. • Monitor flare (continuous) for any malfunctioning, etc. (including any drop-out). • Include training on how to care for downed seabirds as part of induction and ongoing awareness training.								
With mitigation Flaring lighting	Low	Site	Short term	Very Low	Medium	**VERY LOW**	-ve	High
Hydrocarbon 'drop-out'	Low	Site	Medium term	Very Low	Medium	**VERY LOW**	-ve	High
Produced water discharge.	Very Low	Site	Medium term	Very Low	Medium	**VERY LOW**	-ve	High

8.2.7 Light pollution impacts on pelagic marine fauna associated with construction activities

Artificial light at night is a significant source of light pollution that interferes with the natural cycles of light and darkness and modifies the intensity, spectra, frequency and duration of light reaching and penetrating the natural water bodies, including the ocean's surfaces, and natural landscapes (CWA 2020, Nelson *et al.* 2021, Thompson 2013, Zapata *et al.* 2019). During the construction phase, vessels associated with construction activities, such as pipe laying, are likely to be the greatest source of artificial light at night.

The impact of artificial light at night on natural ecosystems and wildlife populations is receiving increasing research attention, and there is a wealth of information that illustrates that artificial light at night influences animal orientation, circadian rhythm (nocturnal and diel activity), spatial distribution, habitat use, migration/dispersal, foraging efficiency and predatory behaviour, schooling behaviour in fish, stress hormones, and reproduction and life history traits (Bassi *et al.* 2022, Brüning *et al.* 2018, Nelson *et al.* 2021, Thompson 2013). Artificial light at night can influence the different levels of ecosystem organisation from individual organisms' physiology and behaviour through to ecosystem function and provision of ecosystem services (Zapata *et al.* 2019).

The biological effects of artificial light at night include metabolic disruption, oxidative stress, immunological dysfunction, sleep loss, energy expenditure and altered growth rate (Bedrosian *et al.* 2011, Gaston *et al.* 2015, Navara & Nelson 2007, Raap *et al.* 2015, Wyse *et al.* 2011). These effects are linked to organisms' internal rhythms that are driven by daily, seasonal, and lunar light cycles (Gaston *et al.* 2017).

Sensitivity to light and requirements for optimal living conditions and ecological functioning varies between groups of organisms (e.g., invertebrates, fish, birds, reptiles, humans) and even within species (CWA 2020). Most organisms utilise light or visual cues to locate and capture food. For aquatic species, it is well known that different taxa (such as phytoplankton, zooplankton, fish, squid and prawns) respond to artificial light (Timmer and Magellan 2011, Bassi *et al.* 2022, Grubisic 2018, Thompson 2013) and biological responses will vary with the magnitude, duration, frequency, and predictability of exposure to artificial light at night (Zapata *et al.* 2019).

Fish have exhibited changes in circadian rhythm at illuminances (1 lux) that occur in indirectly illuminated environments (Brüning *et al.* 2015). Values well below 1 lux are commonly found for moonlight and skyglow (Jägerbrand & Bouroussis 2021). Normal working light from a ship has been found to disrupt fish and zooplankton behaviour to at least 200 m depth across an area of >0.125 km^2 around the ship (Berge *et al.* 2020). It is important to note that behavioural responses to artificial light vary among taxa. While some species are known to be attracted to light, others are known to avoid light (Marangoni *et al.* 2022). Zooplankton tend to avoid light, undertaking diel vertical migration to depth during daylight to avoid the threat of visual predation, and surfacing at night to feed. Diurnal vertical migration is a characteristic feature in all oceans and is considered to be the largest synchronised movement of biomass on the planet (Hays 2003). This process has a strong effect on the movements of pelagic communities and as it occurs in response to light, has the potential to be greatly affected by artificial light (Berge *et al.* 2020).

Offshore, where oceanscapes tend to have less artificial lighting than near the coast, an intense source point of artificial light can attract marine birds across long distances (Montevecchi 2006). Bird strikes, involving a variety of species, on artificially lit vessels at sea are common at night (Merkel 2010). Many nocturnal seabird species are highly attracted to artificial light, as they forage on bioluminescent prey (Montevecchi 2006, Imber 1975). Intense artificial light can cause birds, particularly migrating passerines, to circle the light source for hours to days, especially during foggy and overcast conditions, sometimes resulting in the birds collapsing from exhaustion, potentially limiting them from having sufficient energy to make landfall or survive winter and/or reproduction. The attraction of marine birds, especially seabirds such as prions, storm petrels, and petrels, to offshore hydrocarbon platforms due to artificial lighting often results in collisions due to disorientation, which may cause mortality. Storm-petrels, petrels and shearwaters are more attracted to artificial light in their fledgling stage than when they are adults, making the fledglings more vulnerable to impacts such as collisions. Marine birds have also been observed feeding in the artificial light from vessels and hydrocarbon platforms, as the light tends to concentrate their prey (Montevecchi 2006, Marangoni *et al.* 2022). The amount of light spill that will reach the areas surrounding the vessels is unknown but will be influenced to a large degree by climate/atmospheric conditions. Artificial skyglow (direct lighting emitted or reflected upwards, scattered in the atmosphere and reflected back to the ground; Kyba *et al.* 2011) can spread light pollution hundreds of kilometres from its source (Luginbuhl *et al.* 2014).

The extent of the unmitigated impact is therefore considered to be local (i.e., confined to within the Application Area and its nearby surroundings), of medium-term duration (i.e., only during the construction phase) (Table 8.12). Given that the Application Area is located along a main marine traffic route, the area is already impacted by increased anthropogenic lighting and the intensity of the impact is considered to be low for the construction phase (Table 8.12). Species listed as globally Endangered or Critically Endangered that may occur in the proposed project areas are already experiencing marine vessel lighting. Thus, the sensitivity of receptors to vessel lighting is considered to be high, resulting in a low impact significance rating prior to mitigation (Table 8.12). Mitigation measures include angling lights downwards rather than out to sea, restricting use of lights to a minimum and the use of red filters.

The use of lighting on project vessels cannot be eliminated due to safety and navigational requirements (Table 8.12). Project Controls include that contractors ensure that the proposed exploration activities are undertaken in a manner consistent with good international industry practice and BAT. This must include the implementation of best practice mitigation measures for reducing lighting impacts (including the use of red filters) and the inclusion of such in the Environmental Management Programme (EMPr).

With the implementation of these Project Controls and additional mitigation measures, the significance of the impact can be reduced to very low (Table 8.12).

Table 8.12. Impact 7: Impacts of light pollution from construction activities on marine fauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Low	Local	Medium term	Very Low	High	**LOW**	-'ve	High

Essential mitigation measures — avoid/abate at source

- Reduce the lighting to a minimum compatible with safe operations whenever and wherever possible to reduce nocturnal faunal attraction.
- Position light sources, if possible and consistent with safe working practices, in places where emissions to the surrounding environment can be minimised i.e., aim lighting downward rather than out to sea.
- Include procedures in the EMPr for how to care for downed seabirds and ensure that personnel are adequately trained in this regard.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
• Monitor the presence of seabirds and identify mortalities, even when birds do not land on the vessel, especially in foggy conditions and at night. • Report ringed/banded birds to the appropriate ringing/banding scheme (details are provided on the ring).								
With mitigation	Very Low	Local	Medium term	Very Low	High	**LOW**	-'ve	High

8.2.8 INTRODUCTION OF NON-INDIGENOUS INVASIVE MARINE SPECIES

Human-induced biological invasions have become a major cause for concern worldwide. Biological invasions can negatively impact biodiversity and result in local or even global extinctions of indigenous species, and have socio-economic impact. A pre-cautionary approach to prevent biological invasions is often considered the most efficient method of management and can include identifying and managing important pathways of introduction (Wilson *et al.* 2009, Blackburn *et al.* 2011, Richardson *et al.* 2011). As of 2020, a total of 95 alien marine species have been recorded in South African waters, of which 56 are considered invasive (Robinson *et al.* 2020, Clark *et al.* 2020, Robinson *et al.* 2020).

The primary vectors for the introduction of alien and invasive species as a result of the proposed project activities are linked to 1) ballast water and 2) infrastructure associated with oil and gas production will, over time, develop a fouling community of marine epifauna which may consist of alien invasive species (Atkinson 2010, Biccard *et al.* 2018).

Ballast water is either freshwater or seawater taken up at ports of departure and discharged on arrival where new water can be pumped aboard, the volume dependant on the cargo load (Figure 8-5). Ballast water usually contains living marine organisms from the port of origin, some of which are able to survive in the ballast tanks/holds on their journey from one port to another and are then discharged with the ballast water when a new load of cargo is taken on board (Figure 8-5). After being released, some of these organisms secure a foothold in their new environment and may even flourish in the absence of their natural predators and diseases. Some 45 'invasions' attributable to ballast water discharges have been recorded in various coastal states around the world. In view of the recorded negative effects of alien species transfers, the International Maritime Organisation (IMO) considers the introduction of harmful aquatic organisms and pathogens to new environments via ships ballast water as one of the four greatest threats to the world's oceans (Awad *et al.* 2003).

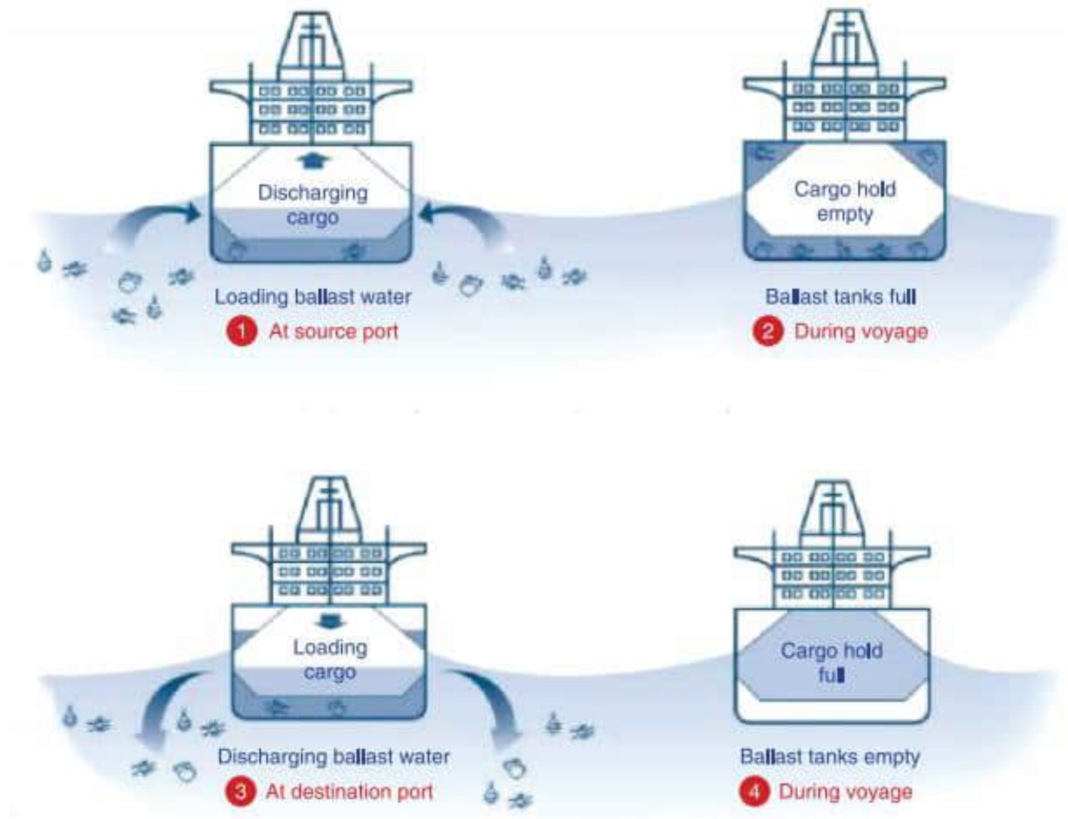


Figure 8-5. Cross section of a ship showing ballast tanks and ballast water cycle Source: GloBallast, International Maritime Organization.

Ballast water will be used and discharged by, for example, construction support vessels and the semi-submersible drilling unit (rig) with dynamic positioning system that will be used (at the well location, the pontoons are partially ballasted with seawater for stability). While this risk is present across all project phases, the risk is highest during phases when vessels from outside the South African EEZ are first operational i.e., during the construction phase.

The movement of the artificial structures and infrastructure associated with oil and gas production (such as vessel hulls, pilings, and platforms) and their associated biofouling communities from one place to another in the ocean also provides an opportunity for the translocation of alien invasive species. It is likely that drilling units, support vessels and production platforms contracted for oil and gas operations would have spent time outside of South Africa's exclusive economic zone prior to drilling. Exposure to foreign water bodies and time spent in port would increase the risk of alien invasive species introduction. The accumulation of fouling species would be further exacerbated by the slow speed at which drilling units and production platforms would be towed to site (Walton Smith 1946, Coutts *et al.* 2009, Coutts *et al.* 2010).

The potential unmitigated impact related to the introduction of alien invasive marine species is considered to be of very high consequence intensity in the long-term with an extent ranging from regional to national. The risk of this impact is, however, reduced by the highly dynamic, wave-exposed coastline of South Africa, which contributes to minimising the establishment of alien invasive species (Blood 2015). The sensitivity of the receptors is therefore considered to be low (Table 8.13). The unmitigated impact is therefore deemed to be of high significance without mitigation, reduced to medium with mitigation (Table 8.13). It is important to note that this impact is not unique to oil and gas exploration and production activities, but rather a threat which is common to the South African marine environment given the numerous vessels that pass through South African coastal waters on a daily basis (Biccard *et al.* 2018). The probability of this impact with the implementation of appropriate mitigation is considered to be unlikely.

Project Controls, to which project vessels will be expected to comply, include the following:

- Ballast water discharged will follow the requirements of the International Maritime Organisation's (IMO) 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments.
    - All vessels must implement a Ballast Water Management Plan, which includes a detailed description of the actions to be taken to implement the Ballast Water Management requirements.
    - All ships using ballast water exchange should, whenever possible, conduct such exchange at least 200 nm (± 370 km) from the nearest land and in water of at least 200 m depth when arriving from a different marine region.
    - Where this is not feasible, the exchange should be as far from the nearest land as possible, and in all cases a minimum of 50 nm (± 93 km) from the nearest land and preferably in water at least 200 m in depth.
    - Ships must also have a Ballast Water Record Book to record when ballast water is taken on board; circulated or treated for Ballast Water Management purposes; and discharged into the sea. Project vessels will comply with these requirements.

Table 8.13. Impact 8: Impacts of the introduction of alien and invasive species to the marine environment.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	High	National	Long term	Very High	Low	**HIGH**	-'ve	High
Essential mitigation measures — avoid/abate at source • Infrastructure (e.g. wellheads, BOPs and guide bases) used in other locations must be thoroughly cleaned before deployment.								
With mitigation	Low	National	Long term	High	Low	**MEDIUM**	-'ve	High

8.2.9 Impacts on fisheries and mariculture as a result of construction activity exclusion zones

Exploration and mining activities in the marine environment can potentially negatively impact fisheries and mariculture by reducing catch and/or catch-per-unit-effort (CPUE) thereby increasing costs and decreasing profit with knock-on socio-economic impacts for communities and business involved in fishing (throughout the supply and marketing chain) (CapMarine 2010, 2018). During the construction phase, the primary impact on fisheries is expected to be related to:

1. The loss of productive fishing grounds due to the implementation of safety zones around construction activities and infrastructure;

2. Direct mortality and/or disturbance of target species at various life-history stages (adults, juveniles, eggs and larvae) due to impacts of drilling (smothering, drillings fluid discharge and noise impacts);

3. Destruction of habitat, or a reduction in the quality of habitat, critical for target species and their supporting ecosystems (direct loss of benthic habitat) thereby reducing the abundance of fishery species; and,

4. Disturbance and negative alteration of fish behaviour (e.g., disruption of annual spawning events or migrations) resulting in reduced biological "fitness" i.e., a reduction in lifetime reproductive output.

During drilling operations, a temporary statutory safety zone of 500 m would be required from the drilling unit (CapMarine 2018). In addition, safety zones would be required for all subsea infrastructure placement. Exclusion of fishing vessels from fishing areas could have (indirect) socio-economic implications for the affected industries. Fisheries might be affected by target species avoiding the construction safety zone area. Furthermore, it follows that the magnitude of potential impacts on particular sectors of the fishing industry would depend on the location of construction activities (i.e., activities in deeper water below 200 m depth are more likely to affect fisheries that operate at this depth, rather than shallow water fisheries) (CapMarine 2010, 2018).

Hake deep-sea trawl: The inshore and deep-sea sectors of the South African hake demersal trawl operate in different areas and so have been mapped separately. During construction phase, only the offshore trawl fishing grounds overlap with construction and laying of the pipelines (pipeline and safety area) (Figure 3-29). The pipeline safety zones (for either routing options) cumulatively overlap approximately 6 km^2 of offshore trawl fishing grounds which is about 0.01% of offshore trawl fishing grounds. Furthermore, this area is only fished 20-50% of the time (relative offshore trawl fishing effort). Considering this, the intensity of the construction phase impacts on this fishery are considered to be low, with a local extent and a short-term duration. The sensitivity is considered to be medium. The unmitigated impact is therefore assessed to be very low (Table 8.14). There is no perceived overlap with the hake deep-sea trawl with the construction footprint within the Project Development Area.

Demersal hake longline: There is no perceived overlap of either pipeline routing options and well construction and associated exclusion areas with demersal hake longline fishing activity (Figure 3-31). The construction and installation of pipelines and subsea production systems may directly disturb and/or remove benthic fauna in the construction footprint as a result of physical disturbance of the seabed. However, construction footprint within the Project Development Area does not overlap with hake spawning areas and the Cape hake is a semi-pelagic spawner so is not directly impacted by localised benthic disturbance. The unmitigated significance of the construction phase on this fishery is scored accordingly as negligible (Table 8.14).

Mid-water trawl: There is no overlap between construction footprint within the Project Development Area and associated safety areas with mid-water trawling activity (Figure 3-33). The construction and the installation pipelines and subsea production systems may directly disturb and/or remove benthic fauna in the pipeline footprint as a result of physical disturbance of the seabed. However, the mid-water trawl fishery mainly targets the Cape horse mackerel *Trachurus capensis*, a semi-pelagic fish that moves throughout the water column to feed on plankton. Any benthic impacts caused during construction phase activities are not expected to impact this species and the sensitivity is therefore considered low. The overall unmitigated significance of the construction phase on this fishery is scored accordingly as negligible (Table 8.14).

Traditional/Commercial line fishery: There is no perceived overlap of either pipeline routing options and well construction and associated safety areas with commercial line fishing activity (Figure 3-36). Furthermore, the main species targeted by the commercial line fishery are pelagic and semi-pelagic species whose spawning grounds do not overlap with construction footprint within the Project Development Area and associated safety areas e.g., Carpenter *Argyrozona arizona* whose nurseries were identified in Algoa Bay on the eastern Agulhas Bank but not as far east Project Development Area, and on the central Agulhas Bank. Kob species *Argyrosomus* spp. which have estuarine dependant periods of their life histories and do not spawn far offshore. Geelbek *Atractoscion aequidens* which spawn from August to November in KwaZulu-Natal waters, mainly over offshore reefs in depths of 40-60 m, where they form large spawning aggregations at night, so do not overlap with the Project Development Area. Any benthic impacts caused during construction phase activities are therefore not expected to impact key commercial line fish target species and the sensitivity subsequently considered very low. The unmitigated significance of the construction phase on this fishery is scored accordingly as negligible (Table 8.14).

Large pelagic longline: There is a slight overlap with the long-line fishery targeting large pelagic species and the safety areas within the Project Development Area (Figure 3-35). Large pelagic fishing activity is concentrated along the shelf break to target large pelagic species. Evidence suggests that pelagic species have more sensitive hearing (thresholds at lower frequencies) than demersal species, and that catch rates could drop significantly areas affected by construction activities (CapMarine 2017). The unmitigated magnitude of impact caused by construction on large pelagic longline fishers and ecological receptors of the fishery is rated as medium. However, due to the scale of overlap with large pelagic fishing, potential impacts were assessed to be of low significance. There is no perceived overlap of either pipeline routing options and large pelagic longline fishing activity. If all six proposed wells and safety areas (4.7 km^2) were to be sited in areas of large pelagic long fishing activity this would cover 0.002 km^2 of large pelagic fishing grounds. In the worst-case scenario overlapping grounds are only fished 60% of the time. The impact is therefore assessed to be of low significance both before and after mitigation (Table 8.14).

Small pelagic purse-seine: There is no perceived overlap of either pipeline routing options and well construction and associated safety areas with small pelagic purse-seine fishing activities (Figure 3-38). The small pelagic purse-seine fishery mainly targets the sardine or pilchard *Sardinops sagax* and horse mackerel *T. capensis* as well as the smaller anchovy *E. encrasicolus*. The fishery also exploits the red-eye round herring *Etrumeus whiteheadi* and the chub mackerel *S. japonicas*. These pelagic species spawn by releasing gametes into the water column. Any benthic impacts caused during construction phase activities are not expected to impact this species and the sensitivity is therefore considered very low. The unmitigated significance of the construction phase on this fishery is accordingly deemed to be negligible (Table 8.14).

South Coast Rock Lobster: There is no perceived overlap of the construction safety areas with the South Coast Rock Lobster fishery (Figure 3-39). The South Coast Rock Lobster

Palinurus gilchristi is found mainly offshore on the Agulhas Bank in an area roughly 200 kilometres from the coast, and closer inshore (two to 50 kilometres from the coast) between Mossel Bay and East London. *P. gilchristi* is a cold-water species that grows slowly and is long-lived. The inshore area between Danger Point and Cape Agulhas is an important settlement area for juveniles, which migrate to adult habitats on the Agulhas Bank and in the inshore area between Mossel Bay and Port Elizabeth. The areas important for *P. gilchristi's* life history do not overlap with the proposed construction. The unmitigated significance of the construction phase on this fishery is scored accordingly as negligible (Table 8.14).

Chokka squid jig: There is no perceived overlap of either pipeline routing options and well construction and associated exclusion areas with commercial Chokka squid fishing activity (Figure 3-40). Chokka squid spawn in two different environments, both inshore warm waters of the eastern Agulhas Bank between 10 and 60 m deep and in deeper waters on the mid-shelf, with 25% of Chokka spawning in waters deeper than 60 m (Oosthuizen & Roberts 2009). Despite this, areas important for spawning are a significant distance away from the construction safety areas. The unmitigated significance of the construction phase on this fishery is scored accordingly as negligible (Table 8.14).

Small-scale, recreational and mariculture: There is no overlap of either pipeline routing options and well construction and associated safety areas with anticipated activities of small-scale and recreational fishers, nor with mariculture activities. The unmitigated significance of the construction phase on this fishery is scored accordingly as negligible (Table 8.14).

Project Controls include that the drilling contractor will ensure that the proposed project is undertaken in a manner consistent with good international industry practice and BAT.

The key stakeholders that should be consulted and informed of the proposed activities (including navigational co-ordinates of the area, timing and duration of proposed activities) include:

- Fishing industry / associations, including the South African Deep-Sea Trawling Industry Association (SADSTIA), the South East Coast Inshore Fishing Association (SECIFA), the South African Midwater Trawling Association, the South African Hake Longline Association (SAHALLA), the Shark Longline Association, the South African Tuna Long-Line Association (SATLA), the South African Marine Linefish Management Association (SAMLMA), the South African Pelagic Fishing Industry Association (SAPFIA), and South Coast Rock Lobster Association, and the South African Squid Management Industrial Association (SASMIA).
- Other associations and organs of state, including PASA, DFFE, Transnet National Ports Authority, SAMSA and the South African Navy Hydrographic office.
- Overlapping and neighbouring right holders.

These stakeholders should again be notified at the completion of construction activities when the drilling vessel and support vessels are off location. The operator must request, in writing, that the South African Navy Hydrographic office release Radio Navigation Warnings and Notices to Mariners prior to the period of construction activities. The Notice to Mariners should give notice of (1) the co-ordinates of the construction area, (2) an indication of the proposed timeframes of surveys and day-to-day location of the construction vessel(s), and (3) an indication of the 500 m safety zones and the proposed safe operational limits of the construction activities. These Notices to Mariners should be distributed timeously to fishing companies and directly onto vessels where possible.

Table 8.14. Impact 9: Impacts on fisheries as a result of construction related exclusion zones.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Deepsea trawl Without mitigation	Very Low	Local	Short Term	Very Low	Medium	**VERY LOW**	-ve	High
Hake longline Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Mid-water trawl Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Line fishery Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Large pelagics Without mitigation	Medium	Local	Short Term	Low	High	**LOW**	-ve	High
Small pelagics Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Rock lobster Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Squid jig Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Small-scale Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Recreational Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Mariculture Without mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Best practise mitigation measures — avoid/abate at source • Avoid siting well infrastructure in areas of higher fishing intensity if feasible. This particularly relates to the Large Pelagic Longline sector. • Prior to commencement, key stakeholders should be consulted and informed of the proposed activities (including navigational co-ordinates of the area, timing and duration of proposed activities) and the likely implications thereof. • Maintain adequate safety clearance between fishing vessels and construction phase vessels and equipment through at-sea communications with vessels in the vicinity of the survey area.								
Deepsea trawl With mitigation	Very Low	Local	Short Term	Very Low	Medium	**VERY LOW**	-ve	High
Hake longline With mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Mid-water trawl With mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Line fishery With mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Large pelagics With mitigation	Medium	Local	Short Term	Low	High	**LOW**	-ve	High
Small pelagics With mitigation	Very Low	Local	Short Term	Very Low	Very Low	**NEGLIGIBLE**	-ve	High
Rock lobster With mitigation	Very Low	Local	Short Term	Very Low	Very Low	**NEGLIGIBLE**	-ve	High
Squid jig With mitigation	Very Low	Local	Short Term	Very Low	Very Low	**NEGLIGIBLE**	-ve	High
Small-scale With mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Recreational With mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Mariculture With mitigation	Very Low	Local	Short Term	Very Low	Low	**NEGLIGIBLE**	-ve	High

8.3 PRODUCTION PHASE IMPACTS

Given the proposed project activities detailed in Section 1.2.2, the production phase impacts are expected to include:

- Potential impacts on marine water quality resulting from production phase (i.e., operational) discharges;
- Changes to the marine habitat (both benthic and above water) as a result of the presence of project infrastructure;
- Impacts on marine fauna resulting from artificial light;
- The potential introduction and development of alien invasive species;
- The impacts on fisheries due to exclusion areas during operations; and,
- Operational and accidental spillages on benthic macrofauna, fish and larvae, seabirds, marine mammals and turtles (including a blowout).

8.3.1 IMPACTS TO WATER QUALITY AND MARINE SYSTEMS RESULTING FROM PRODUCTION FACILITIES OPERATIONAL DISCHARGES

Water quality in the vicinity of operations may be impaired by various forms of waste discharged into the marine environment. During the production phase, discharges to sea can come from a variety of sources. The unmitigated impacts on marine life depend on the properties of the waste discharged. There may be physiological effects associated with the ingestion of hydrocarbons, detergents and other waste could have adverse effects on marine fauna and marine food chain, which could ultimately result in mortality. The discharge of galley waste and sewage may result in an additional food source for opportunistic feeders, speciality pelagic fish species, but may also lead to the attraction of predatory species, such as sharks and pelagic seabirds, to the aggregation of pelagic fish attracted by the increased food source. Discharged produced water may contain hydrocarbons at varying concentrations and when discharged in the marine environment could, without treatment, have an immediate detrimental effect on water quality, with the toxic effects potentially resulting in mortality (e.g., suffocation and poisoning) of marine fauna or affecting faunal health (e.g., respiratory damage).

The various types of waste produced at sea, their associated impacts are outlined below. Project Controls require that contractors ensure that the proposed campaign is undertaken in compliance with the applicable requirements in MARPOL 73/78.

- Galley waste will place a small organic and bacterial loading on the marine environment, resulting in an increased Biochemical Oxygen Demand (BOD). As per the applicable requirements in MARPOL 73/78 Annex V [14], biodegradable food wastes (this excludes cooking oil and grease which will be shipped to shore for treatment / disposal) may only be discharged from vessels after it has been passed through a grinder in cases where the drilling unit is located more than 3 nautical miles offshore. Discharge of whole food waste is permitted beyond 12 nautical miles offshore. The ground wastes must be capable of passing through a screen with openings <25 mm. The daily volume of discharge from a standard drilling unit is expected to be <0.5 m^3 (Pulfrich 2015).

- Deck drainage consists of liquids from rainfall, sea spray, deck and equipment washing (using water and an approved detergent), and any spillages (chemical or fuel). Deck drainage will be variable depending on the vessel characteristics, deck activities and rainfall amounts. Detergents used for washing exposed marine deck spaces are discharged overboard. The toxicity of detergents varies greatly depending on their composition, but low-toxicity, biodegradable detergents should preferably be used. Deck and machinery space drainage may also result in small volumes of oils, detergents, lubricants and grease, the toxicity of which varies depending on their composition, being introduced into the marine environment. Contaminated or hazardous deck drainage must be collected and directed into sump tanks on board for treatment prior to discharge to ensure compliance with MARPOL 73/78 Annex I. This Annex governs the discharge of oily water (deck drainage, bilge and mud pit wash residue) to the marine environment, and stipulates that vessels must have:
    - A Shipboard Oil Pollution Emergency Plan (SOPEP).

[14] This excludes cooking oil and grease which will be shipped to shore for treatment and/or disposal.

  - A valid International Oil Pollution Prevention Certificate, as required by vessel class.
  - Equipment for the control of oil discharge from machinery space bilges and oil fuel tanks, e.g. oil separating/filtering equipment and oil content meter. Oil in water concentration must be less than 15 ppm prior to discharge overboard. This is achieved through use of an oily-water separation system. The oily substances must be skimmed off the top of the discharge water and added to the waste (oil) lubricants and disposed of on land.
  - Oil residue holding tanks.
  - Oil discharge monitoring and control system. The system will ensure that any discharge of oily mixtures is stopped when the oil content of the effluent exceeds 15 ppm.
- Machinery space or bilge water drainage will be occasionally discharged after treatment. Bilge water is drainage water that collects in a ship's bilge space (the bilge is the lowest compartment on a vessel, below the waterline, where the two sides meet at the keel).
- Grey water and sewage will be treated and discharged intermittently throughout operations and will vary according to the number of persons on board (the treated sanitary effluents discharged into the sea are estimated at around 200 litres per person per day). Sewage waste will place a small organic and bacterial loading on the marine environment, resulting in an increased biological oxygen demand. In accordance with MARPOL 73/78 Annex IV:
  - Vessels are required to have a valid International Sewage Pollution Prevention Certificate (ISPPC).
  - Vessels must have an onboard certified sewage treatment plant providing primary settling, chlorination before discharge of treated effluent.
  - Discharge beyond 12 nm requires no treatment provided that the sewage is discharged at a moderate rate when the ship is *en route* and proceeding at not less than 4 knots, and provided that the sewage effluent does not produce visible floating solids in, nor cause discolouration of, the surrounding water. The treatment system must provide primary settling, chlorination and dechlorination before the treated effluent can be discharged into the sea.
  - Sewage must be comminuted and disinfected for discharges between 3 nm (± 6 km) and 12 nm (± 22 km) from the coast. This will require an onboard sewage treatment plant or a sewage comminuting and disinfecting system.
  - Disposal of sewage originating from holding tanks must be discharged at a moderate rate while the ship is proceeding en route at a speed not less than 4 knots.
  - The discharge depth is variable, depending upon the draught of the drilling unit/support vessel at the time, but should not be less than 5 m below the surface.

Sewage and grey water will be treated using a marine sanitation device to produce an effluent with:

- A biological oxygen demand (BOD) of <25 mg/l (if the treatment plant was installed after 1/1/2010) or <50 mg/l (if installed before this date).
- Minimal residual chlorine concentration of 0.5 mg/l.
- No visible floating solids or oil and grease.

- Electricity on drilling units and production platforms is typically provided by diesel-powered engines and generators, which are cooled by pumping water through a set of heat exchangers. The cooling water is then discharged overboard. Other equipment is cooled through a closed loop system, which may use chlorine as a disinfectant. Such water would be tested prior to discharge and would comply with relevant Water Quality Guidelines.

- Cooling waters and freshwater surplus generated by the water supply system (including brine) are likely to contain a residual concentration of chlorine (generally less than 0.5 mg/l for freshwater supply systems). Cooling water and drinking water surplus must be tested prior to discharge and would comply with relevant Water Quality Guidelines for residual chlorine, salinity and temperature relative to the receiving environment.

- Contractors will be required to develop a Waste and Discharge Management Plan for all wastes generated at the various sites and a Chemical Management Plan detailing the storage and handling of chemicals, as well as measures to minimise potential pollution. These plans will include / address the following:

  - Environmental awareness to ensure wastes are reduced and managed as far as possible.

  - Avoidance of waste generation, adopting the Waste Management Hierarchy (reduce, reuse, recycle, recover, residue disposal), and use of BAT.

  - Treatment of wastes at source (including maceration of food wastes, compaction, incineration, treatment of sewage and oily water separation).

  - Development of a waste inventory that classifies (hazardous, non-hazardous or inert) and quantifies waste, and identifies treatment and disposal methods.

  - Waste collection and temporary storage, which is designed to minimise the risk of escape to the environment (for example by particulates, infiltration, runoff or odours).

  - On-site waste storage, which is limited in time and volume.

  - Provision of dedicated, clearly labelled, containers (bins, skips, etc.) in quantities adequate to handle anticipated waste streams and removal frequency.

  - Chemicals will be appropriately stored onboard the project vessels (segregation, temperature, ventilation, retention, etc.).

All reasonable measures must be implemented to ensure that no littering takes place during operation of oil and gas production facilities. Large numbers of marine organisms, including fish and marine mammals, are killed or injured by becoming entangled in debris, while others, including seabirds, are at risk through the ingestion of small plastic particles (Gregory 2009, Wright *et al.* 2013). The problem of litter entering the marine environment has escalated dramatically in recent decades, with an ever-increasing proportion of litter consisting of non-biodegradable plastic materials. Objects that are particularly harmful to marine fauna include plastic bags and bottles, pieces of rope and small plastic particles (Gregory 2009, Wright *et al.* 2013).

Due to the long-term and medium intensity, the overall significance of operational discharges is assessed as medium (Table 8.15). After mitigation, and based on the small volumes, distance offshore and prevailing sea conditions, the potential unmitigated impact of operational discharges from installation and operation of production facilities on the marine environment are of low intensity, and limited to the immediate area around the vessel, drill unit or production facility. The potential impact of operational discharges on the marine environment is therefore considered to be of low significance with mitigation (Table 8.15). It is also noted that the majority of these discharges are not unique to the project vessels, but common to the numerous vessels that operate in or pass through South African coastal waters on a daily basis.

Table 8.15. Impact 10: Impacts of operational discharge to the marine environment.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Site	Long term	Medium	Medium	**MEDIUM**	-'ve	High
Essential mitigation measures — avoid/abate at source • Prohibit discharges within MPAs and EBSAs (and up current when in close proximity) during surveying or transit to and from the operations site. • TEEPSA will continue to engage with PetroSA regarding the use of good international industry practice in the operation and maintenance of the F-A Platform. • Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected. • All process areas should be bunded to ensure drainage water flows into the closed drainage system. • Drip trays should be used to collect run-off from equipment that is not contained within bunded areas, and the contents routed to the closed drainage system. **Essential mitigation measures — abate at source** • Low-toxicity biodegradable detergents should be used in the cleaning of deck spillages.								
With mitigation	Low	Site	Long term	Low	Medium	**LOW**	-'ve	High

8.3.2 IMPACTS ON THE LOCAL BENTHIC ENVIRONMENTS FROM PRESENCE OF SUBSEA INFRASTRUCTURE

The physical presence of subsea infrastructure during the operational phase is likely to have a number of effects on the local ecology, depending both on the locality of the disturbance, type of structure deployed, and water depth of the disturbance. The structures predicted to remain on the seafloor include anchors of metocean buoys as well as any residual cement used during cementing, plugging, and risered drilling stages of well installation. In particular, the presence of the subsea pipeline will likely have the most significant impact on the local benthic environments when compared to the other subsea structures, because of the extent of the linear infrastructure (~109-115 km, depending on the routing option). The unmitigated impacts are also dependent on whether the infrastructure remains above the sediment (i.e., as artificial rocky habitat), or if it is buried by sediments.

Studies available on the impacts of subsea infrastructure at comparative depths have found changes in megabenthic structures over a short (three month) period, particularly in mid-depths, with increased faunal densities found near the pipe (Biede *et al.* 2022). This could be a result of the increased shelter provided by the pipeline and/ or due to organic matter being trapped by the structures and leading to a localised increase in food resource, which could lead to megafaunal aggregations, especially when soft sediment is replaced by hard habitat, albeit artificial (Billet *et al.* 2001). Indeed, subsea oil and gas infrastructure appears to provide a sheltering habitat for fish usually associated with complex reef habitats (such as kingklip and jacopever), and it has been proposed that infrastructure may positively affected larval production, which could subsequently result in increased recruitment success (Blood 2015). Furthermore, the 'artificial hard substrate' infrastructure may become fouled with benthic epifauna resulting in increased diversity and abundance of marine species and ultimate alteration of benthic community structure. While this 'reef effect' may have positive implications to certain fish species that demonstrate a preference for structural seabed features, it may also enhance colonisation by non-indigenous species, thereby posing a threat to natural biodiversity. However, due to the water depths in the new drill area, colonisation by invasive species is unlikely to pose a significant threat to natural biodiversity in the deep-sea habitats (see Section 8.2.8).

Overall, should the infrastructure not become buried in sediment, the physical presence of the pipeline is expected to reduce the area of unconsolidated seabed habitat available for colonisation by infaunal communities but will provide an alternative hard substratum for colonising benthic communities (including VME species) or resulting in faunal attraction to fish and mobile invertebrates. Changes in benthic community structure are likely to occur with the loss of immobile, sedentary soft-bodied species and survival of more robust taxa such as molluscs and crustaceans (Savage *et al.* 2001, Sciberras *et al.* 2018, Biccard *et al.* 2018). The rate of colonisation (and recolonisation) by species on these new substrates will likely vary based on water depth and temperature, with colonisation rates typically being higher in shallower, warmer waters and vice versa (Biede *et al.* 2022). Localised alterations of the local habitat linked to the pipeline are anticipated to be more exacerbated in areas with soft substrate as opposed to hard rocky areas. The communities present in the vicinity of the pipelines are predicted to closely match the baseline condition in areas with hard substrates over time (Taormina *et al.* 2018). The converse is likely true for naturally soft substrates, where the introduction of hard surface may lead to colonisation by reef species and ultimately form reef habitat outside of its baseline context. The rate of colonisation (and recolonisation) by species on these new substrata will likely vary based on water depth and temperature, with colonisation rates expected to be higher in shallower, warmer waters and vice versa (Mercier *et al.* 2017, Girard *et al.* 2019, Biede *et al.* 2022).

The increase or modification of a site's biodiversity due to the presence of subsea structures would be considered a site specific/local impact of low intensity. Due to the relatively small area which will be altered by this infrastructure and pipeline, coupled with the fact that the pipeline will pass through mosaic areas of both sandy and rocky substrate, the operational phase impact intensity is rated as being very low (Table 8.16). Preliminary results of the 2022 Environmental Baseline Survey for Block 11B/12B support the presence of largely mosaic habitat types along both pipeline routes, indicating that benthic impacts of each route will be similar. However, VME indicator species were found along both proposed pipeline routes, and the sensitivity of receptors is therefore assessed as high (Table 8.16). The unmitigated impact is therefore considered to be of low significance prior to mitigation (Table 8.16). The impact is rated as negative, because will result in a shift in community structure. It is recommended that, once installed, this structure be left as undisturbed as possible. Should the infrastructure become buried by sediment, the impact is assessed to be of very low impact, site specific and short term, resulting in a negligible significance rating (Table 8.17). Project Controls require that the contractors ensure that the proposed project is undertaken in a manner consistent with good international industry practice and BAT.

Table 8.16. Impact 11a: Impacts of physical artificial hard substrate infrastructure — infrastructure not buried.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Very Low	Site	Long term	Very Low	High	**LOW**	-'ve	High
Essential mitigation measures — abate at source • Post-construction/drilling ROV surveys should be undertaken to scan seafloor for any dropped equipment and other removable features (e.g. excess cement) around the well site. Thes must be retrieved/removed, where practicable, after assessing the safety and metocean conditions. • The impact may be mitigated to some extent by the choice of pipeline material, as some sessile rocky shore and reef organisms are predicted to recolonize the concrete and pipeline surface in time. Further mitigation measures include minimising the surface area impacted by cementing. Alternatively bolting the pipeline directly to the rocky substratum or to concrete bases would minimize the area impacted. • Once the pipeline is installed, it is recommended that further disturbance along the route is minimised to allow the new (novel) community to stabilise with time. Given the long-term nature of the pipeline and the anticipated community that will establish, it should not be removed during ultimate decommissioning.								
With mitigation	Very Low	Site	Long term	Very Low	High	**LOW**	-'ve	High

Table 8.17. Impact 11b: Impacts of physical artificial hard substrate infrastructure — infrastructure buried.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Very Low	Site	Short term	Very Low	Low	**NEGLIGIBLE**	-'ve	High
Best practise mitigation measures — abate at source • Post-construction/drilling ROV surveys should be undertaken to scan seafloor for any dropped equipment and other removable features (e.g. excess cement) around the well site. Thes must be retrieved/removed, where practicable, after assessing the safety and metocean conditions.								

8.3.3 IMPACTS OF PHYSICAL PRESENCE OF ABOVE WATER INFRASTRUCTURE ON AVIFAUNA

Above water infrastructure associated with oil and gas production includes production platforms, drilling rigs, and support vessels etc. Seabirds are the predominant group affected by this infrastructure. It is well established that seabirds are attracted to offshore above water oil and gas infrastructure as roosting sites, due to foraging opportunities (platforms tend to aggregate food availability), and due to disorientation by and attraction to light sources (the latter is assessed separately in Section 8.2.7 and Section 8.3.4) (see Tasker *et al.* 1986, Baird 1990, Burke *et al.* 2005, Russell 2005, Weise *et al.* 2001, Ronconi *et al.* 2015). Indeed, both Tasker *et al.* (1986) and Baird (1990) noted seabird densities (birds/m^2) of six to seven times higher closer of platforms than the surrounds.

The presence of above water infrastructure can have direct lethal effects on seabirds, through direct collisions, flame from gas flares (assessed in Section 8.2.6) and exposure to oil (assessed in Section 8.6.3) (Wilhelm *et al.* 2007, Ronconi *et al.* 2015). There are also documented sub-lethal effects, even when direct collisions are avoided, where migratory birds that circle platforms for long periods deplete body reserves and die especially when inclement weather limits visibility (see Section 8.3.4). Other sub-lethal effects include displacement from feeding habitats due to industrial activity, increased exposure to predators and increased exposure to hazardous substances discharge from the rig (see Section 8.3.1 and Section 8.6.1) (Wiese *et al.* 2001, Roncon *et al.* 2015). These lethal and sub-lethal effects can affect both individual birds as well as resident and migratory populations (Roncon *et al.* 2015).

The extent of the impact is considered small, concentrated around the site i.e., just around the infrastructure itself, with a long-term duration, persisting for the entirely of the production period (Table 8.18). While species listed as globally Endangered or Critically Endangered may potentially occur in the area, the 11B/12B Production Right Application Area is located along a main marine traffic route, and therefore receptor sensitivity is assessed of medium (Table 8.18). Most of the impact of above sea infrastructure on birds is linked to lighting (assessed separately in Section 8.3.4), with the remaining unmitigated impacts considered to be low intensity, and low overall significance (Table 8.18).

Table 8.18. Impact 12: Impacts of the physical presence of above water infrastructure.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Low	Site	Long term	Low	Medium	**LOW**	-'ve	Medium
Essential mitigation measures — avoid/reduce at source • In consultation with PetroSA the following are required: o Include procedures in the EMPr for how to care for downed seabirds and ensure that personnel are adequately trained in this regard. o Monitor the presence of seabirds and identify mortalities, even when birds do not land on the vessel, especially in foggy conditions and at night. o Report ringed/banded birds to the appropriate ringing/banding scheme (details are provided on the ring).								
With mitigation	Low	Site	Long term	Low	Medium	**LOW**	-'ve	Medium

8.3.4 Light pollution impacts associated with production

The impacts of artificial light at night are discussed in the context of the construction phase in Section 8.2.6. The production phase will include many of the same impacts relating to vessels, but also light from the F-A platform.

Operations at oil fields introduce considerable amounts of artificial light (e.g., electric lighting, gas flares) that can potentially affect ecological processes in the upper ocean, such as diel vertical migration of plankton (Moore *et al.* 2000). Artificial night light also attracts numerous species, including squid, large predatory fishes, and birds (Longcore & Rich 2004). Underwater lighting, such as used on remotely operated vehicles, is likely to be of comparatively modest impact, though it may be significant in the case of species with extremely sensitive visual systems (Herring *et al.* 1999).

As the light emitted from platforms has been shown to extend up to 10 m into the water column, it could significantly impact the nocturnal landscape around these structures. This halo of light may change the community composition around platforms, concentrating visual predators near lit surface waters and modifying both schooling and predatory behaviour (Barker & Cowan 2018, Keenan *et al.* 2007). A field study observed more fish near lit platforms than unlit platforms, indicating the attraction of many fish species to light, but also observed that fish left the surface waters near the platform at night, potentially to avoid increased predation pressure caused by artificial lighting (Barker & Cowan 2018).

The attraction of marine birds, especially seabirds such as prions, storm petrels, and petrels, to offshore hydrocarbon platforms due to artificial lighting, particularly the bright light of the gas flare, often results in collisions due to disorientation, which may cause mortality, not only behavioural changes (Montevecchi 2006, Wiese *et al.* 2001). As these are small birds that can be hard to notice, especially if they fall into the sea after crashing, the number of birds affected is likely to be underestimated. Marine birds have also been observed feeding in the artificial light from vessels and hydrocarbon platforms, as the light tends to concentrate their prey (Montevecchi 2006, Marangoni *et al.* 2022). There is evidence that migratory birds attracted by platform lights and flares become entrained in circling patterns and circle platforms for long periods, deplete body reserves and die, especially when inclement weather limits visibility (see Hope Jones 1980, Ronconi *et al.* 2015). Indeed, the most commonly identified cause of mortality (46% of deaths) for seabirds at offshore platforms in the Gulf of Mexico was starvation (Russell 2005).

Projects controls will require that contractors ensure that the proposed exploration campaign is undertaken in a manner consistent with good international industry practice and BAT, and that best practice mitigation measures for reducing lighting impacts (including the use of red filters) are included in the Environmental Management Programme (EMPr).

The extent of the unmitigated impact is considered to be local (i.e., confined to within the project concession / licence area and its nearby surroundings) but of long-term duration (i.e., for the duration of the production phase) (Table 8.19). While species listed as globally Endangered or Critically Endangered may potentially occur in the area, the Application Area is located along a main marine traffic route, with the area is already impacted by anthropogenic lighting. However, the use of the site by a large number of migratory seabirds results in a medium intensity of the impact for the operational phase (Table 8.19). Thus, the sensitivity of receptors to F- A Platform and vessel lighting is considered to be high, resulting in a medium impact significance rating before mitigation (Table 8.19).

The use of lighting during the operational phase cannot be eliminated due to safety and navigational requirements (Table 8.19). The implementation of suitable mitigation measures, which would reduce the impact to low significance (Table 8.19).

Table 8.19. Impact 13: Impacts of operational artificial lighting on the marine environment.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Long term	Medium	High	**MEDIUM**	-'ve	High

Essential mitigation measures — avoid/reduce at source

- In consultation with PetroSA the following are required:
    - Reduce the lighting to a minimum compatible with safe operations whenever and wherever possible to reduce nocturnal faunal attraction.
    - Position light sources, if possible and consistent with safe working practices, in places where emissions to the surrounding environment can be minimised i.e., aim lighting downward rather than out to sea.
    - Include procedures in the EMPr for how to care for downed seabirds and ensure that personnel are adequately trained in this regard.
    - Monitor the presence of seabirds and identify mortalities, even when birds do not land on the vessel, especially in foggy conditions and at night.
    - Report ringed/banded birds to the appropriate ringing/banding scheme (details are provided on the ring).

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
With mitigation	Low	Local	Long term	Low	High	**LOW**	-'ve	Medium

8.3.5 IMPACTS ON FISHERIES AND MARICULTURE AS A RESULT OF SAFETY ZONES

A general overview of production phase safety zones for the proposed development indicates that each production well requires a safety zone of 785 398 m^2 (0.8 km) while all linear infrastructure requires an safety area of 250 m to either side of the median (Figure 8-6). It is assumed that the proposed subsea production system will require an safety zone of 785 398 m^2 (0.8 km^2).

Given that the proposed project activities include the drilling of up to six development wells, and the placement of some 231 861 m of linear infrastructure (both flow line and umbilical), the total area that could be demarcated as a safety zone as a result of the proposed production phase is estimated at 63 463 km^2 (Table 8.20). The safety zone area would constitute approximately 0.5% of the Application Area and 3% of the Project Development Area.

Table 8.20. Estimates of the required safety areas for the production phase (Groenewald E., Pers. Comm. 2023)

Structure	Number	Total safety area (km^2)
Flowline (linear)	118 718 m	29.68
Umbilical (linear)	113 143 m	28.29
Operational wells	6	4.71
Subsea Production System	1	0.79
TOTAL		**63.46**

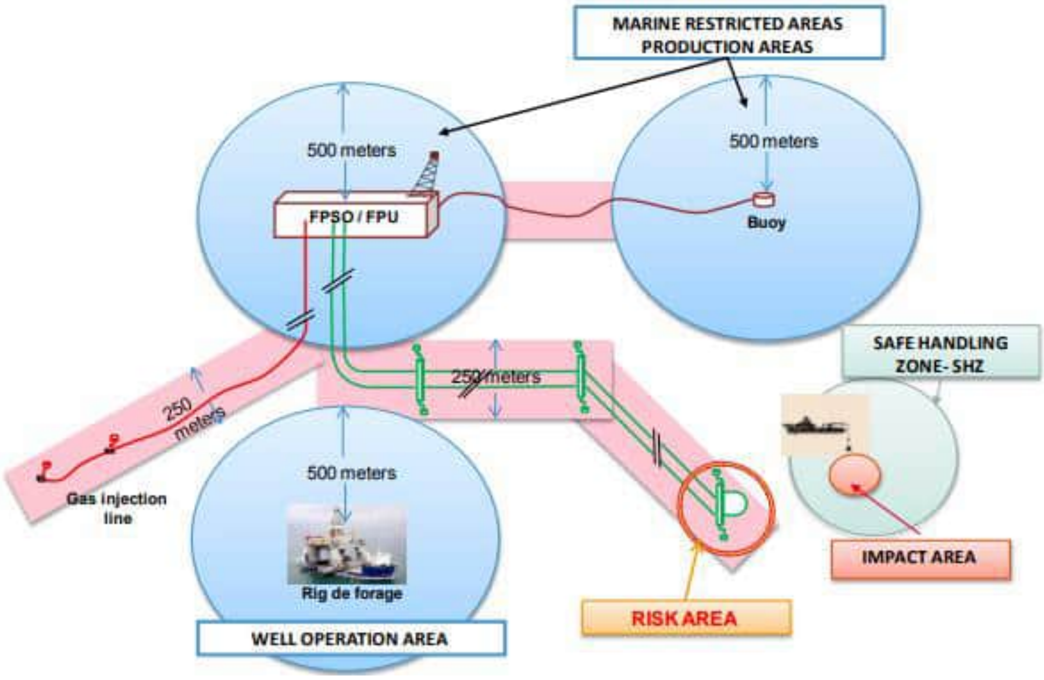


Figure 8-6. Example of safety zones ('operational boundaries') for subsea installations (Groenewald E., Pers. Comm. 2023). Diagram for illustration purposes only

During the production phase, exclusion of fishing vessels from fishing grounds could have socio-economic implications for the affected industries. Fisheries might be affected by the loss of productive fishing grounds, and therefore may directly impact catch, or Catch Per Unit Effort (CPUE), with (indirect) socio-economic implications for the affected industries, and through the damage to or dislocation of fishing equipment deployed in the area by production activities. Furthermore, it follows that the magnitude of potential impacts on particular sectors of the fishing industry would depend on the location of production activities (i.e., activities in deeper water below 200 m depth are more likely to affect fisheries that operate at this depth, rather than shallow water fisheries) (CapMarine 2010, 2018).

Hake deep-sea trawl: The inshore and deep-sea sectors of the South African hake demersal trawl operate in different areas and have been mapped separately. During the production phase, only the offshore trawl fishing grounds overlap with both pipeline routing options (pipeline and safety area) (Figure 3-29). The pipeline safety zones cumulatively overlap approximately 6 km^2 of offshore trawl fishing grounds which is about 0.01 km ^{2} of offshore trawl fishing grounds. Furthermore, this area is only fished 20-50% of the time (relative offshore trawl fishing effort). The sensitivity is considered to be medium and the impact is therefore assessed to be of very low significance both before and after mitigation (Table 8.21).

Demersal hake longline: There is no perceived overlap of either pipeline routing options and the Project Development Area with demersal hake longline fishing activity. The area for production does not overlap with hake spawning areas and the Cape hakes are semi-pelagic spawners so are not directly impacted by localised benthic disturbance. The unmitigated significance of the production phase on this fishery is scored accordingly as negligible (Table 8.21).

Mid-water trawl: There is no perceived overlap of either pipeline routing options and the Project Development Area with mid-water trawling activity (Figure 3-33). The mid-water trawl fishery mainly targets the Cape horse mackerel *Trachurus capensis*, a semi-pelagic fish that occurs on which moves throughout the water column to feed on plankton. Any benthic impacts are caused during production phase activities are not expected to impact this species and the unmitigated sensitivity is therefore considered low. There are no anticipated socio-economic impacts and the overall significance of the production phase on this fishery is scored accordingly as negligible (Table 8.21).

Traditional/Commercial line fishery: There is no perceived overlap of either pipeline routing options and the Project Development Area with line fishing activity (Figure 3-36). Furthermore, the main species targeted by the line fishery are pelagic and semi-pelagic species whose spawning grounds do not overlap with the Project Development Area , e.g., Carpenter *Argyrozona arizona*, Kob species *Argyrosomus* spp. Production phase activities are not expected to impact key commercial line fish target species and the unmitigated sensitivity subsequently considered low. The overall significance of the production phase on this fishery is scored accordingly as negligible (Table 8.21).

Large pelagic longline: The long-line fishery targeting large pelagic species operates within the Application Area but only to a limited extent within the Project Development Area (Figure 3-35). Large pelagic fishing activity is concentrated along the shelf break to target large pelagic species. While there is no perceived overlap of either pipeline routing options and the large pelagic longline fishing activity, if all six proposed wells and associated safety areas (4.712 km^2) were to be sited in areas of large pelagic long fishing activity this would cover 0.002 km^2 of large pelagic fishing grounds. In the worst-case scenario, overlapping grounds are only fished 60% of the time. The impact is therefore assessed to be of low significance (Table 8.21).

Small pelagic purse-seine: There is no perceived overlap of either pipeline routing options and the Project Development Area with small pelagic purse-seine fishing activities (Figure 3-38). The small pelagic purse-seine fishery mainly targets the *S. sagax, T. capensis, E. encrasicolus*, *E. whiteheadi* and *S. japonicas*. These pelagic species spawn by releasing gametes into the water column. The unmitigated significance of production activities on this fishery is scored accordingly as negligible (Table 8.21).

South Coast Rock Lobster: There is no perceived overlap of production phase activities with the South Coast Rock Lobster fishery (Figure 3-39). The South Coast Rock Lobster (*Palinurus gilchristi*) is found mainly offshore on the Agulhas Bank in an area roughly 200 kilometres from the coast, and closer inshore (two to 50 kilometres from the coast) between Mossel Bay and East London. *P. gilchristi* is a cold-water species that grows slowly and is long-lived. The inshore area between Danger Point and Cape Agulhas is an important settlement area for juveniles, which migrate to adult habitats on the Agulhas Bank and in the inshore area between Mossel Bay and Gqeberha. The areas important for *P. gilchristi's* life history do not overlap with the Project Development Area. The unmitigated significance of the production phase activities on this fishery is scored accordingly as negligible (Table 8.21).

Chokka squid jig: There is no perceived overlap of either pipeline routing options and the Project Development Area with commercial Chokka squid fishing activity (Figure 3-40). Chokka squid spawn on eastern Agulhas Bank and in some sites at depth greater than 60 m (Oosthuizen & Roberts 2009). Despite this, these areas important for spawning are a significant distance away from the Project Development Area . The unmitigated significance of the production phase on this fishery is scored accordingly as negligible (Table 8.21).

Small-scale, recreational and mariculture: There are no perceived overlap of either pipeline routing options and the Project Development Area with small-scale or recreational fisheries, nor mariculture activities. The unmitigated significance of the production phase on these fisheries is scored accordingly as negligible (Table 8.21).

Table 8.21. Impact 14: Impacts on fisheries as a result of production related exclusion zones.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Deepsea trawl Without mitigation	Very Low	Local	Long Term	Low	Medium	**VERY LOW**	-ve	High
Hake longline Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Mid-water trawl Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Line fishery Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Large pelagics Without mitigation	Low	Local	Long Term	Low	High	**LOW**	-ve	High
Small pelagics Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Rock lobster Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Squid jig Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Small-scale Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Recreational Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Mariculture Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Best practise mitigation measures — avoid/abate at source • Avoidance of siting well infrastructure in areas of higher fishing intensity if feasible. This particularly relates to the Large Pelagic Longline sector.								
Deepsea trawl Without mitigation	Very Low	Local	Long Term	Low	Medium	**VERY LOW**	-ve	High
Hake longline With mitigation	Very Low	Local	Long Term	Very Low	Very Low	**NEGLIGIBLE**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Mid-water trawl With mitigation	Very Low	Local	Long Term	Very Low	Very Low	**NEGLIGIBLE**	-ve	High
Line fishery With mitigation	Very Low	Local	Long Term	Very Low	Very Low	**NEGLIGIBLE**	-ve	High
Large pelagics With mitigation	Low	Local	Long Term	Very Low	High	**LOW**	-ve	High
Small pelagics With mitigation	Low	Local	Long Term	Low	Very Low	**NEGLIGIBLE**	-ve	High
Rock lobster With mitigation	Low	Local	Long Term	Low	Very Low	**NEGLIGIBLE**	-ve	High
Squid jig With mitigation	Low	Local	Long Term	Low	Very Low	**NEGLIGIBLE**	-ve	High
Small-scale With mitigation	Low	Local	Long Term	Low	Very Low	**NEGLIGIBLE**	-ve	High
Recreational With mitigation	Low	Local	Long Term	Low	Very Low	**NEGLIGIBLE**	-ve	High
Mariculture With mitigation	Low	Local	Long Term	Low	Very Low	**NEGLIGIBLE**	-ve	High

8.4 Exploration phase impacts

It is proposed that up to four exploration and appraisal wells be drilled in the Exploratory Priority Area, with associated activities including vertical seismic profiling (VSP), well logging and testing, and well plugging.

Once drilling is completed, the well will be sealed with cement plugs, tested for integrity and either abandoned temporarily or permanently according to international best practices. If appropriate, the well will be left on the seafloor with an abandonment cap (approximately 5 x 5 m with a height of 4 m, designed to allow for overtrawling) (WSP 2023). For wells where a hydrocarbon resource is confirmed, a monitoring gauge may be installed on the wellhead (under the cap) to monitor pressure and temperature. Finally, a remotely operated vehicle (ROV) will be used to survey the seafloor to confirm the location of the wellhead on the seafloor and confirm there is no other infrastructure or debris on the seafloor.

8.4.1 Biochemical effects related to exploratory drilling and cementing operations

The primary effects related to the discharge of cement, as with the discharge of drilling fluid, include direct toxicity and bioaccumulation. These impacts are expected to be similar to, or of lesser intensity and extent, than production drilling (see Section 8.2.2). It is assumed that similar drilling fluids will be used for the exploratory phase drilling (namely, WBMs). Up to four exploration and appraisal wells will be drilled in the Exploratory Priority Areas to the east of the Application Area (see Figure 1-1). Both unmitigated and mitigated impact assessment results are presented in Table 8.3.

The Environmental Baseline Survey (BSL 2023) note that the greatest numbers of VMEIs per transect was recorded in the south-western/western corner of the Block 11B/12B Production Right Application Area (Section 3.3.2). A number of potential paleontological artifacts, including cetacean bones and wood, were also observed most notably in the southwest and central areas of Block 11B/12B. Overall, the western region of Block 11B/12B should be considered 'High' epifaunal sensitivity (BSL 2023). However, there are still areas of sensitivity and significance close to the eastern Exploratory Priority Area, notably the Port Elizabeth Corals MPA to the northeast, and the Kingklip Corals EBSA to the north.

For the proposed exploration wells (assuming one well is drilled at a time), toxicity effects from discharge of drilling fluid are of greater concern in the lower water column (and linked to the riserless drilled sections) as the dispersion of the drilling fluid may extend up to 35 km from the drill site, and is modelled to remain in the lower water column for up to 15.9 days under base case drilling scenarios, while a longer drilling time frame will result in the duration of up to 25.5 days per well (Section 6). Cumulatively, should all four exploration wells be drilled, the drilling fluid will remain in the lower water column for a total of up to 63 days under base case drilling scenarios, and 102 days under the longer drilling time frame (Section 6). Model results show that, under 2012 environmental conditions, impacts from drill discharge plumes from the drilling of wells in the Exploratory Priority Area are not expected to overlap with the Kingklip Corals EBSA to the north (Figure 6-11, Figure 6-12 and Figure 6-13).

Therefore, the significance of the impact is reduced by ensuring plumes generated by exploratory drilling in the bottom waters do not overlap with these high areas of sensitivity. Mitigation measures are the same areas as those specified for production drilling, with a particular requirement that pre-installation site surveys (with ROV) must be undertaken (Table 8.3). In addition, given the large range of impacted areas depending on site and season, and because the precise well locations are unknown at this stage, as well as the potential for overlap with highly sensitive sites, it is recommended that drill cutting dispersion modelling studies are undertaken prior to any drilling activities within the eastern Exploratory Priority Area to demonstrate that the impact plume (PEC/PNEC > 1) within the bottom water is not expected to intersect with any sensitive species (VME indicators), areas (such as MPAs or EBSAs), habitats or structures. If an overlap does occur, drilling must take place in such a way as to prevent overlap (i.e., during the season of lowest impact, or change the drilling approach), or the well must be moved.

8.4.2 IMPACTS ASSOCIATED WITH EXPLORATORY DRILLING DISCHARGES

It is anticipated that up to four exploration and appraisal wells will be drilled in the Exploratory Priority Area (see Figure 1-1). The unmitigated and mitigated impacts of exploratory drilling on the sediment are described in Section 6.4.2. The impacts to the benthos are expected to be similar to those described for construction (see Section 8.2.2) on the assumption that similar drilling fluids will be used for the exploratory phase drilling (namely, WBMs). The impacts of the proposed drilling activities during the exploratory phase are very similar to those under the production phase (see Section 8.2.3). Impact assessment results for infaunal, pelagic system and epifaunal communities are presented in Table 8.4, Table 8.5 and Table 8.6 respectively. Impacts of elevated turbidity on light penetration are presented in Table 8.7.

8.4.3 LIGHT AND WATER POLLUTION IMPACTS OF EXPLORATORY WELL (FLOW) TESTING/FLARING

Impacts of well flow testing/flaring during the exploratory phase are expected to be similar to that of the construction phase (see Section 8.2.6). It is assumed that there will be zero flaring from gas, but an allowance has been made here for flaring if required for unplanned events or in an emergency. Impact assessment results are presented in Table 8.11.

8.4.4 NOISE POLLUTION IMPACTS FROM EXPLORATORY DRILLING ACTIVITIES ON MARINE MEGAFAUNA, FISH, TURTLES AND AVIFAUNA

Impacts of noise pollution resulting from exploratory drilling activities are expected to be similar to that of production drilling (see Section 8.2.5). As the duration of the impact is expected to last 16 months (assuming four wells are drilled), the unmitigated impact is rated over the short term. Given the sensitivity of the area, the recorded occurrence of a number of sensitive species within the site, and the uncertainty surrounding the implication of behavioural impacts over the long term, the intensity of the impact is assessed as medium. Impact assessment results are presented in Table 8.22.

Table 8.22. Impact 18: Exploratory drilling noise impacts on marine fauna.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation – 24-hour	Medium	Local	Short term	Low	High	**LOW**	-'ve	High
Without mitigation – 30-minutes	Low	Local	Short term	Very Low	High	**LOW**	-'ve	High
Essential mitigation measures • An independent Marine Mammal Observer (MMO) must accompany the pre-drilling survey to undertake validation of cetacean migration/distribution models. • In the unlikely event of a cetacean sighting within the Permanent Threshold Shift (PTS) threshold distance for the most sensitive species (400 m) immediately prior to drilling commencement, drilling may not commence until an independent MMO aboard a drilling support vessel confirms that no cetaceans are present within this PTS radius.								
With mitigation	Medium	Local	Short term	Low	High	**LOW**	-'ve	High

8.4.5 NOISE POLLUTION IMPACTS FROM VERTICAL PROFILING ACTIVITIES ON MARINE MEGAFAUNA

Vertical seismic profiling (VSP) is a standard method used during well logging and can generate noise that could exceed ambient noise levels. VSP is used to generate a high-resolution stratigraphic profile, which can be used to determine the size and shape of rock formations and oil/ gas deposits, etc. VSP entails drilling a borehole or well, in which a series of geophones can be lowered to specific target depths (Birin & Maglić 2020). A small near-surface airgun array is then used as a seismic wave source, which both reflects and refracts off/ through the rock layers, with these waves being recorded by the geophone array and interpreted. The geophone array can then be moved vertically through the borehole to determine the full desired stratigraphy range.

To determine the stratigraphy directly at the well point, a non-offset VSP can be used, with the airgun array being positioned almost directly above the wellpoint (Figure 8-7, left). To determine the stratigraphy present between the borehole and a source located a single distance away from the borehole (an offset) an offset VSP can be used (Figure 8-7, right). A VSP with a progressively increasing offset is called a walkaway VSP, which entails moving the airgun array progressive distances from the borehole and following the same process of firing the gun array with the geophones at a set depth, which can generate high resolution stratigraphic imagery of an area along a transect (Birin & Maglić 2020). A 3D VSP can also be conducted which, like a walkaway VSP, involves moving the seismic source varying distances from the borehole, however, the vessel will then complete circling manoeuvres/ orbits around the borehole at these set distances with the guns firing at set intervals, allowing for a 3D stratigraphic representation of the area to be generated.

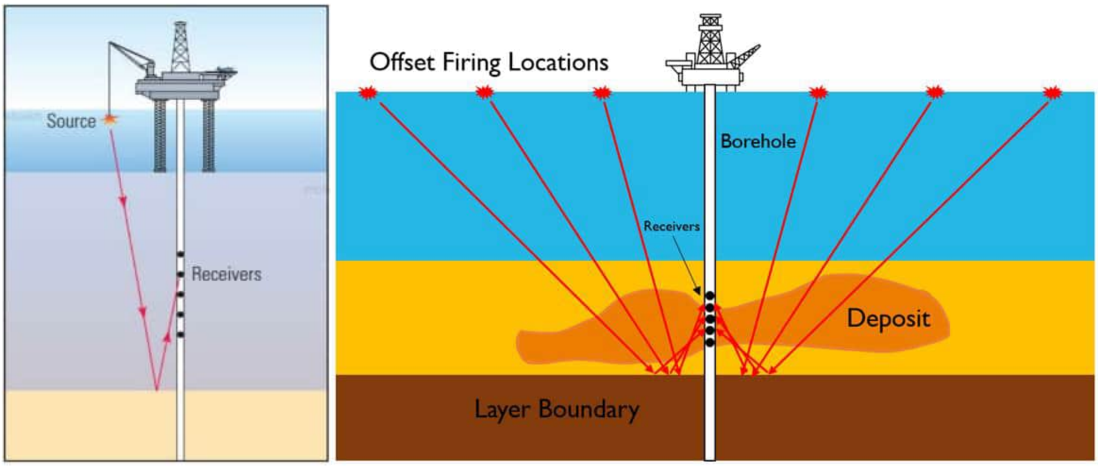


Figure 8-7. (Left) Diagrammatic representation of a non-offset VSP (http://researchgate.net/figure/Rig-Source-Vertical-Seismic-Profile) and (right) simplified Representation of an offset VSP (Oil rig image: Freepic.com)3

A key strength of the VSP methodology is that the relatively short distances that the seismic waves need to travel through the earth means that less seismic energy has dissipated by the time of recording compared to utilising surface hydrophone arrays, therefore allowing for high resolution data to be acquired with only relatively small airgun arrays. As such, it is assumed that the VSP operations will utilise a small airgun array (a Dual Delta Sodera G-Gun or equivalent), operated from the drilling unit at a depth of 7-10 m depth below the surface. It is understood that the exploratory activities will only utilise non-offset VSP. During VSP operations, receivers are positioned in a section of the borehole and the airgun array is discharged. The generated sound pulses are reflected through the seabed and are recorded by the receivers to generate a profile along a 60-75 m section of the well. This process is repeated as required for different stations in the well and it may take to 8-12 hours to complete approximately 250 shots, depending on the well's depth and number of stations being profiled. If all four exploratory wells are drilled, this will entail an approximate cumulative total of 1000 source shots.

The underwater noise modelling study undertaken by WSP (2023b) (Section 5) indicated that the peak pressure levels generated with each VSP air gun pulse are sufficient to cause permanent (permanent threshold shifts) and temporary direct physical injury (temporary threshold shifts) to hearing in marine mammals, and sea turtles, as well as death or injury to fish (Table 5.6 and Table 5.7). For a single VSP pulse, the distances at which these impacts occur are very small — permanent damage is expected for very high-frequency cetaceans if they occur within 20 m of VSP operations, with temporary damage at a distance of 50 m; all other cetacean groups, sea turtles and fish would need to be within 10 m of the VSP operations for any damage to occur (Table 5.6). Cumulative impacts (for the estimated 250 pulses over a 24-hour period) have a far greater extent of impact, with temporary damage occurring at a distance of up to 2.2 km for baleen whales (low frequency cetaceans) and 170 m for turtles, and permanent damage predicted at a distance of 200 m for baleen whales (Table 5.6). For fish, cumulative impacts of 250 pulses over 24-hours predicted temporary damage to fish both with and without swim bladders at a distance of 370-400 m, and mortality and potential mortal injury of both fish, fish eggs and larvae at 10-30 m (Table 5.7).

Behavioural effects of noise must also be considered, as these may affect life functions, including individual health and fitness, foraging efficiency, avoidance of predation, swimming energetics and reproductive behaviour (Popper & Hawkins 2016). The maximum thresholds of behavioural disturbance from the source were shown to be 2 km for marine mammals in all hearing groups, 350 m for turtles, and 19.2 km for penguins / diving birds (Table 5.8, Figure 5-7). Since four exploratory drill sites are proposed for the current exploratory activity, and assuming only one well is assessed at a time, the maximum unmitigated area of impact for behavioural disturbance at any point in time will equate to some 1 158 km^2 for penguins / diving birds. The majority of Algoa Bay penguins forage within 20 km of the coast, and while they have been recorded as far as 60 km offshore following pelagic shoaling fish species within the 200 m isobath (Section 3.3.5), the Block 11B/12B Production Right Application Area lies more than 70 km offshore below the 200 m contour, and as such, penguin behaviour is unlikely to be directly impacted by VSP activities. Cape gannets regularly feed as far offshore as 100 km and Cape cormorants have been reported up to 80 km from their colonies (Section 3.3.5), and therefore these species may be impacted behaviourally by VSP activities should sufficient mitigation not be implemented.

It is considered likely that pelagic species, including Endangered and Critically Endangered species of turtles, seabirds, cetaceans, large fish, and sharks, which have the potential to be directly harmed by the VSP seismic sources, will migrate through the area in proximity to the VSP wells. Receptor sensitivity is therefore assessed as high. It is considered likely that most of these highly mobile pelagic species would move away once noise activities commence, with species likely leaving the area. This has a behaviour cost; however, the area of behaviour impact is very small (12 km^2 for cetaceans), as is the cumulative area of direct physiological impact for both cetaceans (~15 km^2 TTS, ~0.1 km^2 PTS) and fish (~0.1 km^2 TTS) (Section 5). The likelihood of VSP activities causing a significant, irreversible change in habitat use of these species is therefore considered unlikely, and the intensity of the impact is assessed as low after mitigation (Table 8.23).

Since localised impacts are of greatest concern, mitigation measures must be put in place to reduce the chance of species entering the immediate vicinity of the source. Project Controls include undertaking VSP activities are undertaken in a manner consistent with good international industry practice and BAT.

Additional extensive impact mitigation measures are available, and include avoidance of areas of ecological significance for the placement of exploratory wellpoints and VSP activities; the appointment of marine mammal observers and acoustic monitoring equipment to monitor for the presence of marine species in the vicinity of the source; the use of pre-start protocols to allow animals to exit the areas; the use of a 500 m buffer zone to protect marine species; and an SOP for handling equipment shut downs and conditions of compromised visibility to minimise impacts.

Noise pollution impacts for exploratory VSP and sonar profiling activities are assessed as low overall significance (Table 8.23). With mitigation, the intensity is reduced to low, which still results in a very low magnitude and therefore the impact remains as a low significance because of the high ecological sensitivity of receptors (Table 8.23).

Table 8.23. Impact 19: Noise pollution impacts for exploratory VSP and sonar profiling activities.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Short Term	Very Low	High	**LOW**	-'ve	High

Essential mitigation measures — avoid at source

- Prohibit VSP surveys in declared MPAs.

Essential mitigation measures — avoid/abate at source.

- Pre-borehole site ROV surveys must be untaken to ensure construction activities do not disturb or destroy the sensitive and significant VME epifaunal communities identified in Section 3.3.2, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops). These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform drill site location planning.
- Ensure a buffer of a one km radius of any sensitive species, areas (such as MPAs or EBSAs), habitats or structures.

Essential mitigation measures — abate at source.

- A minimum of two dedicated Marine Mammal Observer (MMO), with a recognised MMO training course, must be on board for marine fauna observation (360 degrees around drilling unit), distance estimation and reporting. One MMO should also have Passive Acoustic Monitoring (PAM) training, should a risk assessment, undertaken ahead of the VSP operation, indicate that the PAM equipment can be safely deployed considering the metocean conditions (specifically current). MMOs should arrive five days prior to VSP commencement to make preliminary observations.
- Ensure drilling unit vessel is fitted with PAM technology (one or more hydrophones), which detects animals through their vocalisations, should it be possible to safely deploy PAM equipment
- VSP profiling should, as far as possible, only commence during daylight hours with good visibility. However, if this is not possible due to prolonged periods of poor visibility (e.g. thick fog) or unforeseen technical issue which results in a night-time start, refer to "periods of low visibility" below.
- Undertake a one hour (as water depths > 200 m) pre-shoot visual and possible acoustic scan (prior to soft-starts / airgun tests) within the 500 m radius mitigation zone in order to confirm there is no cetaceans, turtles, penguins and shoaling large pelagic fish activity close to the source.
- Implement a "soft-start" procedure of a minimum of 20 minutes' duration when initiating the acoustic source (except if testing a single airgun on lowest power). This requires that the sound source be ramped from low to full power rather than initiated at full power, thus allowing a flight response by marine fauna to outside the zone of injury or avoidance. Delay "soft-starts" if cetaceans, turtles and shoaling large pelagic fish are observed / detected within the mitigation zone during the pre-shoot visual / acoustic scan. A "soft-start" should not begin until 20 minutes after cetaceans depart the mitigation zone or 20 minutes after they are last seen or acoustically detected by PAM in the mitigation zone. In the case of penguins, shoaling large pelagic fish and turtles, delay the "soft-start" until animals are outside the 500 m mitigation zone.
- Maintain visual observations and possibly acoustic detections within the 500 m mitigation zone continuously during VSP operation to identify if there are any cetaceans present.
- Should a shutdown/break of more than 20 minutes occurs, a full pre-watch and soft-start process should be carried out before the survey re-commences. If an MMO/PAM operator has been monitoring during the breakdown period, this time can contribute to the 60-minute pre-watch time. If a cetacean is detected in the mitigation zone during the breakdown period, there must be a minimum of a 20-minute delay from the time of the last detection within the mitigation zone and a soft-start must then be undertaken. In the case of penguins, shoaling large pelagic fish or turtles, the animals are outside the 500 m mitigation zone within the 20 minutes period.
- Ensure that during periods of low visibility (where the mitigation zone cannot be clearly viewed out to 500 m), including night-time, the VSP source is only used if PAM technology is in place to detect vocalisations (subject to a risk assessment indicating that the PAM equipment can be safely deployed considering the metocean conditions) or:
    - there have not been three or more occasions where cetaceans, penguins, shoaling large pelagic fish or turtles have been sighted within the 500 m mitigation zone during the preceding 24-hour period;
    - a two-hour period of continual observation of the mitigation zone was undertaken (during a period of good visibility) prior to the period of low visibility and no cetaceans, penguins, shoaling large pelagic fish or turtles were sighted within the 500 m mitigation zone.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
With mitigation	Low	Local	Short Term	Very Low	High	LOW	-'ve	High

8.4.6 THE IMPACTS OF NOISE ASSOCIATED WITH GENERAL EXPLORATORY ACTIVITIES ON MARINE MEGAFAUNA AND AVIFAUNA

This noise will include sound produced by helicopters and vessels. These elevated noise levels may disturb faunal species resulting in behavioural changes or displacement from important feeding or breeding areas (direct negative impact). Assessment of these unmitigated and mitigated impacts are presented in Section 8.2.5.

For helicopter noise, mitigation such as maintenance of the regulation altitude over the coastal zone and flying perpendicular to the coast reduces the intensity of the impact to very low, and the impact is assessed to be of low significance (Table 8.9). The potential physiological injury or behavioural disturbance as a result of vessel noise is considered to be of low magnitude, and low significance prior to mitigation (Table 8.10).

8.4.7 IMPACTS ON FISHERIES AND MARICULTURE AS A RESULT OF SAFETY ZONES

There are two direct impacts as a result of the proposed exploratory activities, both of which result in the loss of access to fishing grounds:

- The temporary exclusion of all fishing activity from the safety zone established during exploration activities such as drilling and flaring; and
- The potential exclusion of demersal fisheries from operating in the area around an abandoned wellhead due to the risk of obstruction or snagging of fishing gear (CapMarine 2018).

The impacts of the implementation of safety (exclusion) zones around the proposed exploration activities will follow those specified in Section 8.2.9. During drilling operations, a temporary statutory safety zone of 500 m from the drilling unit would be required and, following installation, a subsurface safety zone of 500 m from each well would be requested. If the exploration well is temporarily abandoned, then the potential impacts of the presence of an abandoned well include both the exclusion of trawling and anchoring within a distance of 500 m of the wellhead. For a permanently abandoned well, the location would be surveyed and SAMSA would make a determination regarding the risk to vessels and, if necessary, have the location marked as a hazard on navigation charts.

TEEPSA is also proposing to mobilise metocean buoys within the Application Area in order to measure oceanographical, meteorological and possibly acoustic data, i.e., currents, waves, water temperature, ambient water noise levels, wind and air parameters. Metocean survey scope will be defined depending on the need for complementary parameters regarding metocean conditions. The wave buoy would require a temporary safety zone of between 500 m and 2 km radius on the sea surface (depending on the water depth). All vessels would be excluded from entering this safety zone.

Prior to commencement, the following key stakeholders should be consulted and informed of the proposed exploration activity (including navigational co-ordinates of the survey area, timing and duration of proposed activities) and the likely implications thereof:

- Fishing industry / associations, including the South African Deep-Sea Trawling Industry Association (SADSTIA), the South East Coast Inshore Fishing Association (SECIFA), the South African Midwater Trawling Association, the South African Hake Longline Association (SAHALLA), the Shark Longline Association, the South African Tuna Long-Line Association (SATLA), the South African Marine Linefish Management Association (SAMLMA), the South African Pelagic Fishing Industry Association (SAPFIA), and South Coast Rock Lobster Association, and the South African Squid Management Industrial Association (SASMIA).

- Other associations and organs of state, including PASA, DAFF, Transnet National Ports Authority, SAMSA and the South African Navy Hydrographic office.

- Overlapping and neighbouring right holders.

These stakeholders should again be notified at the completion of exploratory activities when the survey vessel and support vessels are off location. The operator must request, in writing, that the South African Navy Hydrographic office release Radio Navigation Warnings and Notices to Mariners prior to the period of exploratory activities. The Notice to Mariners should give notice of (1) the co-ordinates of the exploration survey area, (2) an indication of the proposed timeframes of surveys and day-to-day location of the survey vessel(s), and (3) an indication of the 500 m safety zones and the proposed safe operational limits of the exploratory activities. These Notices to Mariners should be distributed timeously to fishing companies and directly onto vessels where possible.

Exploration activities in the Exploratory Priority Area would directly overlap three commercial fisheries and potentially a portion of small-scale fishers (Section 3.6). The squid fishery and offshore demersal trawl fishery overlap with the northern portion of the Exploratory Priority Area (Figure 3-29, Figure 3-40). Commercial squid jigging activity in the area of overlap is high (area fished 90% of the time) which suggest this area is important for fishing value and catch (Figure 3-40). As the squid fishery is centred around this area of South Africa's territorial waters, the potential impact of exploration on the wider fishery is significant and catch rates could drop significantly areas affected by exploration activities (CapMarine 2017). This is either through direct overlap with fishing activities or underwater noise impacts that would be associated with exploration. Without mitigation, the impacts of exploration phase on this fishery is rated as medium, which reduced to low with mitigation (Table 8.24).

The overlap with the offshore demersal trawl fishery is not as pronounced. A small amount of fishing activity is undertaken in the northern area of the Exploratory Priority Area, but this area is <1% of total offshore trawling grounds and the area is only fished 40% of the time (Figure 3-29). Without mitigation, the impacts of exploration are rated as low, which reduced to very low with mitigation (Table 8.24). The rating is given with consideration to the advanced navigational capacity of offshore trawlers, where the trawl net can be accurately guided over subsea obstacles when the position of such obstacles is charted.

Some 90% of the Exploratory Priority Area overlaps with the Large Pelagic fishery, with some of the most fished areas in this area (Figure 3-35). This area totals 38.6% of the total Large Pelagic Fishing grounds. Of this area, almost 50% is fished > 70% of the time so this area is regularly fished. As evidence suggests, pelagic species have more sensitive hearing (thresholds at lower frequencies) than demersal species, and that catch rates could drop significantly areas affected by exploration activities (CapMarine 2017). Assuming fishing effort as a proxy for presence of large pelagic animals the magnitude of impact caused by exploration on large pelagic longline fishers and ecological receptors of the fishery is rated as medium (causing a moderate change to normal fishing processes). This considers the likely presence of fishers in the area balanced against the potential impacts of benthic exploration activities on pelagic dwelling species. With mitigation this impact significance remains medium (Table 8.24).

In particular, the squid fishery overlaps with the northern portion of the Exploratory Priority Area. Squid is one of the resources within the small-scale fishers 'basket' as per the amended MLRA and small-scale fisheries policy, and 15% of the squid TAC available to South Africa is earmarked to be reapportioned to the small-scale sector. There is an equivalent overlap of 2.4 % of the overall total squid fishing effort and 2.91% of overall squid catch landed by the sector with the Exploratory Priority Area. If 15% of the squid TAC is allocated to the small-scale sector, and the unmitigated impacts are assumed to be directly proportional, this equates to an overlap of 0.44% of overall squid catch landed by the small-scale fisheries. In similarity to the commercial squid fishery, squid fishing appears to be high around the area of overlap and so the impact to catch for small-scale fishers calculated here may be an underestimate (there is currently no good data available on small-scale fishing effort or activities). The potential impact of exploration on the wider fishery could be significant and catch rates could drop as a result of the proposed activities via direct overlap with fishing activities or underwater noise impacts that would be associated with exploration (CapMarine 2017). Small-scale fishers by nature are less resilient to any impacts than other commercial fisheries. Historical inequalities, the slow pace of transformation, inadequate capacity building and less financial input in small-scale fishing communities have made it difficult for these fishers to build resilience into their fishing practices. Sudden stressors and shocks have been shown to be particularly detrimental to small-scale fishers, as highlighted by the COVID-19 pandemic (Mbatha *et al.* 2021). Considering this, despite the small degree of overlap between the exploration phase and potential fishing grounds, without mitigation the impacts on small-scale fisheries are rated as medium, which reduced to low with mitigation (Table 8.24).

Project Controls for abandoned wells include the fitting of wellheads with an over-trawlable structure, to minimise the risk of damage to trawl gear and vessels.

Table 8.24. Impact 21: Impacts on fisheries as a result of safety zones in the Exploratory Priority Area.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Deepsea trawl Without mitigation	Low	Local	Long term	Low	Medium	**LOW**	-ve	High
Hake longline Without mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Mid-water trawl Without mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Line fishery Without mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Large pelagics Without mitigation	Medium	Local	Long term	Medium	Medium	**MEDIUM**	-ve	High
Small pelagics	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation								
Rock lobster Without mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Squid jig Without mitigation	Medium	Local	Long term	Medium	Medium	**MEDIUM**	-ve	High
Small-scale Without mitigation	Medium	Local	Long term	Medium	Medium	**MEDIUM**	-ve	High
Recreational Without mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Mariculture Without mitigation	Very Low	Local	Long Term	Very Low	Low	**NEGLIGIBLE**	-ve	High
Essential mitigation measures – abate at source: • Notify the operators of pelagic long-line vessels of the timing, area and safety clearance requirements prior to the commencement of the exploratory activities through the SATLA. • Maintain adequate safety clearance between fishing vessels and exploratory vessels and equipment through at-sea communications with vessels in the vicinity of the survey area. • Appoint an on-board fisheries liaison officer (FLO) on survey vessels to facilitate communication with fishing vessels whilst on location. The FLO should report daily on vessel activity and respond and advise on action to be taken in the event of encountering fishing gear in the survey area.								
Deepsea trawl With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Hake longline With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Mid-water trawl With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Line fishery With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Large pelagics With mitigation	Medium	Local	Long term	Medium	Medium	**MEDIUM**	-ve	High
Small pelagics With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Rock lobster With mitigation	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High
Squid jig With mitigation	Medium	Local	Long term	Medium	Medium	**MEDIUM**	-ve	High
Small-scale With mitigation	Medium	Local	Long term	Medium	Medium	**MEDIUM**	-ve	High
Recreational	Low	Local	Long term	Low	Low	**VERY LOW**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
With mitigation								
Mariculture With mitigation	Very Low	Local	Long Term	Very Low	Low	NEGLIGIBLE	-ve	High

8.5 Activities across all project phases

8.5.1 Impacts of marine surveys

Seafloor sampling will be undertaken to collect sediment samples to supplement geotechnical and geophysical studies and for environmental baseline studies as well as for monitoring purposes. TEEPSA is also proposing to deploy metocean buoys within the Block in order to measure oceanographical, meteorological and possibly acoustic data, i.e., currents, waves, water temperature, ambient water noise levels, wind and air parameters. The deployment of these instruments, seafloor sampling and ROV surveys will all cause disturbance to the benthic substrate.

The area of impact is considered to be highly site specific, limited to, for example, the turbidity plume generated by the ROV thrusters (a few metres around the ROV and/or ROV flight track), or in the immediate vicinity of any metocean mooring system. The crushing of biota due to to surveys mooring would also highly be localised. The impact is considered to be of low intensity, and of temporary duration, with transient turbidity effects as sediments would redeposit after the ROV has departed the area or after initial mooring deployment. The Exploratory Priority Area (as per Figure 1-1) falls within an area of medium sensitivity, but a high sensitivity of receptors is anticipated should exploration area fall within the Kingklip Corals EBSA and the Port Elizabeth Corals Marine Protected Area completely (see Section 4.3). It is imperative therefore that the placement of receivers or metocean buoys in declared MPAs (in this case, the Port Elizabeth Corals MPA) is prohibited (Table 8.25). The unmitigated impact is considered to be of low significance without mitigation and drops to very low significance with mitigation (Table 8.25).

Table 8.25. Impact 22: Disturbance to sediments, seabed and benthic communities as result of exploratory marine surveys (ROV, metocean, sediment sampling).

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Low	Local	Short term	Very Low	High	LOW	-ve	High
Essential mitigation measures — avoid at source • Prohibit the placement of receivers or metocean buoys in sensitive areas such as declared MPAs and EBSAs. **Essential mitigation measures — avoid/abate at source** • Limit the area directly affected by physical contact with infrastructure to the smallest area required. **Essential mitigation measures — abate at source** • Ensure the ROV does not land or rest on the seabed as part of normal operations.								
With mitigation	Low	Local	Short term	Very Low	Medium	VERY LOW	-ve	High

8.5.2 NOISE POLLUTION IMPACTS FROM SONAR PROFILING ACTIVITIES

As detailed in Section 5, it is assumed that sonar surveys will be carried out using a Kongsberg EM 712 MBES system (or equivalent) within the development area and along the pipeline route with a worst-case sonar operating frequency of 40 kHz (WSP 2023b).

The underwater noise modelling study undertaken by WSP (2023b) (Section 5) indicated that the peak pressure levels generated with each sonar profiling activities are sufficient to cause permanent (permanent threshold shifts) and temporary direct physical injury (temporary threshold shifts) to hearing in marine mammals, as well as death or injury to fish (Table 5.9, Table 5.10 and Table 5.11). Worst-case cumulative impacts (over a 24-hour period) are expected to result in Permanent Threshold Shift (PTS) for high frequency cetaceans at 275-300 m from the source, and at less than 10 m for low frequency cetaceans, and at around 10 m for true seals and other marine carnivores. Maximum single impacts are even smaller, causing PTS at 60-70 m from the source for very high frequency cetaceans, and at <10 m for other marine species (Table 5.9). Worst-case (cumulative) temporary effects occurred at 20 m for low frequency cetaceans was predicted, 70-80 m for high frequency cetaceans, and 640-860 m for very high frequency cetaceans. Physical impacts on fish mortality and potential mortal injury or recoverable injury to fish are estimated at 20 and 40 m, respectively, while the predicted cumulative thresholds distances (over 24-hours exposure) were less than 10 m for all fish, fish eggs and fish larvae (Table 5.10) (WSP 2023b).

The maximum predicted behavioural threshold distances for sonar survey activities were 1.8 km for marine mammals, and 2.45 km for penguin/diving birds (Table 5.11). Given that sea turtles have a frequency hearing range of below approximately 2 kHz, there are no expected behavioural impacts of high frequency sonar sources on these species (Finneran *et al.* 2017, WSP 2023b).

As with Section 8.4.5, while receptor sensitivity is assessed as high, the likelihood of exploratory sonar use causing a significant, irreversible change in habitat use of these species is considered unlikely, and the intensity of the impact is assessed as low with mitigation (Table 8.23). Mitigation measures also serve to reduce the chance of species entering the immediate vicinity of the source, and act quickly to halt activities if important marine animals are spotted during operations. With mitigation, the intensity is reduced to low, which still results in a very low magnitude and therefore the impact remains as a low significance because of the high ecological sensitivity of receptors (Table 8.23).

Table 8.26. Impact 23: Noise pollution impacts for exploratory sonar profiling activities.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	High	Local	Short Term	Low	High	**LOW**	-'ve	High

Essential mitigation measures — avoid at source

- Prohibit sonar surveys in declared MPAs and EBSAs.

Essential mitigation measures — abate at source.

- A minimum of two dedicated Marine Mammal Observer (MMO), with a recognised MMO training course, must be on board for marine fauna observation (360 degrees around drilling unit), distance estimation and reporting. One MMO should also have Passive Acoustic Monitoring (PAM) training, should a risk assessment, undertaken ahead of the sonar operation, indicate that the PAM equipment can be safely deployed considering the metocean conditions (specifically current).
- Ensure drilling unit vessel is fitted with PAM technology (one or more hydrophones), which detects animals through their vocalisations, should it be possible to safely deploy PAM equipment.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
• Sonar surveys should, as far as possible, only commence during daylight hours with good visibility. However, if this is not possible due to prolonged periods of poor visibility (e.g. thick fog) or unforeseen technical issue which results in a night-time start, refer to "periods of low visibility" below. • Undertake a one hour (as water depths > 200 m) pre-shoot visual and possible acoustic scan (prior to soft-starts / airgun tests) within the 500 m radius mitigation zone in order to confirm there is no cetaceans, turtles, penguins and shoaling large pelagic fish activity close to the source. • Implement a "soft-start" procedure of a minimum of 20 minutes' duration when initiating the acoustic source (except if testing a single airgun on lowest power). This requires that the sound source be ramped from low to full power rather than initiated at full power, thus allowing a flight response by marine fauna to outside the zone of injury or avoidance. Delay "soft-starts" if cetaceans, turtles and shoaling large pelagic fish are observed / detected within the mitigation zone during the pre-shoot visual / acoustic scan. A "soft-start" should not begin until 20 minutes after cetaceans depart the mitigation zone or 20 minutes after they are last seen or acoustically detected by PAM in the mitigation zone. In the case of penguins, shoaling large pelagic fish and turtles, delay the "soft-start" until animals are outside the 500 m mitigation zone. • Maintain visual observations and possibly acoustic detections within the 500 m mitigation zone continuously during sonar survey operation to identify if there are any cetaceans present. • Should a shutdown/break of more than 20 minutes occurs, a full pre-watch and soft-start process should be carried out before the survey re-commences. If an MMO/PAM operator has been monitoring during the breakdown period, this time can contribute to the 60-minute pre-watch time. If a cetacean is detected in the mitigation zone during the breakdown period, there must be a minimum of a 20-minute delay from the time of the last detection within the mitigation zone and a soft-start must then be undertaken. In the case of penguins, shoaling large pelagic fish or turtles, the animals are outside the 500 m mitigation zone within the 20 minutes period. • Ensure that during periods of low visibility (where the mitigation zone cannot be clearly viewed out to 500 m), including night-time, the sonar source is only used if PAM technology is in place to detect vocalisations (subject to a risk assessment indicating that the PAM equipment can be safely deployed considering the metocean conditions) or: ○ there have not been three or more occasions where cetaceans, penguins, shoaling large pelagic fish or turtles have been sighted within the 500 m mitigation zone during the preceding 24-hour period; ○ a two-hour period of continual observation of the mitigation zone was undertaken (during a period of good visibility) prior to the period of low visibility and no cetaceans, penguins, shoaling large pelagic fish or turtles were sighted within the 500 m mitigation zone.								
With mitigation	Low	Local	Short Term	Very Low	High	**LOW**	-'ve	High

8.5.3 Impacts of Increased Vessel Traffic Across All Project Phases on Marine Ecosystems and Users

As detailed in Section 5, there is an expected increase in vessel traffic during all phases of the project from construction through to exploration. With several major ports on the coast of South Africa, including Cape Town, Mossel Bay, Gqeberha, East London, and Durban, the 2020 vessel traffic map shown in Figure 5-3 demonstrates how Block 11B/12B is located within the main vessel traffic routes that pass around southern Africa. MMO surveys within Block 11B/12B from 28 November 2022 to 9 December 2022 recorded 50 vessels, which mostly comprised of bulk carriers (17), crude oil tankers (9) and fishing vessels (9) (BSL & CapMarine 2023). The intensity of this increase in vessel traffic when considering current levels of vessel presence within the area is rated as medium.

The main marine ecological impact likely is collision with cetaceans. Vessel traffic between the Application Area and the coast can have a significant disturbance impact on cetaceans during their breeding and mating season (Pisces 2020). Of particular concern are the potential overlaps in vessel movement with migrating Humpback whales and Southern Right whales inshore of the concession area (the former April to December, with calving season from July to October, peaking in early August, and the latter June and November) (Best 2007). Southern Right whales utilise the sheltered bays of the South Coast to breed and calve, with winter concentrations recorded all along the southern and eastern coasts of South Africa, with the most significant concentration currently on the South Coast between Cape Town and Gqeberha. As per Section 3.3.7, it is highly likely that several hundred right whales can be expected to pass directly through the Application Area between May and June and then again November to January. Smaller cetaceans in the area include the Indo-Pacific Humpback dolphin, which occurs as a localised population concentrated around shallow reefs in the Plettenberg Bay-Algoa Bay region. Other species of concern that are likely to be encountered frequently in the Application Area include the Vulnerable Bryde's whales (throughout the year, with peak encounter rates occurring in late summer and autumn), the Endangered Sei whale (peaking in abundance on the East Coast in June and September), and the Vulnerable Sperm whale (high probability throughout the year, increasing in winter). Collisions with Leatherback and Loggerhead turtles that occur in offshore waters around southern Africa, and likely to be encountered in Block 11B/12B are also of concern.

Although some of these species are listed as globally Endangered or Critically Endangered may potentially occur in the area (see Section 3), the placement of the Application Area within a main marine traffic route underpins the assumption that marine receptors will already experiencing elevated marine traffic and vessel noise. Thus, the sensitivity of receptors to vessel collision is rated as medium after mitigation (Table 8.27).

The most likely cumulative impact will be linked to the displacement of fishers from fishing grounds due to increasing coastal traffic, and the increased likelihood of vessel collisions. However, given current levels of vessel traffic, the increase in vessel numbers from this project is not considered to increase traffic substantially and intensity is rated as low after mitigation. Overall, the unmitigated impacts related to increased vessel traffic as results of the project are considered to be of low intensity, of local extent and have a magnitude of very low after mitigation. The sensitivity of receptors is considered medium after mitigation and the overall significant is rated as very low after mitigation (Table 8.27).

Table 8.27. Impact 24: Impacts of increased vessel traffic across all project phases on marine ecosystems and user fishers.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Local	Short term	Very Low	High	**LOW**	-ve	High
Essential mitigation measures — avoid/abate at source • Ensure vessel transit speed between the survey / drill area and port is a maximum of 12 knots (22 km/hr), except within 25 km of the coast where it is reduced further to 10 knots (18 km/hr). • Ensure that all vessel paths avoid breeding areas or migration routes during peak migration or breeding times of year, if possible. • Placing a trained, dedicated observer onboard a vessel to help increase the detection rate of cetaceans or turtles along a vessel's route during day-light hours. • No hovering or circling over whales, or other marine megafauna. • Educate and create awareness with mariners about collision risks								
With mitigation	Low	Local	Short term	Very Low	Medium	**VERY LOW**	-ve	High

8.6 Unplanned event impacts

8.6.1 Pollution generated through general discharges, littering, fuel leaks, refuelling or vessel collisions on the marine environment

Water quality in the vicinity of construction vessels, production platforms, exploration vessels and associated support vessels may be impaired by various forms of waste discharged into the marine environment. Objects which are particularly detrimental to aquatic fauna include plastic bags and bottles, pieces of rope and small plastic particles. All reasonable measures must be implemented to ensure that no littering takes place during installation, operation and closure of oil and gas production facilities. Large numbers of aquatic organisms are killed or injured daily by becoming entangled in debris or as a result of the ingestion of small plastic particles (Gregory 2009, Wright *et al.* 2013). If allowed to enter the ocean, this solid waste may be transported by currents for long distances out to sea and around the coast. Thus, unlike fuel or sewage contamination, the extent of the damage caused by solid waste is potentially large. The unmitigated impact of floating or submerged solid materials on aquatic life (especially birds and fish) can be lethal and can affect rare and endangered species.

There is a risk of spillage of a variety of hazardous substances occurring with the use of heavy machinery and construction vessels. For example, spillage may occur as a result of fuel leaks, refuelling (bunkering), or collision. Bunkering refers to the supplying of fuel for use by ships including the logistics of loading and distributing the fuel among available shipboard tanks. While a contingency plan would be prepared and be in place at all times during operations, accidental, or non-routine, discharges of hydrocarbons may also include the accidental loss of fuel during refuelling or from vessel collisions could occur.

Diesel or hydraulic fluid spills are another risk of ship-to-ship bunkering. These substances, if spilled in the marine environment, will have an immediate detrimental effect on water quality. Being highly toxic, marine diesel released during an accidental spill will negatively affect any marine fauna in which it comes into contact. In the offshore environment, the taxa most vulnerable to spills are coastal and pelagic seabirds. Since the commencement of the bunker operations in Algoa Bay, for example, there have been four recorded oil spill incidents as a result of bunkering, most of which resulted in the oiling of African penguins (Seabreeze Maritime Consultants 2020). In August 2016 approximately 100 litres of oil were allegedly spilled during bunkering operations, while approximately 200-400 litres of oil were allegedly spilled during bunkering operations in July 2019, both during night-time operations (Seabreeze 2020). As spilled oil is less visible at night, night-time spills are more difficult to manage and clean up. Hydrocarbons are toxic to aquatic organisms and precautions must be taken to prevent them from contaminating the environment.

Project Controls for this impact include the following:

- Compliance with COLREGS (the Convention dealing with safety at sea, particularly to reduce the risk of collisions at sea) and SOLAS (the Convention ensuring that vessels comply with minimum safety standards).
- To be prepared in the event of a spill incident, the project will implement an emergency response system to mitigate the consequences of the spill. As standard practice, the Emergency Response Plan (ERP) will include crisis contacts and protocols and an Oil Spill Contingency Plan (OSCP) will be prepared and available at all times during the drilling operation.

- Regulation 37 of MARPOL Annex I will be applied, which requires that all ships of 400 gross tonnage and above carry an approved Shipboard Oil Pollution Emergency Plan (SOPEP). The purpose of a SOPEP is to assist personnel in dealing with unexpected discharge of oil onboard, to set in motion the necessary actions to stop or minimise the discharge to the sea and to mitigate its effects on the marine environment. Thus, project vessels will be equipped with appropriate spill containment and clean-up equipment, e.g. dispersants and absorbent materials. All relevant vessel crews will be trained in spill clean-up equipment use and routine spill clean-up exercises.

- All deck drainage from workspaces and ballast water to be discharged must meet the MARPOL compliance level of 15 ppm oil in water thought use of an oily-water separation system (Table 8.28).

The implementation of suitable Project Controls and additional mitigation provided in Table 8.28 reduces the significance rating of the impact from medium to low (Table 8.28).

Table 8.28. Impact 25: Pollution generated through littering, fuel leaks, refuelling (bunkering), or collision.

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Without mitigation	Medium	Regional	Medium term	Medium	Medium	**MEDIUM**	-ve	High
Essential mitigation measures — avoid/abate at source • Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected. • Use breakaway couplings with shut-off valves during refuelling. As a result, any spill during refuelling is likely to be of a relatively small volume before it will be detected and stopped. • Give preference to vessels using marine gas oil (MGO), which (if spilled) is less persistent in the marine environment than heavy fuel oil (HFO). • As far as possible, and whenever the sea state permits, attempt to control and contain the condensate spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill. • In the case of small operational diesel spills offshore, no action would be required unless large numbers of pelagic seabirds are present, in which case the spill should be sprayed with dispersants (if sea conditions permit and permission has been obtained from the relative authority). • Ensure adequate resources are available to collect and transport oiled birds to a cleaning station. • All process areas should be bunded to ensure drainage water flows into the closed drainage system. • Drip trays should be used to collect run-off from equipment that is not contained within bunded areas, and the contents routed to the closed drainage system. • Ensure offshore bunkering is not undertake in the following circumstances: o Wind force and sea state conditions of ≥6 on the Beaufort Wind Scale; o During any workboat or mobilisation boat operations; o During helicopter operations; o During the transfer of in-sea equipment; and o At night or times of low visibility. **Essential mitigation measures — abate at source** • Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station. • Include training on how to care for downed seabirds as part of induction and ongoing awareness training. • Low-toxicity biodegradable detergents should be used in the cleaning of all deck spillages. • Obtain permission from DFFE to use low toxicity dispersants. Use cautiously.								
With mitigation	Low	Regional	Medium term	Low	Medium	**LOW**	-ve	High

8.6.2 FAUNAL STRIKES

While increased vessel traffic increases the risk of collisions with cetaceans (see details in Section 8.5.3). Project Controls include:

- Contractors will ensure that all proposed vessel operations are undertaken in a manner consistent with good international industry practice and BAT.
- All whales and dolphins are given protection under South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel.

This risk can be successfully mitigated through limits on vessel transit speed (see Table 8.27).

8.6.3 UNCONTROLLED SPILLAGE OF HYDROCARBONS (CRUDE OIL AND CONDENSATE), INCLUDING A BLOWOUT ON MARINE HABITATS AND COMMUNITIES

The greatest environmental threat from offshore drilling operations is the risk of a major spill of crude oil and/or natural gas occurring either from a blowout or loss of well control. A blowout is the uncontrolled release of crude oil and/or natural gas from a well after pressure control systems have failed.

Any release of liquid hydrocarbons has the potential for direct, indirect and cumulative effects on marine fauna (and associated habitats) and the fishing industry in the offshore, nearshore and coastal environment. Spilled hydrocarbons move according to the prevailing weather conditions with the greatest possible impact realised if it makes landfall. Spilled fuel can have toxic and/or smothering effects on organisms in the path of a spill, with coastlines being particularly vulnerable. These effects include physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton (particularly copepods), pelagic eggs and fish larvae, and habitat loss or contamination (CSIR 1998b; Perry 2005). Spills can also have socio-economic implications if fisheries and coastal tourism (among others) are disrupted.

Hydrocarbons spilled in the marine environment would have an immediate detrimental effect on water quality. Most of the toxic effects are associated with the mono-aromatic compounds and low molecular weight polycyclic hydrocarbons, as these are the most water-soluble components of the spill. Hydrocarbon spills are most toxic in the first few days after the spill, losing some of its toxicity as it begins to weather and emulsify. For the purposes of this report impacts are assessed here for operational spills of condensate and diesel occurring both offshore and nearshore.

Various factors influence the scale of unmitigated impacts of hydrocarbons, such as condensate or oil, on the marine environment. The physical properties and chemical composition of the condensate/oil, local weather and sea state conditions and currents greatly influence the transport and fate of the released product (Pulfrich 2015). The magnitude of coastal unmitigated impacts related to such spill events are also dependent on the location (inshore/offshore) and volume of hydrocarbons spilled i.e., large volumes spilled in close proximity to the coast would have a greater impact than smaller amounts spilled offshore. The physical properties that affect the behaviour and persistence of oil spilled at sea are specific gravity, distillation characteristics, viscosity and pour point, all of which are dependent on the composition of the oil (e.g., the amount of asphaltenes, resins and waxes). Spilled oil undergoes physical and chemical changes (collectively termed 'weathering'), which in combination with its physical transport determine the spatial extent of oil contamination and the degree to which the environment will be exposed to the toxic constituents of the released product (Pulfrich 2015). As soon as oil is spilled, various weathering processes begin breaking down the oil. Although the individual processes may act simultaneously, their relative importance varies with time (Figure 8-8). Whereas spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill, the ultimate fate of oil is determined by the longer-term processes of oxidation, sedimentation and biodegradation (Pulfrich 2015).

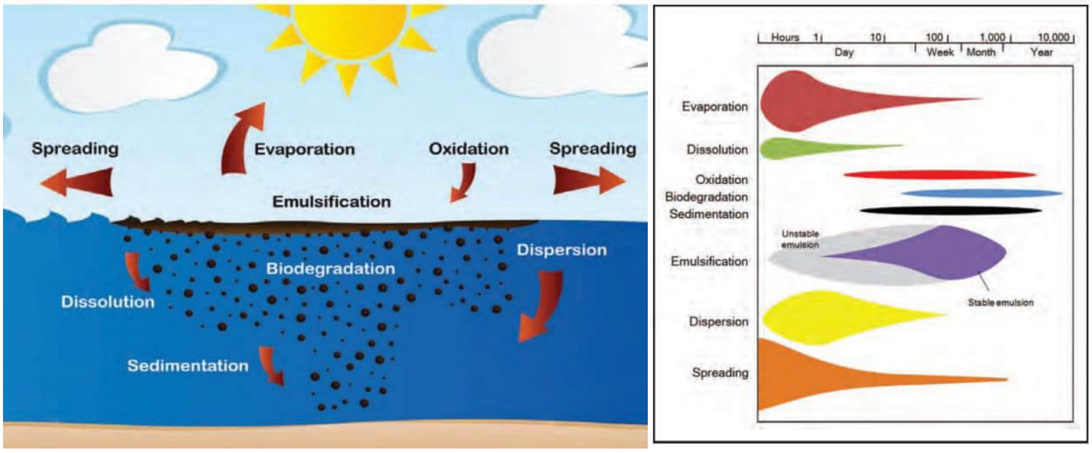


Figure 8-8. (Left) Weathering processes acting on oil at sea. (Right) Relative importance of weathering processes on a crude oil spill with time; the width of each band indicates the importance of each process. Source: ITOPF, from Biccard *et al.* (2018).

The unmitigated impact of a blowout on the marine environment is largely dependent on the quantity and physical state of the hydrocarbons released (Biccard *et al.* 2018). A blowout will result in a jet release rising through the water column of two-phase material (gas and liquids). Gaseous components will be released to the atmosphere, while liquid components will form a slick on the sea surface. Some oil will, however, be dispersed and dissolved into the water column. A seabed blowout will form a crater as a result of the escape of high-pressure gas. Escaping hydrocarbons will form a plume of bubbles, liquids and re-suspended sediments as the gas and liquids are ejected through the water column. The potential hazards to the marine ecosystem are associated with the toxicity of the hydrocarbons, damage to the benthic community, the effects of increased turbidity generated by the rising gas/sediment loaded plume and impacts associated with hydrocarbons in the water column and a slick on the sea surface (Biccard *et al.* 2018).

In the Brulpadda and Luiperd exploration wells, mainly gas with condensate with a thin oil rim were discovered. Due to the analogy with Brulpadda environment, it is expected to find similar types of fluids at wells in the Exploratory Priority Area. However, for the oil spill modelling conducted for the eastern area, only the worst case was considered, namely a spill of crude oil. Crude oil is heavier than condensate and when an oil spill occurs it floats and forms a thick layer on the surface. The oil spill modelling for the Project Development Area focused on the impacts and extent of a spillage (via pipeline rupture and well blowout) of condensate (Section 7.3), while modelling for the Exploratory Priority Area focused on the impacts and extent of a crude oil spillage (Section 7.4). Therefore, the impacts of hydrocarbon spillage, including both condensate and crude oil, on the marine environment are detailed in this section. Below follows an assessment of various biotic components, and the expected impacts of a blowout and pipeline rupture, based on dispersion modelling results presented in Section 7.

PHYTOPLANKTON, ZOOPLANKTON AND MICROBES

The negative unmitigated impacts of hydrocarbon spills on phytoplankton and microbes (cyanobacteria, bacteria, protozoa) is well established (see for example, Abbriano *et al.* 2011 Lewis & Pryor 2013, Ozhan *et al.* 2014, Quigg *et al.* 2021). For example, the reduction in light penetration through the water column as a result of the shading by the buoyant oil reduces phytoplankton photosynthesis and growth and exposure to both the hydrocarbons and dispersant materials can impact both the physiological functioning of these organisms themselves (Quigg *et al.* 2021). These impacts can have cascading indirect effects on trophic functioning by changing/disrupting between phytoplankton and zooplankton, and among phytoplankton and heterotrophic microbes (Quigg *et al.* 2021). These physiological effects as a result of direct exposure to petroleum-based hydrocarbon pollutants through a spill are difficult to predict at a community level (different studies have shown both negative and positive effects on growth) and are likely influenced by site specific conditions and species composition (Teal & Howarth 1984, Ozhan *et al.* 2014, Bretherton *et al.* 2018, cited in Quigg *et al.* 2021). Additionally, the use of chemical dispersants have been shown to modify the uptake and accumulation of crude oil residues in both laboratory and in situ studies (Quigg *et al.* 2021).

As with phytoplankton, the unmitigated impacts of oil spills on marine zooplankton depends on species composition and life history stage, exposure time, oil type and concentration, as well as site conditions (temperature, salinity, nutrients) (Moore & Dwyer 1974, Daly *et al.* 2021). Zooplankton species found in the surface waters are particularly vulnerable to hydrocarbon pollution (National Research Council, 2003, Daly *et al.* 2021). In addition, some zooplankton (including dinoflagellates, gelatinous doliolids and copepods) have been shown to ingest oil and egest oil in faecal, which may be re-ingested by other particle-feeding zooplankton, creating a transferral of oil pollution to deeper waters though the sinking of marine snow and faecal pellets (Lee *et al.* 2012, Almeda *et al.* 2014, Almeda *et al.* 2016 in Daly *et al.* 2021).

Genomic studies showed that, after the Deepwater Horizon oil spill, microbial communities were predominantly (90%) comprised of oil degrading species in areas exposed to hydrocarbons (Kleindienst *et al.*, 2016). This result implies that the baseline microbial community in the vicinity of the spill was almost completely replaced by species able to take advantage of the oil 'resource', with a "succession of microbial blooms with species adapted to degrade specific types of petroleum compounds in the water column and in surface sediments" (Kleindienst *et al.* 2016; Yang *et al.* 2016 a, b Kostka *et al.* 2020). Sediment microbe communities recovered within two years (Mason *et al.* 2014, Overholt *et al.* 2019, Schwing *et al.* 2020). Note that because the South Coast of South Africa does not have confirmed oil seep anomalies, the area is unlikely to have established oil-degrading microbial communities (especially considering the dynamic offshore oceanographic conditions), and the impacts of deposited oil on the seabed are therefore likely to persist over the long-term (Table 8.30).

BENTHIC FAUNA

The unmitigated impacts of hydrocarbon spills, particulate large blowouts, on infaunal macrofauna communities (of size 300 µm-30 mm) have been shown to be moderate to severe, with decreases in abundances and diversity indices (Schwing *et al.* 2020). Indeed, the literature details how, after historic catastrophic blowouts, abundance and diversity of macrofauna were depressed relative to background values across throughout an area of approximately 148 km^2 and 24 km^2 from the point of contamination (Montagna *et al.* 2017). These impacts are likely related to chronic pollution of the benthos as well as smothering, with recovery times in excess of four year (Reuscher *et al.* 2017). Tolerances and sensitivities between species vary greatly; while sessile and mobile molluscs (e.g., mussels and crustaceans) are highly susceptible to direct oiling or coating and are highly sensitive to oil residue exposure, opportunistic polychaetes are known to persist and aid with the bioturbation and degradation of oiled sediments (Gordon *et al.* 2011, Washburn *et al.*, 2016, Biccard *et al.* 2018). Based on estimates of sedimentation rates, oil residue degradation rates, and metabolic rates, Montagna *et al.* (2017) estimated that, "it may take between 50 and 100 years to fully bury and/or degrade (the)-contaminated sediment below macrofaunal bioturbation depths, thus allowing a full recovery of benthic species diversity and abundance" (Schwing *et al.* 2020). Chronic oiling from a large blowout may also cause additional sub-lethal responses in various taxa at different life stages, affecting their survival and ability to re-colonise oiled areas (Biccard *et al.* 2018).

Filter-feeders in particular are vulnerable from the ingestion of oil in solution, in dispersion or adhered to fine particles. The unmitigated impacts of large-scale blowout events on epifauna including deep water corals are particularly severe and include colony injury and tissue/branch loss (Silva *et al.* 2015). In situ studies have found slow recovery in deepwater coral communities affected by elevated hydrocarbon concentrations, with some work documenting a continued decline in health years after a pollution event (Etnoyer *et al.* 2016). While the wider long-term significance of such spills on broader cold-water coral populations remain unclear, the recovery rate of these species appears to be dependent on the level of initial impact (Roberts & Cairns 2014). Model results based on branch loss/growth from 2010 to 2017 estimated that damaged communities can take up to 30-100 years to recover fully from a large spill (Girard *et al.* 2018, Girard & Fisher 2018, Schwing *et al.* 2020). Based on estimated growth rates and polyp recruitment, the replacement of entire colonies is estimated to take centuries (Doughty *et al.* 2014, Schwing *et al.* 2020).

The impacts of sedimentation processes (i.e., the buoyant oil moving down through the water column to the benthos) in the fate of both condensate and crude oil in the marine environment as a result of oil spills was not included in either the western Project Development Area and the eastern Exploratory Priority Area (DHI 2023, HES 2020c, d; see Section 7). It is presumed therefore that the studies deem these processes to be an insignificant mechanism. However, the literature pertaining to biological processes involved in the movement of oil to the benthos (see Lee *et al.* 2012, Almeda *et al.* 2014, Almeda *et al.* 2016 in Daly *et al.* 2021) suggests that it cannot be assumed that little to no oil will reach the benthos. Therefore, the assessment of the impacts, and in particular, the impacts of crude oil on the benthic environment, was conducted with medium confidence (Table 8.30 and Table 8.31).

FISH

Many species of larval and juvenile fish spend their earliest life history stages as zooplankton, and fish eggs are another important component of plankton (Cushing 1995). Various studies on the effects of hydrocarbon exposure have identified Polycyclic aromatic hydrocarbons (PAHs) as the most damaging and cardiotoxic (damaging to the heart) to the sensitive early-life stages, due to their high lipophilicity and enduring persistence in the marine environment (Carls *et al.* 1999; Incardona *et al.* 2004; Hicken *et al.* 2011; Incardona *et al.* 2013). Thus, fish larvae are considered to be highly vulnerable to lethal and sub-lethal exposure even at very low levels of hydrocarbon exposure (Pasparakis *et al.* 2019).

Unmitigated impacts of oil on juvenile and adult fish can be lethal, as gills may become coated with oil. Sub-lethal and long-term effects can include disruption of physiological and behavioural mechanisms, reduced tolerance to stress, and incorporation of carcinogens into the food chain (Thomson *et al.* 2000). While highly mobile, fish are likely to be able to avoid a large spill, a large-scale pollution event within an important nursery area would have a significant impact on recruitment of juveniles. Juvenile fish are unlikely to be able to move out of an affected area and, depending on the size of the spill, mortality is to be expected. It is likely that commercially important species would also be affected, thus having a negative impact on fisheries. The time of year during which a large spill takes place will significantly influence the magnitude of the impact on plankton, pelagic fish eggs and larvae and consequently a reduction in recruitment (Baker *et al.* 1990). However, spawning and recruitment success varies with each season and environmental conditions are likely to have a far greater impact than a single large spill (Neff, 1991). As such, significant loss of pelagic eggs and fish larvae can be expected if they are present in the area of an oil spill. Should it coincide with a major spawning peak, it could result in severe mortalities and hence a in recruitment. It follows that the time of year would greatly affect the degree of this impact.

Studies have also documented sublethal impacts of oil spills and hydrocarbon pollution on fish that may persist through development, and result in decreased fitness and survival at later life stages (Pasparakis *et al.* 2019). These effects include delayed growth and latent mortality following embryo/larval exposure (i.e., delayed mortality after survival of the initial pollution event) (Duffy *et al.* 2016, Johansen *et al.* 2017). Deceased growth following the Deepwater Horizon oil spill has been demonstrated in a number of fish species, including the bay anchovy (*Anchoa mitchilli*) (Duffy *et al.* 2016).

A crude oil spill that covers the coastal MPAs could have negative impacts on the fish protected with these areas. For example, worst-case model results show that there is a 70-90% probability that a blowout at Discharge-2 (crude oil) will result in a surface oil slick (> 5 µm thick) that covers 84.61% of the Tsitsikamma MPA (Section 7). This MPA, along with the others along the South Coast that are also likely to be affected (such as the Addo Elephant National Park MPA and Goukamma MPA) are especially important for the protection of over exploited, endemic seabream fish species, see Section 4.2).

SEABIRDS

Seabirds are particularly vulnerable to being coated by spilled oil, and chronic and acute oil pollution is a significant threat to both pelagic and inshore species (Vanstreels *et al.* 2023). Oiled seabirds may be more vulnerable to hypothermia, as oil reduces their insulation. Oil can also cause them to experience skin irritation and develop ulcers. Seabirds often try to preen the oil off their plumage and subsequently ingest the toxic fuel oil, which can have endocrine-disrupting effects. Flightless birds, such as penguins, are especially prone to oiling, as they cannot fly over polluted areas and there have been cases of substantial penguin mortality as a result of oil spills (Wolfaardt *et al.* 2008, 2009). In addition, certain seabirds travel great distances to feed, and it should be noted that an oil spill may impact birds roosting some distance from the spill site (Biccard *et al.* 2018).

Seabirds likely to be encountered in Block 11B/12B include the Endangered Cape cormorant *Phalacrocorax capensis* (reported up to 80 km from their colonies) and Cape gannet *Morus capensis* (regularly feed as far offshore as 100 km), Indian yellow-nosed albatross *Thalassarche carteri* and Atlantic yellow-nosed albatross *T. chlororhynchos*, as well as the Vulnerable White chinned petrel *Procellaria aequinoctialis* Leach's storm petrel and Wilson's storm petrel

Oceanodroma leucorhoa (see Section 3.3.5). An oil spill that remains offshore is likely to affect these species. However, should an oil spill reach the shore, a more diverse range of species will be affected, including breeding colonies of the Endangered African penguin *Spheniscus demersus* (Vanstreels *et al.* 2023). This of particular concern in the case of model results presented for a blowout of wells in the Exploratory Priority Area; the worst-case (winter) model results indicate a 30-50% probability of an oil spill reaching Addo Elephant National Park MPA (Algoa Bay) if there is a blowout at Discharge-1, and 50-70% probability of an oil spill reaching the Addo MPA if there is a blowout at Discharge-2 (Section 7). Oiling of the Addo MPA and Algoa Bay would be of catastrophic consequences for seabirds, as the Bay is host to the most important breeding islands for the endangered Cape gannet and African penguin on the south coast, and arguably in South Africa (see Section 3.3.6).

Some species, including penguins and gannets, have a history of being successfully rehabilitated via cleaning of the birds or temporary removal of breeding pairs to prevent oiling (DEA 2013, Helm *et al.* 2015, Tseng & Ziccardi 2019, Chilvers *et al.* 2021). However, not all oiled birds will be found, particularly pelagic seabirds (Table 3.6). Moreover, even if they are found and cleaned, there can be long term impacts on their ability to breed (Wolfaart *et al.* 2008). After a large oil spill in 2000, pairs involving at least one rehabilitated penguin (that had been oiled) showed a reduced breeding success of 0.66 chicks per year compared to 1.02 chicks per year in unaffected pairs (Barham *et al.* 2007). Furthermore, there can be substantial costs associated with rehabilitating oiled seabirds, particularly if chicks or eggs need to be rescued due to their "parents" being oiled, which significantly extends the timeframe of the response. Due to their Endangered status, the Cape gannet, Cape cormorant and African penguin may be even more sensitive to these unmitigated impacts. As part of the required mitigation, adequate resources must be provided to collect and transport oiled birds to a cleaning station. Include training on how to care for downed seabirds as part of induction and ongoing awareness training.

TURTLES AND MARINE MAMMALS

Unmitigated Impacts of hydrocarbon spills and blowouts on turtles are thought to primarily affect hatchling survival (CSIR and CIME 2011). Turtles encountered offshore would mainly be migrating adults and vagrants. While direct coating of nesting females, contamination of nests and absorption of oil by eggs and hatchlings will occur with heavy shoreline oiling, with far-reaching effects on recruitment success and population status (Putman *et al.* 2015). However, the nesting sites in South Africa are all located some 1 000 km away on the KwaZulu Natal coastline these would not be affected in the event of a spill, but hatchlings carried southwards in the Agulhas Current may become oiled. As turtles spend much of their time at the surface, inhalation of the volatile oil fractions will occur to hatchlings and adults leading to respiratory stress, while coating of eyes, nostrils and mouths with oil will cause vision loss, inhalation and ingestion.

The effects of hydrocarbon pollution on marine mammals are poorly understood (White *et al.* 2001). Little work has been done on the effect of an oil spill on fur seals, but they are expected to be particularly vulnerable as oil would clog their fur and they would die of hypothermia (Pulfrich 2015). The most likely immediate unmitigated impact of an oil spill on cetaceans being the risk of inhalation of volatile, toxic benzene fractions when the oil slick is fresh and unweathered (Scholz *et al.* 1992). Direct oiling of cetaceans is not considered a serious risk to thermoregulatory capabilities, as cetacean skin is thought to contain a resistant dermal shield that acts as a barrier to the toxic substances in oil (Pulfrich 2015). Baleen whales may experience fouling of the baleen plates, resulting in temporary obstruction of the flow of water between the plates and, consequently, reduce feeding efficiency. The unmitigated impact of oil pollution on local and migrating cetacean populations would depend on the timing and extent of the spill. In particular, oil pollution in areas of critical importance to cetaceans, such as near-shore calving grounds of the Southern Right whale or summer feeding grounds off the Cape, would most likely impact populations.

Field observations record few, if any, adverse effects among cetaceans from direct contact with oil, and some species have been recorded swimming, feeding and surfacing amongst heavy concentrations of oil (Scholz *et al.* 1992). It is assumed that the majority of cetaceans would be able to avoid oil pollution, except where the area of avoidance is critical to population survival. Although adult whales have been noted to swim, and even feed through heavy concentrations of oil, Southern Right whale calves have a far higher surfacing rate than adults and could possibly be affected by inhalation of volatile hydrocarbons (Blood 2015).

COASTAL ENVIRONMENTS

A diverse community of fauna and flora are found in the narrow coastal strip between the high-water mark down to the shallow subtidal. These species found here have evolved to cope with the dynamic nature of this habitat and settle nowhere else. It is this very strip of habitat which is most heavily affected by oil should a slick come ashore (Section 7). Indeed, the most sensitive coastal areas are coastal lagoons and estuaries.

While model results for Discharge-4 and 5 (condensate) indicate a very small probability (0.5-1%) that a pipeline rupture would result in oil shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) entering the Knysna Estuary, the unmitigated impacts of oil entering this system would be of high intensity (Section 7). Modelling results for Discharge-1 and 2 (crude oil) indicate a far higher probability of oil reaching the Knysna Estuary and there is a modelled worst-case, maximum, shoreline impact probability of 100% from George to Gqeberha in winter (July to September), while in autumn (April to June), 98% of shore-line impacts are modelled to occur between Knysna and Gqeberha (Discharge-2, see Section 7). The highest probability of oil-shoreline impact after a well blowout occurring in from July to September for both Discharge-1 and Discharge-2 (Section 7). Even for Discharge-1, there is a 42% probability of the oil reaching shore from Knysna to St. Francis Bay area in spring (Oct-Dec) (Section 7). The Knysna Estuary is one of only three large, permanently open estuarine bays along the South African coastline. The estuary is considered to be the most ecologically significant estuary in South Africa, representing 42.8 % of all estuarine biodiversity (Turpie *et al.* 2002) Knysna is home to a number of critically endangered species, the most famous of which being the Knysna seahorse *Hippocampus capensis*, which is endemic to the Knysna Estuary and wilderness lakes and relies on the survival of the local eelgrass species *Zostera capensis*.

Oil spilled on beaches will results in significant declines in abundance, biomass and diversity of meiofaunal and macrofaunal communities, with recovery of macrofaunal communities typically occurring at between 2-5 years, but with recovery of burrowing and long-lived species potentially taking up to 10 years on heavily oiled beaches (Bejarano & Michel 2016). Recovery of meiobenthos is typically more rapid. In some cases, recovery of the invertebrate communities is hampered by both re-oiling frequency and the type and degree of beach clean-up following a spill, while in other cases clean-up attempts has promoted recovery.

In the case of oiling of rocky shores, natural recolonisation typically begins after the processes of physical and chemical degradation have started, with recovery of exposed rocky shore communities typically occurring over 3-4 years but may take longer on sheltered shores (Sell *et al.* 1995, Finlayson *et al.* 2015). Indeed, wave exposed rocky shores are among the least vulnerable environments to oil spills, because wave action enhances processes that act to degrade the oil, and hence facilitate its removal (Gundlach & Hayes 1978, Finlayson *et al.* 2015). It is important to note however that "recovery" should not simply mean a reduction of oil residue and potential exposure to toxins (Hayworth *et al.* 2011), but needs to account for recovery of community structure and function — this may take several years, and is strongly dependent on the size of the spill, the sensitivity of the receptors impacted, and the type and extent of clean-up (Newey & Seed 1995, Kingston 2002, Bustamante *et al.* 2010, Finlayson *et al.* 2015).

The unmitigated impacts of a worst-case unplanned catastrophic event (well blowout, pipeline rupture) for operations within the Application Area on marine and coastal communities is highly dependent on prevailing metocean conditions at the time of the spill as well as the time of year, duration of the spill and extent and the plume.

For Discharge-4 and 5 (in the Project Development Area), the intensity of the unmitigated impact of a condensate spill on pelagic and coastal systems is rated as high prior to the implementation of mitigation. Impact intensity on seabirds is also rated as high (Table 8.30). As spilled condensate is unlikely to impact the benthos (most of it evaporates rapidly, see Section 7), benthic impacts are assessed as of low intensity, with medium confidence because the Discharge-4 and 5 modelling study did not explicitly include an assessment of effects below the water surface (Table 8.30).

For Discharge-1 and 2 (in the Exploratory Priority Area), the intensity of the unmitigated impact of a crude oil spill on pelagic and coastal systems is rated as very high prior to the implementation of mitigation (Table 8.30).

The sensitivity of receptors, given the presence of a number of critically endangered, endangered and vulnerable species (such as turtle species, various pelagic fish and shark species, sperm whales, Sei whales and the Knysna seahorse), is high (Table 8.30). It is noted that, for modelled wells in the Project Development Area, the probability of oil reaching the coast in a form that has been defined to cause ecological harm is exceedingly small (less than 5% for the worst-case, and a 1% probability it reaches the Knysna Estuary). This probability is significantly higher for a blowout at the modelled Exploratory Priority Area wells, especially Discharge-2 where the results of a modelled worst-case scenario indicate maximum shoreline impact probability to the Knysna area of 98-100%, depending on season (Section 7).

Worst-case model results indicate that for a blowout (depending on season), there is a 90% probability that condensate will extend 250-290 km from the rupture point to the southwest (for Discharge-4 and 5), and a 90% probability that oil will extend 135-340 km from the rupture point to the southwest (for Discharge-1 and 2 to the west) (Section 7). Model results show that surface oil (with >75% probability) will cover a number of EBSAs and MPAs to the south and southwest, and that a crude oil blowout from Discharge-1 and Discharge-2 will also result in surface over coverage of a number of inshore MPAs. The worst-case scenario for Discharge-1 (in winter) shows that there is a probability of 30-50% that the spill will overlap with the Addo Elephant National Park MPA (representing 39.6% of the MPA), 58.6% of the Tsitsikamma MPA, and a 10-30% probability of overlapping 95% of the Goukamma MPA. For Discharge-2 (also in winter), the worst-case results show that there is a 50-70% probability of a surface spill overlapping 28.8% of the Addo Elephant National Park MPA, and a 70-90% probability of overlap with the Tsitsikamma MPA (representing 84.61% of the MPA) and 40.47% of the

Goukamma MPA (Section 7).

The spatial extent of a pipeline rupture is smaller than a well blowout, with worst-case model results predicting with 90% probability that condensate will extend 10 km from the rupture point in all seasons, depending on season. Because there is a possibility that crude oil/ condensate from a well blowout would reach international waters under the worst-case scenario, the extent of the unmitigated impact is rated as international, with a long-term duration (Table 8.30). It is important to note that while the impacts on the ecological systems and communities are assessed as high to very high, the probability of a major spill happening via a well blowout or a pipe rupture is considered to be extremely small.

Project Controls are outlined in Table 8.31 below. A "multi-barrier" (i.e. mitigation) approach in dealing with risks (particularly the risk of oil spills) will be implemented. This approach involves defining multiple preventative barriers (or avoidance mitigation measures) to manage environmental risk and is integrated into the application of the Mitigation Hierarchy ('avoid', 'minimize', 'restore' and 'offset'). The first step and most important priority in applying the Mitigation Hierarchy to manage the risk of a catastrophic oil spill is avoidance (or prevention). If these preventative barriers fail or are not effective under certain conditions, then response/recovery capabilities (minimisation or restoration barriers) will be in place.

In line with the standard industry practice, TEEPSA is prepared to mitigate spills of importance from routine operations (Tier-1), while oil spill situations of higher magnitude are dealt with by industry co-operation and external intervention (Tier 2 and Tier 3).

Table 8.29. Project Controls for oil spill preparedness and response.

Avoidance/Prevention	
Design and Technical Integrity	• Detailed engineering risk analysis undertaken. • Well designed as per TOTAL's company rules for casing design. • Peer reviews organized with HQ specialists. • Optimisation of drilling phase durations / lengths to fit with weather forecasts window. • Robust well architecture. • Optimise drilling sections and casing design according to expected formation pressure profile. Well is designed to withstand the most stringent pressure profile. • Designed with the maximum possible safety factor for possible "kicks"[15]. • Casings able to withstand the max possible load case.
Multiple Barriers	• Casing: Casings will be designed to withstand a variety of forces, such as collapse, burst or tensile failure. They will be used to prevent caving-in of formations, prevent fracture of formations and to provide strong foundations for continued drilling operations. • Wellbore pressure and drilling mud weight: Subsurface pressures above and within the hydrocarbon-bearing strata will be controlled by the use of drilling mud. Mud Hydrostatic pressure to be higher than formation pressure and lower than fracturation pressure.

[15] A "kick" is a well control problem in which the pressure found within the drilled rock is higher than the mud hydrostatic pressure acting on the borehole or rock face. When this occurs, the greater formation pressure has a tendency to force formation fluids into the wellbore. This forced fluid flow is called a "kick".

Avoidance/Prevention	
	The hydrostatic pressure (or weight) of the drilling mud in the well will be adjusted to ensure that it is greater than the formation pressure to prevent the undesired influx of fluids into the wellbore (known as a 'kick'). Pressure monitoring will be undertaken during drilling to ensure that kicks are avoided or managed to prevent escalation into a blow-out. • Blow-out Preventer (BOP) stack: BOP stacks are used to control the pressure of a well through mechanical devices designed to rapidly seal the well (or "shut in") in an emergency. Minimum configuration (online and in working order at all times): o 2 annular preventers; o Capable to safely disconnect with Lower Marine Riser Package (LMRP); o Blind shear rams and casing shear rams; capable to shear any pipe in well o 3 pipe rams to seal around drill pipes • The BOP is regularly tested as per American Petroleum Institute (API) and TOTAL rules, and will inspected by a BOP specialists prior to operations.
Competent Staff	• The operator has trained, competent and certified staff who will design the well and conduct independent sign-off of its design. • Before rigs and crews are moved into place to start drilling, a 'Drill Well On Paper' (DWOP) will be performed to brainstorm and anticipate the future well drilling and completion. • Every unit will have a plan, training and expertise to effectively respond to emergency situations, in order to minimise their potential impact on people, facilities and the surrounding community. All key personnel are International well Control Forum (IWCF) certified level 2 to 4. • Maersk simulator training undertaken focusing on well control procedure in harsh environment.
Testing and Certification	• Safety critical equipment will be subject to testing and certification to ensure that it meets design specifications. The well design, drilling and completion plans will go through several stages of review involving experts from the operator and the drilling contractor prior to the commencement of drilling operations.
Shallow Hazard Survey	• A shallow hazard survey is undertaken to identify all possible constraints from man-made and geological features that may impact the operational or environmental integrity of the drilling and to ensure that appropriate mitigation practices are identified and adopted.
Drilling Operations	• Mud weight based on the Pressure profile (Pore pressure, leak off pressure and fracturation pressure) commitment case (conservative). • Utilisation of High Performance Water Base Mud (HPWBM). • Riser margin available (in case of BOP disconnection). • Logging while drilling (reduction of geological depth uncertainties). • Continuous monitoring systems to monitor all well indications (Rate of penetration, Mud volumes (in versus out, cuttings). • Early kick detection systems and sensors to detect any anomalies with alarms.
Specific Procedures	• Specific well control procedures in harsh environment jointly implemented. • Specific WSOG (Well Specific Operating Guidelines) developed. • Upgrade of metocean forecasts (additional HF radars to be installed). • Well Sentinel initiative in place. • Operations follow-up 24/7 by TOTAL real-time services centre.
Response and Recovery	
Oil Spill Contingency Plan	• As standard practice, an Oil Spill Contingency Plan (OSCP) will be prepared and approved internally by TOTAL HQ and submitted to the South African authorities (SAMSA and PASA) for review and approval. The OSCP specifies how best to control an unlikely spill, how to prevent certain sensitive habitats / environments from exposure to oil, and what can be done to repair the damage done by the spill (containment and recovery). • The OSCP is the operational document prepared and aligned with local and national regulations, including the South Africa's National Oil Spill Contingency Plan, applicable international conventions and internal rules. The primary objective

Avoidance/Prevention	
	of the OSCP is to set in motion the necessary actions to minimise the effects of an oil spill. It also: • Provides an emergency notification system, including a standardised format for oil spill notification; • Describes the escalation monitoring process from Tier 1 to Tier 2 and Tier 3 incidents; • Outlines the system for command and control of the oil spill response operations and organisation; • Provides checklists of actions for key personnel during an oil spill; and • Provides strategy and tactics to respond to the different types and levels of oil spills (Tier 1 t o 3). • The OSCP will be communicated to staff and periodically tested in order to ensure an effective and co-ordinated response to situations. The OSCP will be available at all times during the drilling operation.
Emergency Response Plan	• As standard practice, an Emergency Response Plan (ERP) / Evacuation Plan will be prepared and put in place. A Medical Evacuation Plan (Medevac Plan) will form part of the ERP.
Well Control / BOCP	• Whilst the OSCP defines the approach and strategy required to manage the containment, removal and clean up following a major spill, the well control process is focussed on stopping the source of the leak. A BOCP will set out the detailed response plan and intervention strategy to be implemented in the event of a blow-out to stop any discharge of oil. • Contracts are in place with well response companies (e.g. capping stack) - see below.
Cap and Containment Equipment	• If the BOP does not successfully shut off the flow from the well, the drilling rig will disconnect and move away from the well site while crews mobilise a capping system. The capping system will be lowered into place from its support barge and connected to the top of the BOP to stop the flow of oil or gas. • Oil Spill Response Limited (OSRL), the global oil spill response co-operative funded by more than 160 oil and energy companies, has a base in Saldanha Bay, South Africa, which houses cutting edge well capping equipment designed to shut-in an uncontrolled subsea well. The Saldanha based capping stack is available to oil and gas companies across the industry and provides for swift subsea incident response around the world. The equipment is maintained ready for immediate mobilisation and onward transportation by sea and/or air in the event of an incident. • In addition, Total has its own capping stacks on standby and access to WWC (Wild Well Control) capping stacks under contract.
Additional Equipment	• Implementation of Early Kick & Losses Detection (EKLD) system proven in harsh environment. • Emergency Drill Pipe Hang Off Tools available on site. • Retrievable Test-Treat-Squeeze (RTTS) packer available on rig for testing, treating and squeeze cement operations. • Drop-In Check Valves (DICV) adapted to drilling & landing string. • ROV available on site fully capable of operating BOP. • Tug assist vessel(s) to assist rig remain on location, which has necessary proven in harsh environment.
Containment and clean-up equipment	• The primary tools used to respond to oil spills are mechanical containment, recovery, and clean-up equipment. In order to effectively combat spilled oil, equipment and materials most suited to the type of oil and the conditions at the spill site will be selected and used, as most spill response equipment and materials are greatly affected by such factors as conditions at sea, water currents and wind. • Project vessels will be equipped with appropriate spill containment and clean-up equipment, e.g. booms, dispersants and absorbent materials. All relevant vessel crews will be trained in spill clean-up equipment use and routine spill clean-up exercises. • Logistical arrangements for the integration of additional support will be in place (e.g. from OSRL). Total also has its own internal resources including equipment, dispersant and personnel. Emergency Response Services will be contracted, whenever needed. Total also has its own emergency teams and equipment on standby.

The successful implementation of the Project Controls and additional mitigation measures detailed in Table 8.30 reduces the significance of high impacts to medium, and very high impacts to high (Table 8.30). The impacts of a crude oil blowout from Discharge-1 and Discharge-2 are rated as very high without mitigation, and most are rated as high with the implementation of mitigation (Table 8.31). Therefore, while the risk of occurrence of a blowout at the exploratory wells in the Exploratory Priority Area is low, the implications, of a spill of the magnitude modelled are highly significant, especially if the hydrocarbon considered is indeed crude oil.

Table 8.30. Impact 27a: Impacts on marine ecological systems and communities as a result of condensate spillage, including a blowout — Discharge-4 and Discharge-5 (western sites).

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Plankton Without mitigation	Medium	International	Medium term	High	High	**HIGH**	-ve	High
Benthic fauna Without mitigation	Low	International	Long term	High	High	**HIGH**	-ve	Medium
Fish Without mitigation	Medium	International	Medium term	High	High	**HIGH**	-ve	High
Seabirds Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Turtles Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Marine mammals Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Coastal environment Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High

Essential mitigation measures – abate at source

- Use low toxicity dispersants that rapidly dilute to concentrations below most acute toxicity thresholds (refer to DFFE Oil Dispersant Policy and SAMSA Marine Notice on dispersants). Dispersants should be used cautiously and only with the authorisation of DFFE.
- Ensure a standby vessel is within 30 minutes of the drilling unit and equipped for dispersant spraying and can be used for mechanical dispersion (using the propellers of the ship and/or firefighting equipment). It should have at least 5 m^3 of dispersant onboard for initial response.
- As far as possible, and whenever the sea state permits, attempt to control and contain the spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill.
- In the event of a large spill, use drifter buoys and satellite-borne Synthetic Aperture Radar (SAR)-based oil pollution monitoring to track the behaviour and size of the spill and optimise available response resources.
- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station. Include training on how to care for downed seabirds as part of induction and ongoing awareness training.
- .

Essential mitigation measures – avoid/abate/restore

- Develop a well-specific response strategy and plans (OSCP and BOCP), aligned with the National OSCP, for each well location that specifies the resources and response required to minimise the risk and impact of oiling (shoreline and offshore). This response strategy and associated plans must take cognisance to the local oceanographic and meteorological seasonal conditions, local environmental receptors and local spill response resources. The development of the site-specific response strategy and plans must include the following:

<table>
<tr><th></th><th>Intensity</th><th>Extent</th><th>Duration</th><th>Magnitude</th><th>Sensitivity</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td colspan="9">o Assessment of response resources (equipment and people) and capabilities at time of drilling, location of such resources (in-country or international), and associated mobilisation / response timeframes.
o Selection of response strategies that reduce the mobilisation / response timeframes as far as is practicable. Use the best combination of local and international resources to facilitate the fastest response.
o Well-specific oil spill modelling for planning purposes taking into consideration site- and temporal-specific information, the planned response strategy, and associated resources
o Considering the well-specific modelling, map environmentally or socio-economically sensitive and priority protection areas, in collaboration with an independent Marine Ecologist and Social Scientist.
o Develop intervention plans for the most sensitive areas to minimise risks and impacts and integrate these into the well-specific response strategy and associated plans.
o If modelling and intervention planning indicates that the well-specific response strategy and plans cannot reduce the response times to less than the time it would take oil to reach the shore, additional proactive measures must be committed to. For example:
1. Implement measures to reduce surface response times (e.g., pre-mobilise a portion of the dispersant stock on the support vessels, contract additional response vessels and aircrafts, minimise the time it takes to install the SSDI kit, improve dispersant spray capability, etc.).
2. Deploy and/or pre-mobilise shoreline response equipment (e.g., response trailers, shoreline flushing equipment, shoreline skimmers, storage tanks, shoreline booms, skirt booms, shore sealing booms, etc.) to key localities for the full duration of drilling operation phase to proactively protect sensitive coastal habitats and areas.
• Schedule joint oil spill exercises including TEEPSA and local departments/organisations to test the oil spill response readiness.
• Ensure contract arrangements and service agreements are in place to implement the OSCP, e.g., capping stack in Saldanha Bay and other international locations, SSDI kit, surface response equipment (e.g., booms, dispersant spraying system, skimmers, etc.), dispersants, response vessels, etc.
Essential mitigation measures – restore
• In the event of a large blowout or loss of control of the well, an oil spill response plan must be implemented taking the following factors into consideration:
o Designated personnel to manage the situation;
o Spill response, containment and clean-up equipment on standby with sufficient training provided to the personnel responsible for its maintenance and effective use; and,
o Well control, capping and containment equipment on standby with sufficient training provided to the personnel responsible for its maintenance and effective use.
• Ensure that the following aspects are included in insurance cover to financially manage the consequences of any unplanned event:
o Control of Well.
o Damages and compensation to Third-Parties.
o Decommissioning & Abandonment.
o Evidence to be provided to PASA.</td></tr>
<tr><td>Plankton
With mitigation</td><td>Medium</td><td>Regional</td><td>Medium term</td><td>Medium</td><td>High</td><td>MEDIUM</td><td>-ve</td><td>High</td></tr>
<tr><td>Benthic fauna
With mitigation</td><td>Low</td><td>Regional</td><td>Medium term</td><td>Medium</td><td>High</td><td>MEDIUM</td><td>-ve</td><td>Medium</td></tr>
<tr><td>Fish
With mitigation</td><td>Medium</td><td>Regional</td><td>Medium term</td><td>Medium</td><td>High</td><td>MEDIUM</td><td>-ve</td><td>High</td></tr>
<tr><td>Seabirds
With mitigation</td><td>High</td><td>Regional</td><td>Medium term</td><td>High</td><td>High</td><td>HIGH</td><td>-ve</td><td>High</td></tr>
<tr><td>Turtles
With mitigation</td><td>High</td><td>Regional</td><td>Medium term</td><td>High</td><td>High</td><td>HIGH</td><td>-ve</td><td>High</td></tr>
<tr><td>Marine mammals
With mitigation</td><td>High</td><td>Regional</td><td>Medium term</td><td>High</td><td>High</td><td>HIGH</td><td>-ve</td><td>High</td></tr>
</table>

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Coastal environment With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High

Table 8.31. Impact 27b: Impacts on marine ecological systems and communities as a result of crude oil spillage, including a blowout — Discharge-1 and Discharge-2 (eastern sites).

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Plankton Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Benthic fauna Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	Medium
Fish Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Seabirds Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Turtles Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Marine mammals Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Coastal environment Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Essential mitigation measures • See Table 8.30.								
Plankton With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Benthic fauna With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Fish With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Seabirds With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Turtles With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Marine mammals With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Coastal environment With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High

8.6.4 Uncontrolled spillage of hydrocarbons (crude oil and condensate), including a blowout on commercial and recreational fishing and mariculture

There are several possible impacts of large oil spills on fisheries and mariculture. These include the displacement of species from normal feeding areas, physical contamination of animals (including eggs and larvae) resulting in mortality and/or physiological effects such as clogging of gills, the exclusion of fisheries from polluted areas and gear and mariculture infrastructure related damage due to oil contamination. These unmitigated impacts can range from relatively short term to much longer term if mitigation measures and clean-up efforts are not effective. Various factors influence the scale of impacts of hydrocarbons, such as condensate or oil, on the marine environment. The physical properties and chemical composition of the condensate/oil, local weather and sea state conditions and currents greatly influence the transport and fate of the released product (Pulfrich 2015), and therefore the impact.

CONDENSATE SPILL (DISCHARGE-4 AND 5)

The potential unmitigated impacts on commercial and recreational fishing, and mariculture, as a result of oil spillage, including a blowout are dependent on the extent and behaviour of a spill i.e., the area affected. The proposed well development and pipeline locations (both routing options) are in areas where commercial fisheries currently operate. In a pipeline rupture scenario, worst-case model results indicate that there is a 90% probability that a spill will extend 10 km from the rupture point all seasons. In a well blowout scenario, worst-case model results indicate that there is a 90% probability that a spill will extend 250-290 km from the rupture point to the southwest, depending on season. Model results indicate that there is a 1% chance that a spill will extend 490 km west for all seasons. Based on these model outputs the uncontrolled spillage of oil will overlap with the operations of a number of commercial and recreational fisheries (Table 8.32, Figure 8-9 to Figure 8-14).

The overlap of the modelled oil spill with each fishery has been calculated for both above and below 50% surface oil probabilities. The overlapping area (% of total fishing area) for both scenarios is presented in Table 8.33 below.

In offshore areas, an oil spill would impact on the operational activities of commercial fisheries. The oil spill surface oil (> 5 µm thick) is expected in the event of a blowout. Offshore, the greatest impacts are therefore expected for commercial fisheries that regularly deploy and haul gear, which, in the event of an oil spill, would spatially restrict fishing operations as any fishery that would continue to operate in the area of an oil spill would damage both gear and catch, directly impacting the fishery. In the event of an oil spill, fishing may have to be temporarily suspended in oiled waters.

The intersection between the modelled oil spill with small-scale fisheries have been assessed slightly differently using % of TAC impacted rather than total fishing area as this is not assumed. As TAC for squid and hake are defined, with the remainder of species in the small-scale 'basket' currently without TAC allocations, this is likely an underestimate.

Table 8.32. Area of overlap between the fishing grounds of relevant South African commercial, recreational, and mariculture fisheries and modelled oil uncontrolled oil spill results (Scenarios 1&2). Area is calculated as % of total (national) fishing grounds of each fishery, based on catch and effort data from DFFE and using 'footprint' layers produced for the National Biodiversity Assessment 2018. Area of overlap is calculated for both above and below 50% probabilities of oil presence (areas of 0% (i.e., no overlap) are not included in the calculations). As no small-scale specific area data is available, the overlap with this sector is calculated as % of TAC impacted (% of the TAC for all fisheries combined to which TAC has been allocated to the small-scale sector) rather than total fishing area.

	Percentage of fishing grounds (>50% probability)	Percentage of fishing grounds (<50% probability)
Blowout		
Inshore demersal trawl	2.84	36.53
Deepsea trawl	5.82	32.43
Hake longline	4.95	70.43
Mid-water trawl	17.47	53.00
Line fishery	0.00	10.92
Large pelagics	19.99	31.37
Small pelagics	0.00	11.61
Rock lobster	2.66	68.37
Squid jig	0.08	36.33
Recreational fisheries	0.00	0.93
Mariculture	0.00	0.00
Pipeline rupture		
Inshore demersal trawl	0.00	28.25
Deepsea trawl	0.00	16.10
Hake longline	0.06	42.63
Mid-water trawl	0.16	28.85
Line fishery	0.00	3.80
Large pelagics	0.00	5.87
Small pelagics	0.00	16.73
Rock lobster	0.53	25.26
Squid jig	0.00	22.56
Recreational fisheries	0.00	0.00
Mariculture	0.00	0.00
	Percentage of allocated TAC impacted (>50% probability)	**Percentage of allocated TAC impacted (<50% probability)**
Blowout		
Small-scale fisheries	0.04	23.62
Pipeline rupture		
Small-scale fisheries	0.00	13.18

The model results show that during a well blowout scenario, surface oil presence probability >70% probability overlaps with the activities of the large pelagic fishery to a large degree, and some offshore demersal trawling to a much small degree. The surface oil modelling shows a west, south west, directionality for surface oil and if, as is 90% probable in the modelling scenario, this surface oil travels 200 km from the well head in this direction then substantial overlap with the large pelagic fishery is expected. This fishery would be impacted the most considering both scenario 1 (well blowout) and scenario 2 (pipeline rupture). The magnitude of this impact was scored accordingly in Table 8.33). With mitigation the magnitude reduced from high to medium (Table 8.33).

The behaviour and persistence of the modelled oil spill results suggest the impacts on benthic habitats should be considered minimal in offshore areas. In the nearshore and intertidally, important benthic species of low mobility such as rock lobster, sessile filter feeders (mussels) and grazers are vulnerable to the effects of an uncontrolled oil spill. Particularly vulnerable are mussel and oyster mariculture areas and the highly valuable abalone, *Haliotis midae* (Biccard *et al.* 2018).

The model results show the highest probability of oil-shoreline impact after a well blowout occurs in winter (Season 3, June-August), with >10 g/m^2 oil predicted to potentially impact some 64 km of shoreline (see Section 7). The maximum oil amount found on shore based on the worst-case scenario (deterministic simulation) is 1.2-2.8 tons, with a probability of 1.1-4.8%. The probability of oil reaching shore in these concentrations is, however, very low (1-5% across all seasons). The impacted shoreline is predicted to comprise Cape St Francis, Oyster Bay, Huisklip Nature Reserve, Thyspunt, Rebelsrus Private Nature Reserve, Wasserna's Beach.

The direct effects and vulnerability of many shoreline species, harvested by small-scale and recreational fishers means impacts associated with an uncontrolled spill are higher for this sector. These sectors also have reduced flexibility in terms of redistribution of effort, considering the extent of coastline potentially impacts by an oil spill. The offshore small-scale sector is also likely to be impacted significantly, with a spill of > 50% probability overlapping with some 23% of the total allocated small-scale TAC (across all species) (Table 8.33).

The impacts on commercial and other fishing sectors as a result of oil/fuel spillage, including a blowout has been assessed accordingly in Table 8.33. Without mitigation, the intensity of unmitigated impacts on receptors was rated as high but this was reduced to medium with mitigation. Impacts of oil on the surface from a spill on commercial fisheries persist over the short-term but due to the potential extent of the spread of the oil spill and the potential suspension of fishing practices extent is considered to be on the regional scale (Table 8.33).

Table 8.33. Impact 28a: Impacts on commercial and recreational fishing as a result of condensate spillage, including a blowout — Discharge-4 and Discharge-5 (western sites).

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Demersal trawl Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Hake longline. Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Mid-water trawl Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Line fishery Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Large pelagics Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Small pelagics Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Rock lobster Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Squid jig Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Small-scale Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Recreational Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Mariculture Without mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	High
Essential mitigation measures • See Table 8.30.								
Demersal trawl With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Hake longline. With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Mid-water trawl With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Line fishery With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Large pelagics With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Small pelagics With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Rock lobster With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Squid jig With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	High
Small-scale With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	Medium
Recreational With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	Medium
Mariculture With mitigation	Medium	Regional	Medium term	Medium	High	**MEDIUM**	-ve	Medium

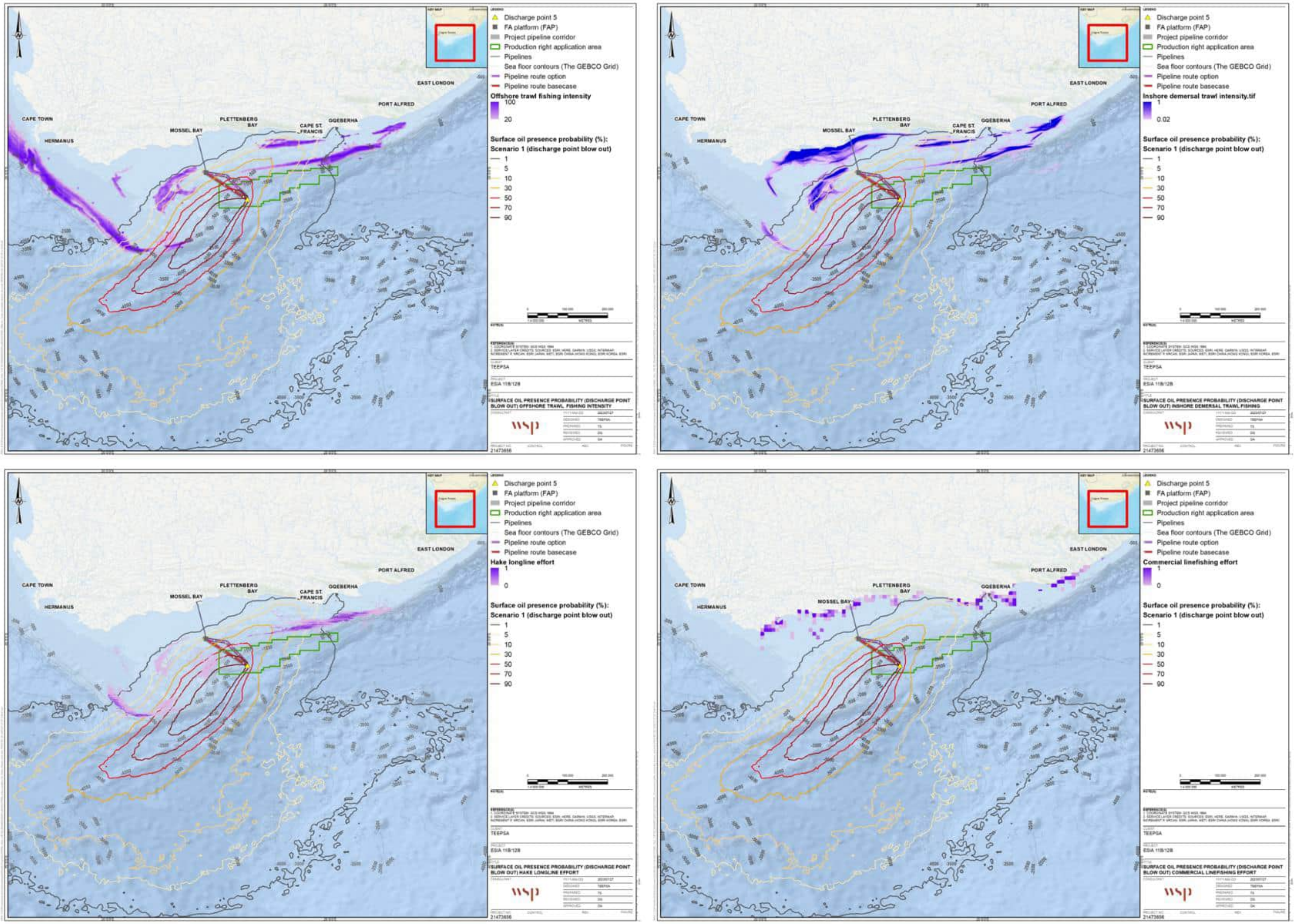


Figure 8-9. Surface oil presence probability well blowout model results for all simulations across the full simulation period with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are inshore hake trawl (top left), offshore demersal trawl (top right), hake longline (bottom left) and linefishing (bottom right).

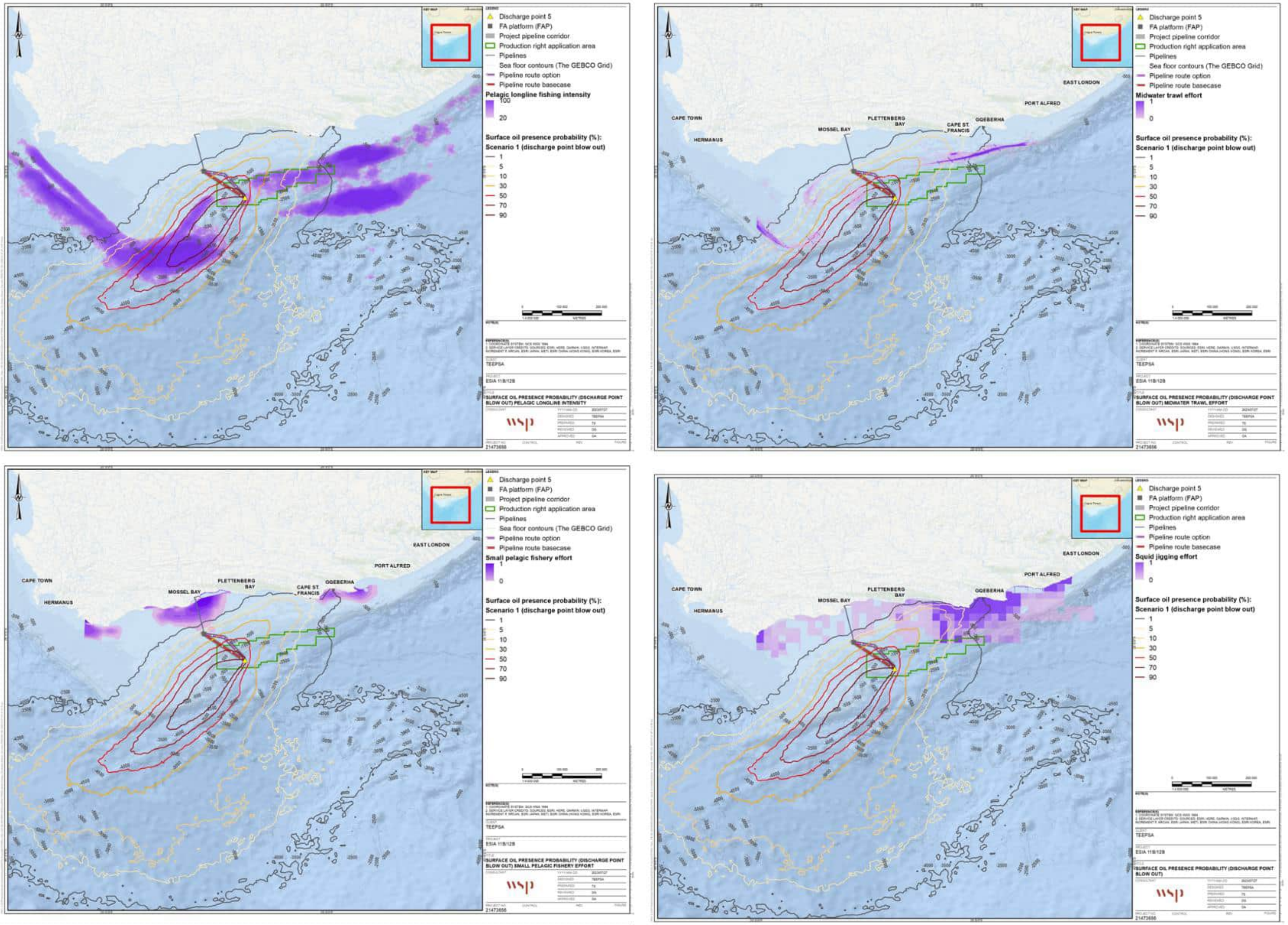


Figure 8-10. Surface oil presence probability <u>well blowout</u> model results for all simulations across the full simulation period with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are pelagic longline (top left), midwater trawl (top right), small pelagic purse seine (bottom left) and squid jig (bottom right).

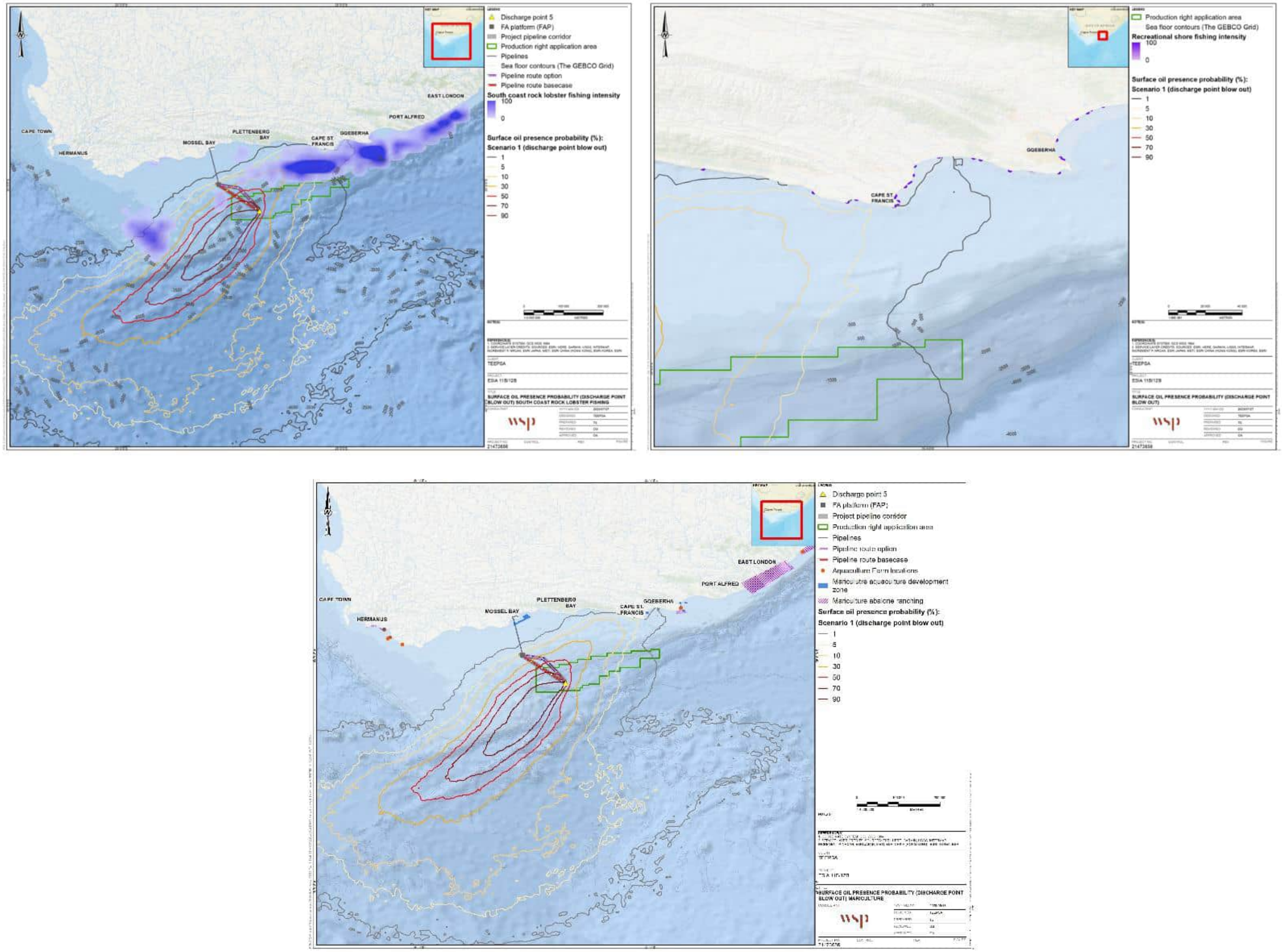


Figure 8-11. Surface oil presence probability well blowout model results (red gradients) for all simulations across the full simulation period with fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are south coast rock lobster (top left), recreational shore angling (top right) and mariculture (bottom).

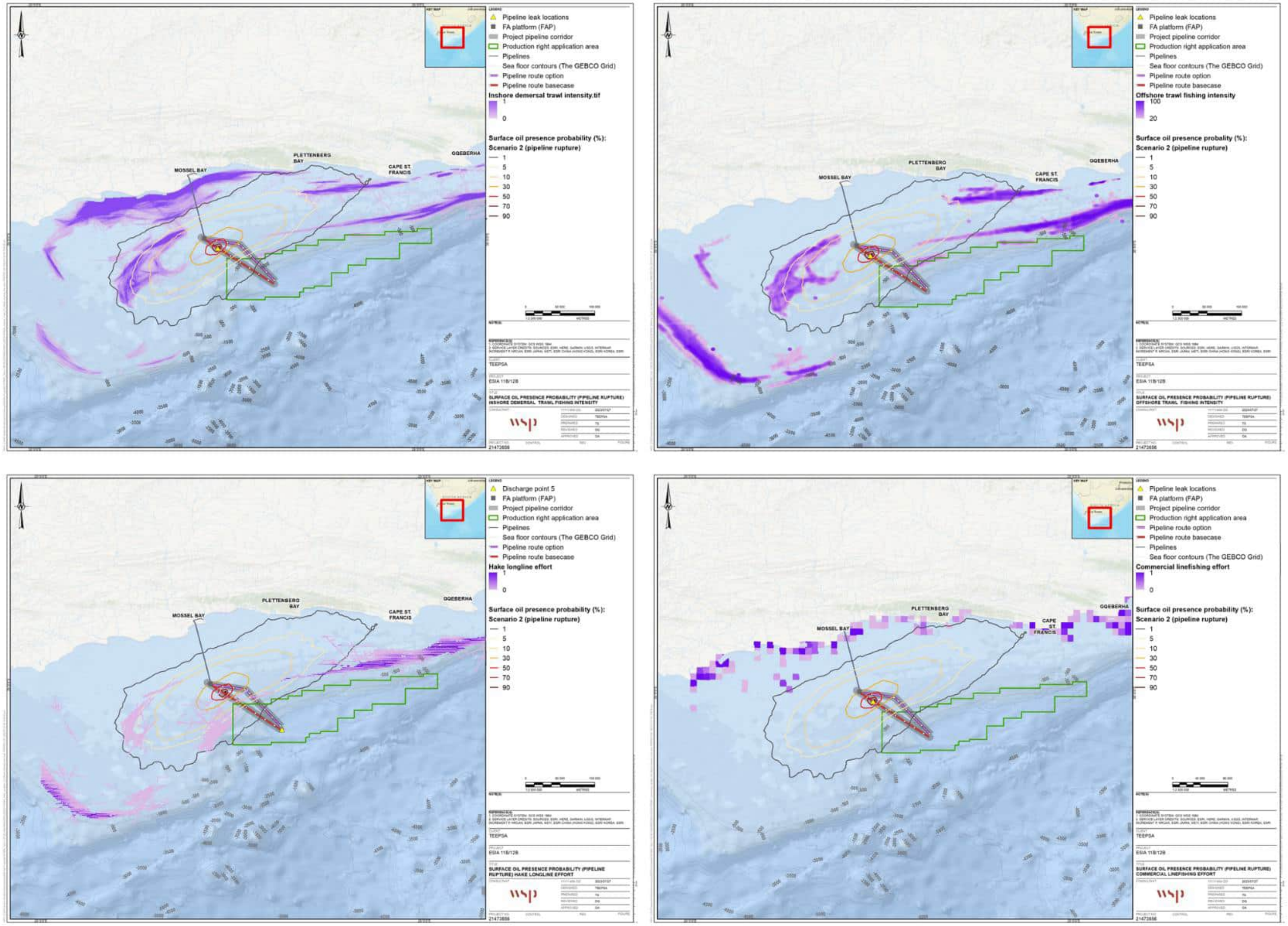


Figure 8-12. Surface oil presence probability <u>pipeline rupture</u> model results for all simulations across the full simulation period with fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are inshore hake trawl (top left), offshore demersal trawl (top right), hake longline (bottom left) and linefishing (bottom right).

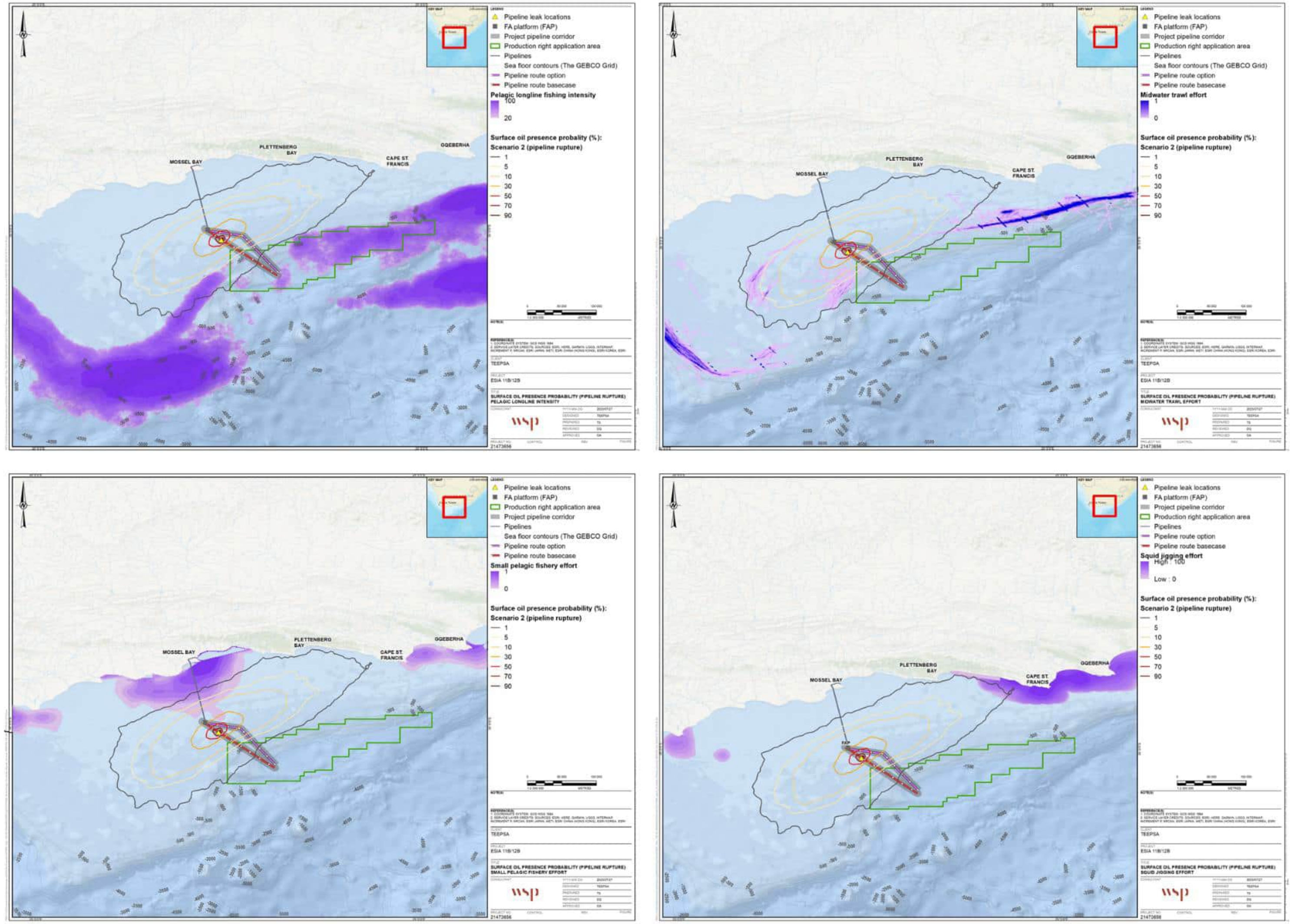


Figure 8-13. Surface oil presence probability <u>pipeline rupture</u> model results for all simulations across the full simulation period with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are pelagic longline (top left), midwater trawl (top right), small pelagic purse seine (bottom left) and squid jig (bottom right).

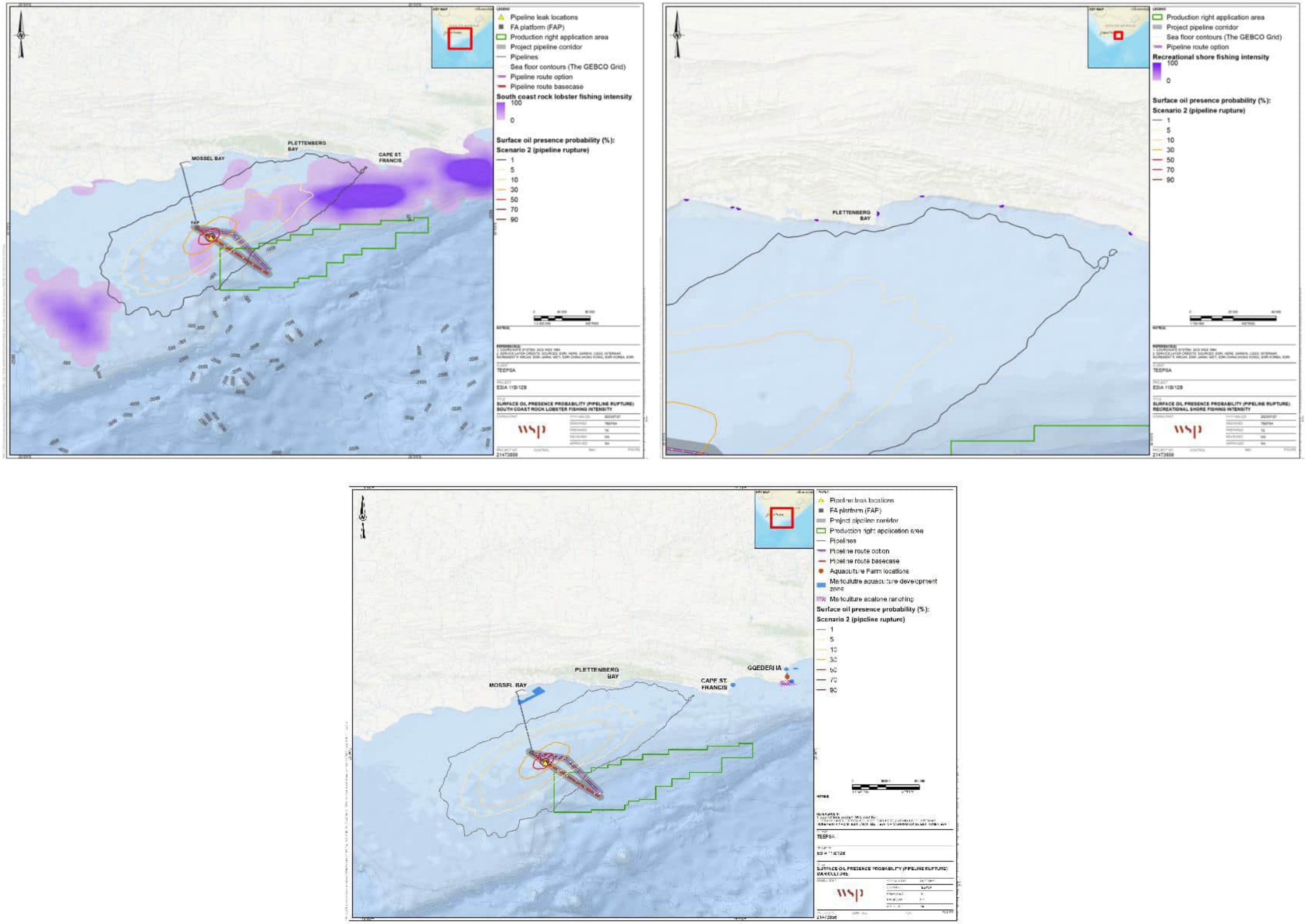


Figure 8-14. Surface oil presence probability pipeline rupture model results for all simulations across the full simulation period with fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are south coast rock lobster (top left), recreational shore angling (top right) and mariculture (bottom).

CRUDE SPILL (DISCHARGE-1 AND DISCHARGE-2)

Unmitigated crude oil spills can have a significant impact on fisheries resources. These impacts can include physical contamination, toxic effects on stock, and direct disruption of fishing (including mariculture) activities (Andrews *et al.* 2021). Oil spills can cause serious damage to the environment, including marine habitats and fish, and can also have negative effects on small-scale fisheries and coastal communities that rely on shore-based harvesting of marine resources and economic income through fishing (Andrews *et al.* 2021).

Some of the spilt oil may evaporate, while some may mix with water and form an emulsion. Emulsification, if it occurs, has a great effect on the behaviour of oil spills at sea. Over time, some of the oil may sink to the bottom of the ocean and settle on the seabed. The fate of crude oil in the water column is complex and depends on many factors.

Crude oil spills can have a significant impact on benthic habitats and the marine life that inhabit them. Oil can harm marine life in two ways: from the oil itself and from the response or cleanup operations (Andrews *et al.* 2021). Oil spills are harmful to marine birds, mammals, fish, and shellfish (Andrews *et al.* 2021). Fish and shellfish may not be exposed immediately but can come into contact with oil if it is mixed into the water column. When exposed to oil, adult fish may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproduction impairment. Fish eggs and larvae can be especially sensitive to lethal and sublethal impacts (Andrews *et al.* 2021). Even when lethal impacts are not observed, oil can make fish and shellfish unsafe for humans to eat.

A serious threat of oil spills to fisheries is the economic loss arising from business interruption. Oil on and in the water, and on the seabed, will temporarily disrupt fishing and impact normal production (and therefore income). It could also lead to a loss of market confidence may occur leading to price reductions or outright rejection of seafood products by commercial buyers and consumers.

Based on the modelling results for the two wells in the eastern part of the production area, the impact of unplanned oil spillage has been assessed (see Section 7). The worst-case scenario (i.e., summer) of the surface probability modelling results are used for this impact assessment.

The impacts of crude oil in the marine system on the direct fishing activities and on the key fishery resources and benthic environment have all been considered. In general, the impact of crude oil spillage will be significant, overlapping with the fishing grounds of most major fisheries of South Africa (demersal trawl, midwater trawl, commercial linefishing, large pelagic longline, small pelagic purse seine, squid jig, south coast rock lobster), small-scale and recreational fisheries (Table 8.35, Figure 8-15 to Figure 8-20.). In terms of the most affected fisheries, hake longline, midwater trawl and south coast rock lobster fisheries will have significant direct impacts with over 20% of their fishing grounds >50% likely to be covered by crude oil in the event of a spillage from Discharge-1, while spillage from Discharge-2 would cover over 20% of grounds of these three fisheries, plus the squid fishery (Table 8.34). This would result in significant disruption to fishery operations in those areas in the short term but impacts of crude oil persisting in the marine system would impact the resource for much longer than this.

Small-scale and recreational fishers that operate on the south coast (coastline and offshore e.g., those targeting squid) would be significantly impacted by the modelled crude oil spill though significant interruption to normal fishing activities and would be detrimental to the populations of species they target (allocated within the small-scale 'basket' of species).

On the coastline, 23.64 % of small-scale fishing grounds are >50% likely to be covered by crude oil in the event of a spillage from Discharge-1, while spillage from Discharge-2 would cover over 15.97 % of small-scale fishing grounds (Table 8.34).

Offshore, the intersection between the modelled oil spill with small-scale fisheries have been assessed slightly differently using % of TAC impacted rather than total fishing area as this is not assumed (Table 8.34). As TAC for squid and hake are defined, with the remainder of species in the small-scale 'basket' currently without TAC allocations, this is likely an underestimate.

Table 8.34. Area of overlap between the fishing grounds of relevant South African commercial, small-scale, recreational and mariculture fisheries and modelled oil uncontrolled oil spill results (worst case scenario). Area is calculated as % of total (national) fishing grounds of each fishery, based on catch and effort data from DFFE and using 'footprint' layers produced for the National Biodiversity Assessment 2018. Area of overlap is calculated for both above and below 50% probabilities of oil presence (areas of 0% (i.e., no overlap) are not included in the calculations). As no small-scale specific area data is available, the overlap with this sector is calculated as % of TAC impacted (% of the TAC for all fisheries combined to which TAC has been allocated to the small-scale sector) rather than total fishing area.

	Percentage of fishing grounds (>50% probability)	Percentage of fishing grounds (<50% probability)
Discharge-1		
Inshore demersal trawl	7.08	89.10
Deepsea trawl	7.50	50.06
Hake longline	21.96	79.89
Mid-water trawl	28.07	67.45
Line fishery	0.00	80.17
Large pelagics	12.22	21.26
Small pelagics	0.00	99.39
Rock lobster	42.38	55.46
Squid jig	5.26	78.53
Recreational fisheries	0.00	23.64
Mariculture	0.00	72.2
Discharge-2		
Inshore demersal trawl	21.19	62.49
Deepsea trawl	16.68	32.32
Hake longline	50.84	43.02
Mid-water trawl	43.52	43.07
Line fishery	10.68	60.34
Large pelagics	8.31	19.03
Small pelagics	5.91	85.69
Rock lobster	20.98	19.11
Squid jig	26.61	43.44
Recreational fisheries	3.19	15.97

	Percentage of fishing grounds (>50% probability)	Percentage of fishing grounds (<50% probability)
Mariculture	0.00	30.00

	Percentage of allocated TAC impacted (>50% probability)	Percentage of allocated TAC impacted (<50% probability)
Discharge-1		
Small-scale fisheries	2.63	79.1
Discharge-2		
Small-scale fisheries	35.91	51.89

The length of time that crude oil remains in the marine environment after a spill can vary greatly depending on a number of factors, including the type of oil spilled, the location of the spill, weather conditions, and the effectiveness of cleanup efforts. In some cases, toxic chemicals from oil spills can remain in the ocean for years, sinking down to the seafloor and poisoning the sediment (Zhang *et al.* 2019). The damage caused by oil spills can be long-term and, in some cases, possibly irreparable (World Economic Forum 2021). It is important to note that the effects of an oil spill can continue to impact marine life and the environment for years after the initial spill event. This would be of particularly concern for demersal fish species such as hake, monk and others. Demersal trawl fisheries would therefore be greatly negatively impacts by crude oil spillage. The model results for both Discharge points predict that a large degree of the South African southern coastline would experience oil spill surface coverage (over 500 km of coastline have a 30% chance of being exposed to crude oil in the event of a spillage). This would negatively impact coastal fishers, fisheries and communities that occupy this part of the coast. Commercial line fisheries and recreational fisheries would therefore be negatively impacted in this case.

Given the likelihood (probability) based on the modelling results the significance of crude oil spillage from Discharge-1 and 2 (worst case scenario) is rated very high on commercial fisheries without mitigation and remains high even with mitigation (Table 8.35). Unmitigated impacts would be of high-very intensity, covering an area beyond South Africa Exclusive Economic Zone and persist in the long term (2-25 years) (Table 8.35).

The model results for both Discharge points predict that particularly in Spring and Summer, the oil spill surface coverage extends into the Western Cape to Cape Town (1-5% probability) (Figure 7-6, Figure 7-9) The stretch of coast between Hermanus to Quoin Point Nature Reserve would be impacted and this is where a number of abalone mariculture farms operate (Figure 3-44). Farming abalone has been introduced around South Africa, to re-populate depleted abalone stocks in the ocean. With a rapid decline in wild abalone fisheries, farming now dominates the abalone export market in South Africa. These farms stock and grow abalone in tanks on land, with seawater circulating continuously. Most farms pump seawater into land-based tanks that are run in flow-through mode (continuous seawater), though Recirculating Aquaculture System (RAS) technology is also used (DFFE 2018). Currently, land-based flow-through systems are the most commonly used production systems in the South African abalone industry. Some farms have both hatchery and on-growing facilities whilst others rely on purchasing juveniles from other hatcheries. It takes about 4 years to grow an abalone from seed to market size (approx. 80 g) (Troell *et al.* 2006). Seawater is pumped from the shore into the tanks continuously under normal operations. One advantage of RAS systems is the ability to avoid pumping seawater for short periods of time when seawater might contain high densities of toxic algae into the farm, or when other types of contaminants are in the area where seawater is pumped into the farm (DFFE 2018).

Together, South Africa's land-based abalone farms produced total of 1300 tons (in 2014), with an estimated farm gate value of US$ 42.3 million (DFFE 2018). Land-based abalone production activities in South Africa have increased by up to 60% since 2014 (as of 2021) (DFFE 2021). Ten land-based abalone farms currently operate in the potentially impacted area of Western Cape shoreline, and these farms are some of the biggest operations in South Africa (DFFE 2018). In the event of an uncontrolled spillage of crude oil, the operations of these large, valuable abalone farms would be severely affected. Sumps for the seawater intake are typically located in areas of high wave action and these will pump oil into the tanks if oil reaches the shoreline. If oil is pumped around the farm the infrastructure will be severely degraded, as will the abalone stock being grown after which high levels of mortality will be experienced. RAS systems have the ability to recirculate water with no freshwater top up for 10-12 hours under ideal conditions and therefore given the persistence of oil in marine systems there would be no feasible mitigation to reduce or avoid the impacts of an oil spill on abalone farming activities (Frik Venter (abalone farmer - Aqunion (Pty) Ltd) personal communications 24 July 2023).

A 'wild' abalone ranching mariculture industry exists in South Africa. This involves the grow-out of juvenile abalone in the sea, until they reach market size (DFFE 2018). DFFE has identified several abalone ranching areas, one of which is located near Cape Recife, Eastern Cape and overlaps with the oil spill modelling results. Under this operation, hatchery produced abalone seed are stocked into kelp beds outside the natural distribution of abalone, which in turn offers substantially lower production costs than traditional land-based, intensive abalone culture systems (DFFE 2018). The unmitigated impacts of an uncontrolled oil spillage on these mariculture activities would be just as severe as on the land-based mariculture, with no plausible mitigation strategies against high levels of mortality and significant disruption to business activities to abalone ranchers.

Small-scale and recreational fisheries are known to typically operate in the intertidal and near shoreline. The direct effects and vulnerability of many shoreline species, harvested by small-scale and recreational fishers means impacts associated with an uncontrolled spill are higher for this sector. These sectors also have reduced flexibility in terms of redistribution of effort, considering the extent of coastline potentially impacts by an oil spill. There may be a handful of small-scale fishers that operate further from shore, accessing offshore fishing grounds (either through cooperatives or as crew of commercial linefish/squid fishing vessel). These fishers are relatively few in number, but they do exist, particularly on the west coast (awaiting full results from the rights allocation appeals process). Spatial and catch data on the activities of these fishers is lacking, but these fishers are known to be accessing mostly linefishing resources and in some instances resources such as squid (DFFE personal communication, January 2023). Considering this, interactions with 11B 12B and its impacts on small-scale fishers, if not coastal, will be captured in the commercial linefishing and squid assessments. That being said, sudden stressors and shocks have been shown to be particularly detrimental to small-scale fishers, as highlighted by the COVID-19 pandemic, and resilience is not built into these small-scale operations. We therefore conclude that any uncontrolled spillage of hydrocarbons would directly impact a substantial area of small-scale fishing grounds, and the species they target (directly and indirectly). Sudden stressors and shocks have been shown to be particularly detrimental to small-scale fishers, and resilience is not built into these small-scale operations, so impacts would be of high impact and high magnitude, even with mitigation (Table 8.35).

The unmitigated impacts on mariculture would be extremely negative and the significance of this impact on mariculture is also rated as very high (Table 8.35). Impacts would be of high-very intensity, covering an area beyond South Africa Exclusive Economic Zone and persist in the long term (2-25 years) (Table 8.35).

Table 8.35. Impact 28b: Impacts on commercial and recreational fishing, and mariculture, as a result of crude oil spillage, including a blowout — Discharge-1 and Discharge-2 (eastern sites).

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Demersal trawl Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Hake longline. Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Mid-water trawl Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Line fishery Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Large pelagics Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Small pelagics Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Rock lobster Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Squid jig Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Small-scale Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	Medium
Recreational Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	Medium
Mariculture Without mitigation	High	International	Long term	Very High	High	**VERY HIGH**	-ve	High
Essential mitigation measures: • See Table 8.30.								
Demersal trawl With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Hake longline. With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium

	Intensity	Extent	Duration	Magnitude	Sensitivity	Significance	Status	Confidence
Mid-water trawl With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Line fishery With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Large pelagics With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Small pelagics With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Rock lobster With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Squid jig With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Small-scale With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Recreational With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium
Mariculture With mitigation	High	Regional	Medium term	High	High	**HIGH**	-ve	Medium

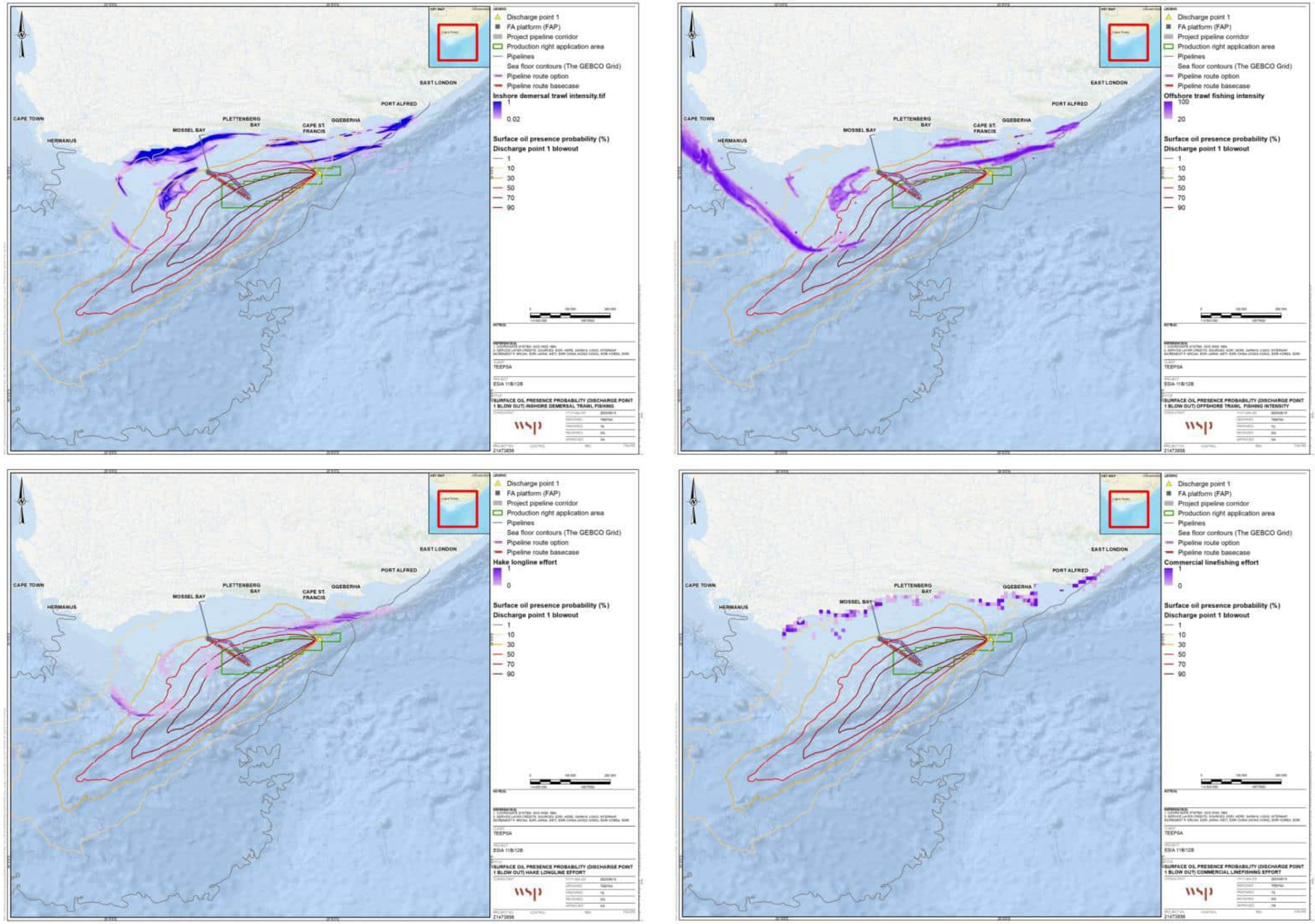


Figure 8-15. Crude oil surface presence probability model results for worst case scenario (Summer) for Discharge-I, with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are inshore hake trawl (top left), offshore demersal trawl (top right), hake longline (bottom left) and linefishing (bottom right).

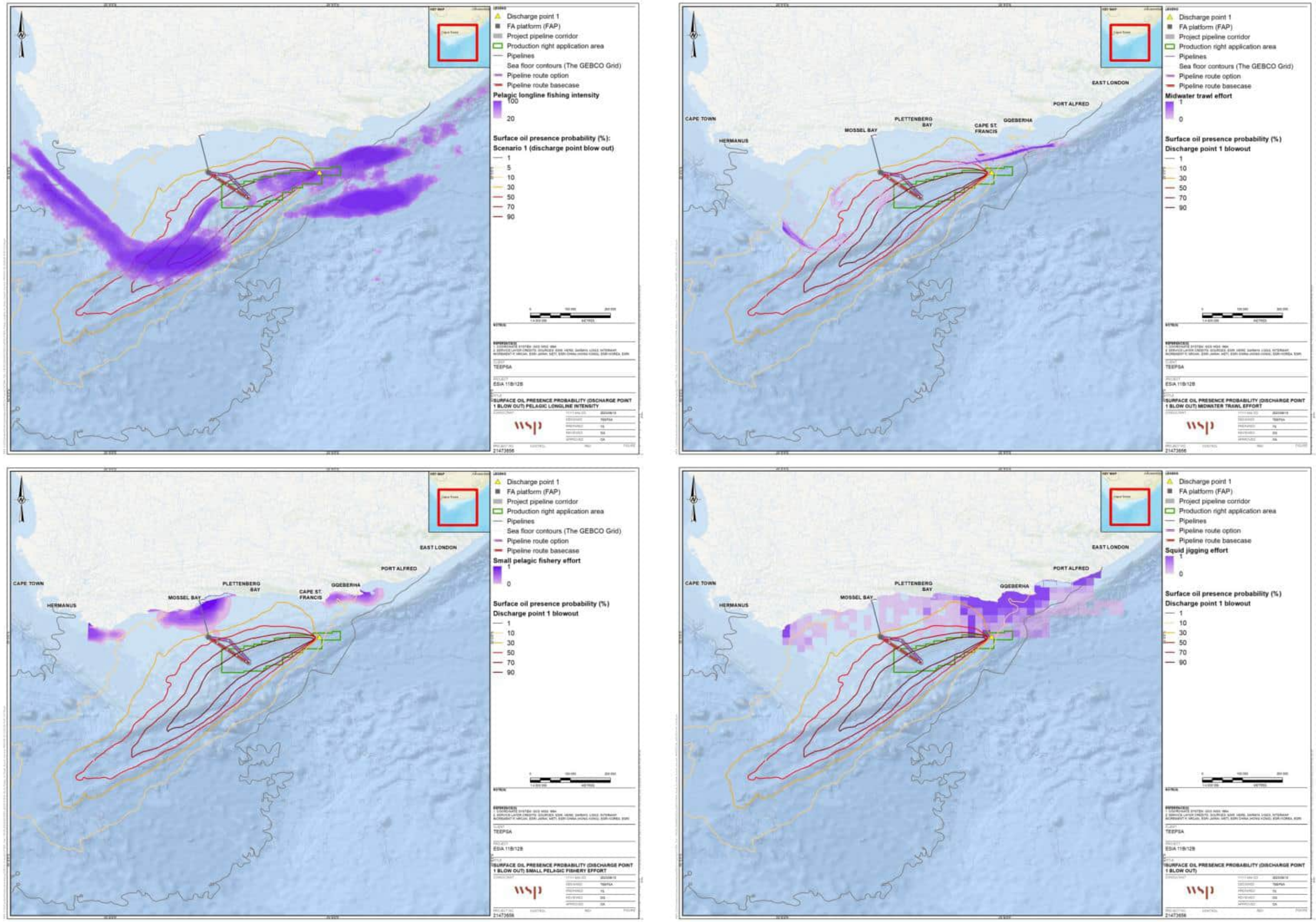


Figure 8-16. Crude oil surface presence probability model results (red gradients) for worst case scenario (Summer) for Discharge-1 , with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are inshore pelagic longline (top left), midwater trawl (top right), small pelagic purse seine (bottom left) and squid jigging (bottom right).

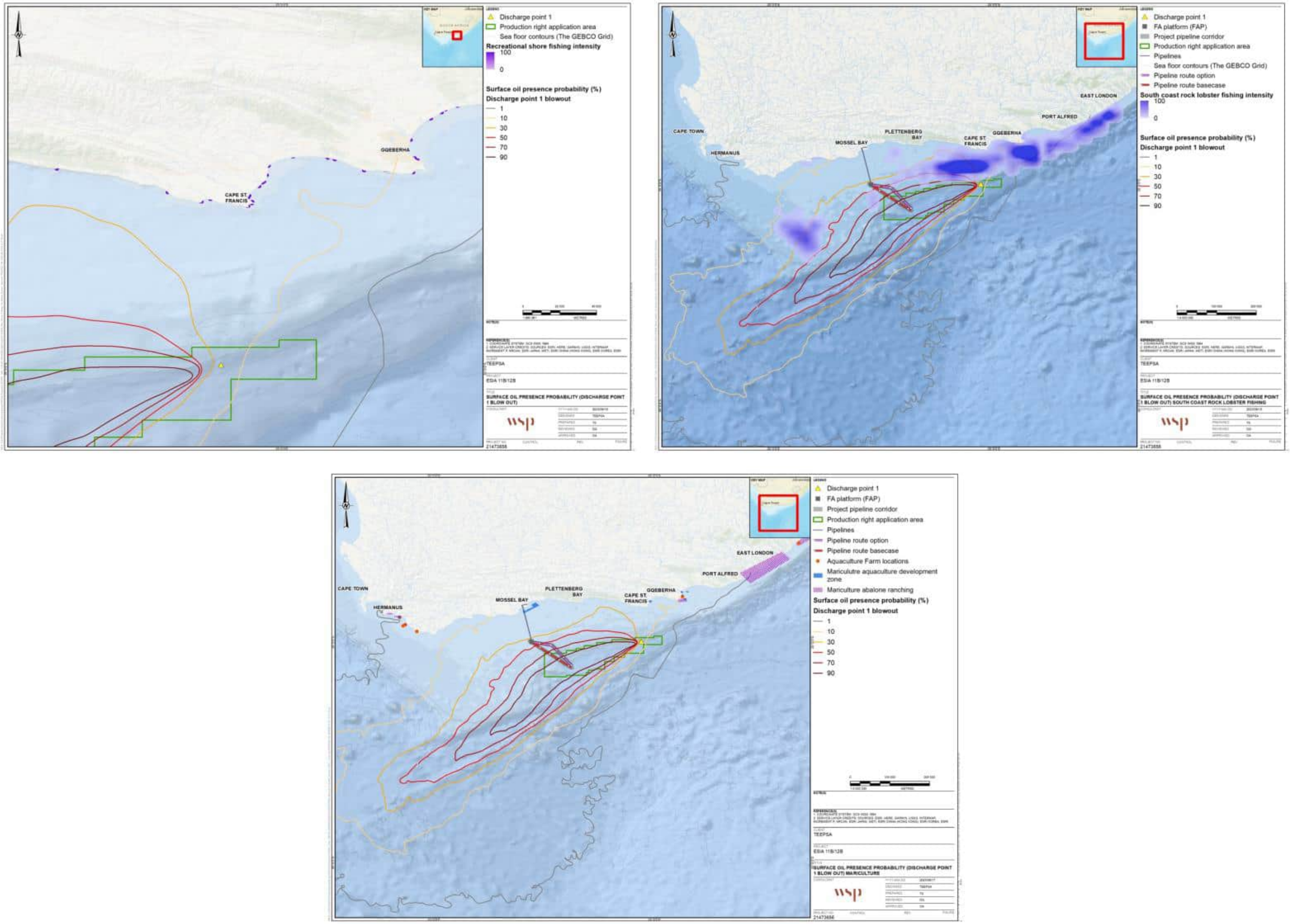


Figure 8-17. Crude oil surface presence probability model results (red gradients) for worst case scenario (Summer) for Discharge-1 , with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are south coast rock lobster (top left), recreational fisheries (top right) and mariculture (bottom).

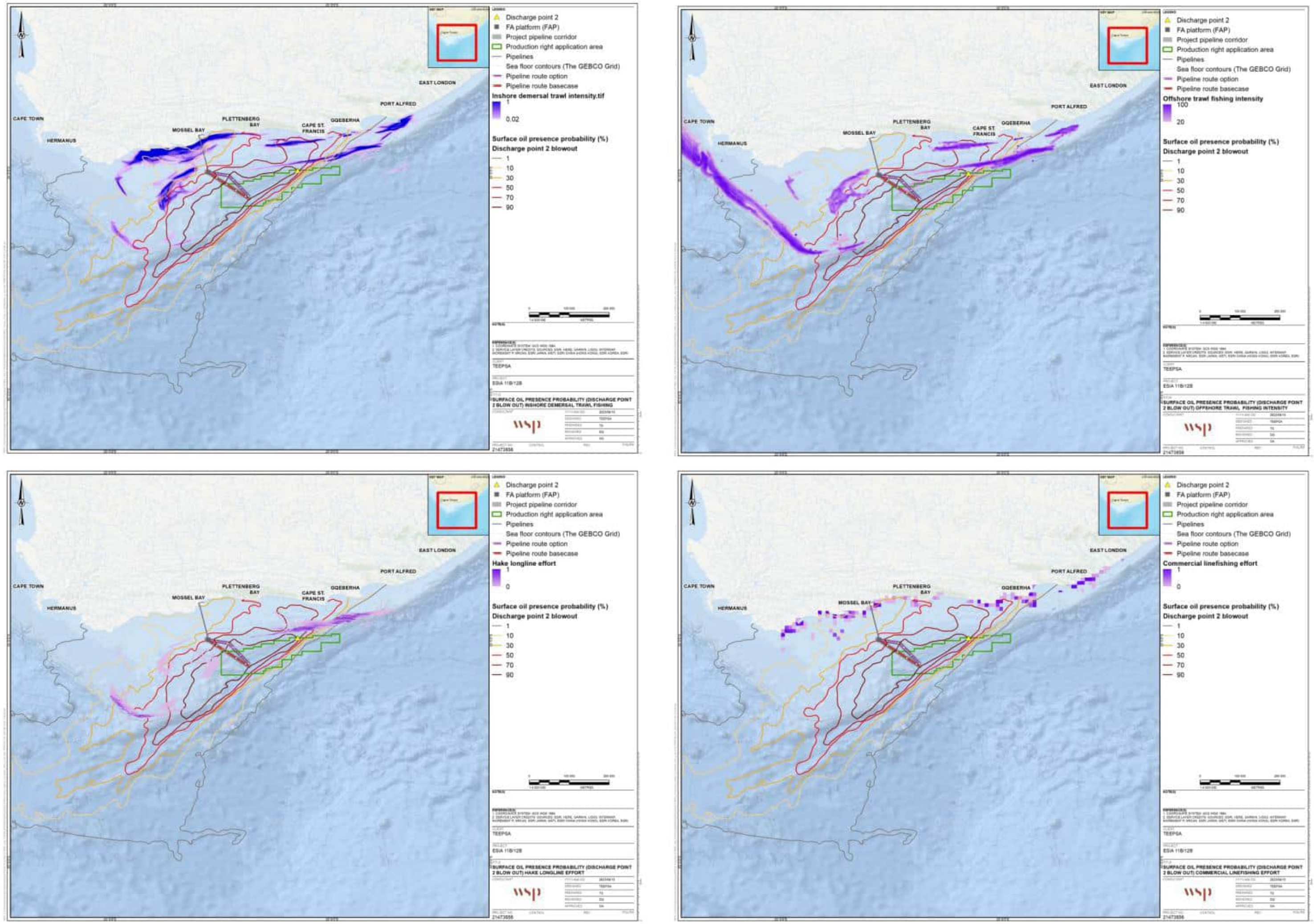


Figure 8-18. Crude oil surface presence probability model results (red gradients) for worst case scenario (Summer) for Discharge-2, with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are inshore hake trawl (top left), offshore trawling (top right), hake longline (bottom left), commercial longline (bottom right)

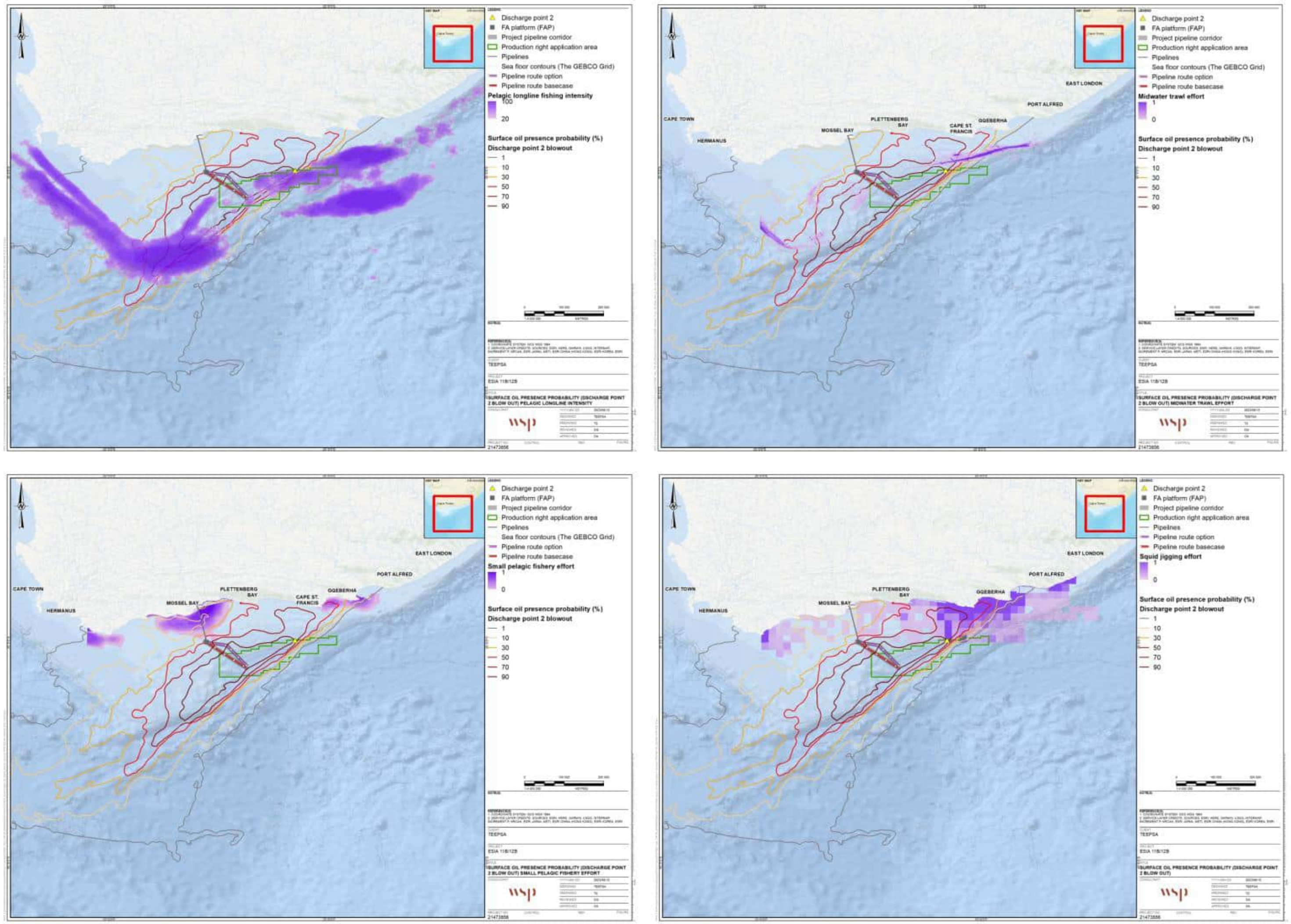


Figure 8-19. Crude oil surface presence probability model results (red gradients) for worst case scenario (Summer) for Discharge-2, with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are inshore pelagic longline (top left), midwater trawl (top right), small pelagic purse seine (bottom left) and squid jigging (bottom right).

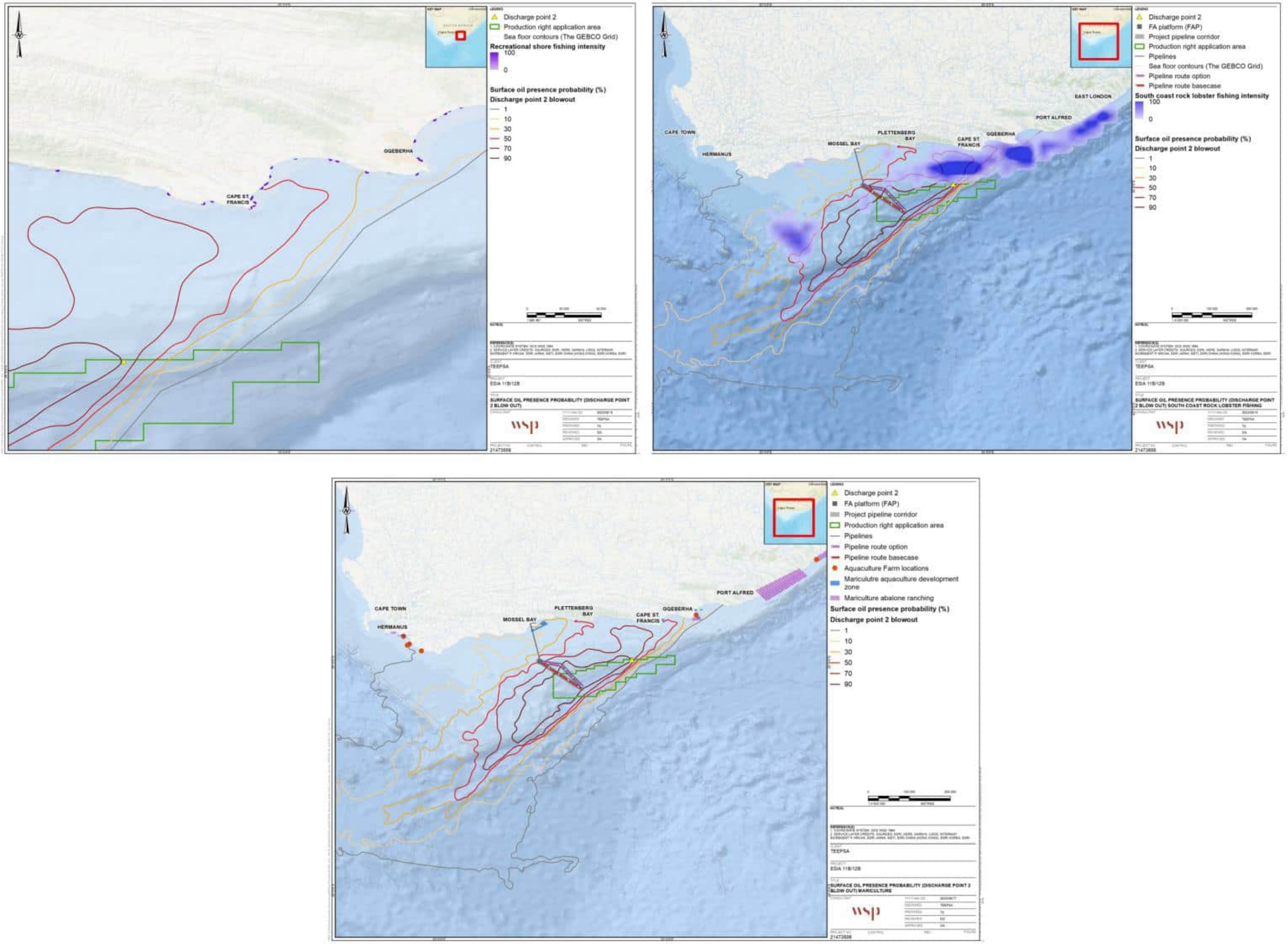


Figure 8-20. Crude oil surface presence probability model results (red gradients) for worst case scenario (Summer) for Discharge-2, with commercial fishing activity for each affected fishery overlaid (blue gradients). Fisheries shown are south coast rock lobster (top left), recreational fisheries (top right) and mariculture (bottom).

8.7 DECOMMISSIONING/CLOSURE PHASE

Decommissioning and closure procedure impacts are expected to be similar (if not less) than those assessed during the construction and exploration phases (Table 8.36). Impacts are predominately related to disturbance on the benthos linked to infrastructure removal and well decommissioning and plugging, as well as safety zones established around vessels during closure activities and the potential hazard to fisheries activities from abandoned infrastructure.

The potential impacts during the decommissioning phase are expected to be minimal and no additional issues related to the marine environment have been identified at this stage. The same mitigation procedures as those explained in the construction phase should be adhered to in the decommissioning and closure phase in order to mitigate any of the impacts listed above.

Table 8.36. Closure components, actions and relevant assessment section.

Equipment	Location	Abandonment action	Relevant potential impact assessment
Production wells	Deepwater	Decommissioned and plugged in-situ	Section 8.2.2 (specifically with regards to cementing), Section 8.2.8, Section 8.3.2, Section 8.4.7
Production manifolds	Deepwater	Left on seabed following a visual inspection	Section 8.2.8, Section 8.3.2, Section 8.4.7
Flowline end termination units	Shallow water	Retrieved	Section 8.2.1
Production flowline (pipeline)	Deepwater	Pigged to remove potential contaminants then left on seabed	Section 8.2.8, Section 8.3.2, Section 8.4.7
Subsea Distribution Units	Deepwater	Left on seabed	Section 8.2.8, Section 8.3.2, Section 8.4.7

8.8 CUMULATIVE IMPACTS

Anthropogenic activities can result in numerous and complex effects on the natural environment. While many of these are direct and immediate, the environmental effects of individual activities or projects can interact with each other in time and space to cause incremental or aggregate effects. Impacts from unrelated activities may accumulate or interact to cause additional effects that may not be apparent when assessing the activities individually. Cumulative effects are defined as the total impact that a series of developments, either present, past or future, will have on the environment within a specific region over a particular period of time (DEAT IEM Guideline 7, Cumulative effects assessment 2004).

By definition, cumulative marine environmental impacts emanating from the proposed project are related to the overlap with various other sources of anthropogenic disturbance in the vicinity of the impact proposed project activities, under normal operating conditions. Potential cumulative impacts therefore include increases in anthropogenic noise, disturbance of the seabed through discharges of drilling material, loss of seabed habitat with the placement of subsea infrastructure (both pipeline routing options), and an increase in the number of vessels and aircraft in the vicinity of the project.

There are a number of active offshore oil and gas exploration and production areas along the South African south coast (detailed in Section 4.6.3, see Figure 4-6). The Bredasdorp Basin on the Agulhas Bank has been the focus of most oil and gas exploration and drilling activity in South Africa, with the development of the Oribi, Oryx and Sable oil fields and F-O gas fields, approximately 120 km south-west of Mossel Bay, which lie to the north of Block 11B/12B. These fields have for the most part been operated by the state-owned energy company PetroSA (Biccard *et al.* 2018) (Figure 4-6). PetroSA's Block 9 licence area covers a surface area of 22 756 km^2 and includes nine gas and condensate fields. Based on data provided by PASA (2021), some 358 wells in total have been drilled in the South African offshore environment to date, with the majority (56%) drilled off the South Coast on the Agulhas Bank, most of these in less than 250 m water depth. Indeed, some 120 exploration wells have been drilled in Block 9. The Application Area is located in waters of 500-2 300 m depth, and some 75 km offshore, a substantial distance from these existing wells.

The cumulative impacts of drill discharge effects are defined by the spatial extent provide by the drill cuttings discharge modelling study (Section 6). The model results indicate a maximum area of upper water column impacts of an estimated 126 km^2, with a maximum duration of 2 days (Table 6.4). Maximum water column impacts extend some 67 km^2, with a maximum duration of 5 days (Table 6.4). The maximum area of sediment impacted over 10-years is 150 m^2 (Table 6.6). If all six production wells, and all four exploration wells are drilled concurrentl (i.e. the worst-case scenario), model results suggest a conservative maximum area of impact on the water column of 1 260 km^2 for a duration of a maximum of 50 days, and a worst-case impact on the sediment of approximately 175 000 m^{2,} (0.175 km^2).

Assuming an estimate of 0.8 km^2 of cumulative seabed affected per well (based on the footprint calculated for a single well, see Section 6), the total cumulative area impacted by the installation and cuttings fall-out of 200 petroleum exploration wells on the Agulhas Bank is estimated at 160 km^2. Based on these figures, the drilling of six production wells and four exploration wells in the Application Area amounts to 8 km^2, an increase of some 5% in area of impact. Data from PASA (2022) (see Figure 4-6) shows that, as of September 2020, there were no existing wells that may intersect with these areas of potential impact for the proposed activities within the Application Area, even if the proposed wells are drilled at the edges of the Application Area. Therefore, cumulative impacts relating to the discharge of drilling material are considered to be of negligible significance.

In a similar manner, the area of benthos that may be disturbed by the placement of the subsea infrastructure, including both pipeline routing options, amounts to some 1 200 km^2. There is no other subsea infrastructure present along the majority of the pipe length. Other impacts on the benthos may arise from deep water trawling activities. However, there is limited overlap between the Application Area and deep-sea trawl area (a 0.87% overlap with deep-sea fishing area, see Figure 3-29). Therefore, cumulative impacts relating to the disturbance of the benthos due to the placement of subsea infrastructure are considered to be of negligible significance.

In terms of other possible well drilling in the near future, Africa Energy is preparing to drill in Block 2B in late 2022/23, and TEEPSA has been granted the right for Exploration drilling (five wells in total) in Block 5/6/7. TEEPSA also hold an Exploration Right for the Deep Water Orange Basin (DWOB) Licence Block (12/3/343 ER), located offshore roughly between Port Nolloth and Hondeklip Bay, approximately 188 km off the West Coast of South Africa. Up to ten wells are proposed, exploratory success dependent. Block 2B is located approximately 400 km to the north of Block 5/6/7, and the latter is located some 250 km to the west of Block

11B/12B. The DWOB Licence Block is located on the West Coast of South Africa, many hundreds of kilometres form Block 11B/12B. Therefore, there are unlikely to be any overlapping impacts from normal operations (e.g., discharges, underwater noise, etc.).

Underwater noise associated with the proposed project activities (drilling noise, VSP surveys etc.) would also have cumulative impact on marine fauna. Due to the licence area being located within the main vessel traffic routes that pass around southern Africa, ambient noise levels are already elevated. Sensitive receptors and faunal species (cetaceans, turtles and certain fish) are unlikely to be significantly additionally affected as faunal behaviour will not be affected beyond 66 km during drilling and beyond 19.2 km during VSP operations (Section 5.4). Noise levels would return back to ambient after drilling is complete. Therefore, cumulative impacts relating to the disturbance of the benthos due to the placement of subsea infrastructure are considered to be of low significance.

While the proposed project activities will result in an increase in ambient, artificial light (especially at night), the extent of this increase above the current levels is likely to be of low intensity, because the Application Area falls within an existing, busy, shipping lane (as per the 2020 vessel traffic map shown in Figure 5-3).

Each of these vessels operating within the area, be it shipping, fishing or production or exploration activities within the Application Area, will make routine discharges to the ocean. While each discharge, and certainly the cumulative effects may impact water quality, and thereby affect ecosystem form and function, compliance with MARPOL conventions should be sufficient to mitigate detectable cumulative effects are anticipated. In addition, the point source nature of each discharge (isolated in time and space), reduces the intensity of the impact, and thereby educes the cumulative effects.

Based on this information, cumulative impacts for normal operations are likely to be no more significant than the impacts assessed in Section 8.2, Section 8.3 and Section 8.4. Although cumulative impacts from other hydrocarbon ventures in the area may increase in future, the cumulative impacts of the proposed project activities within Block 11B/1B and the adjacent Agulhas Bank can be considered of low significance.

8.9 SUMMARY OF POTENTIAL IMPACTS

Identified potential impacts that may be experienced during the construction, production and exploration phases before and after mitigation are summarised in Table 8.37.

Table 8.37. Summary of potential impacts.

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Normal operations						
Construction	**Impact 1a: Loss of benthic habitat and disturbance/mortality of infauna, relative to sensitivity**					
	Before mitigation	Medium	Low	LOW	- 've	High
	With mitigation	Low	Low	VERY LOW	- 've	High
	Impact 1b: Loss of benthic habitat and disturbance/mortality of epifauna, relative to sensitivity.					
	Before mitigation	High	High	HIGH	- 've	High
	With mitigation – without offset/compensation	Medium	High	MEDIUM	- 've	High
	With mitigation – with offset/compensation	Low	High	LOW	- 've	High
	Impact 2: Biochemical and toxicity water column and benthic impacts associated with the discharge of drilling fluid and cuttings.					
	Before mitigation — WBMs	Low	High	LOW	-'ve	High
	Before mitigation — Cement	Very Low	High	LOW	-'ve	High
	With mitigation	Low	High	LOW	-'ve	High
	Impact 3a: Benthic impacts associated with the discharge of drilling muds and cuttings on infauna					
	Before mitigation	Low	Medium	LOW	- 've	High
	With mitigation	Low	Medium	LOW	- 've	High
	Impact 3b: Impacts of elevated turbidity on pelagic marina biota					
	Before mitigation	Very Low	Medium	VERY LOW	- 've	High
	With mitigation	Very Low	Medium	VERY LOW	- 've	High
	Impact 3c: Benthic impacts associated with the discharge of drilling muds and cuttings on epifauna					
	Before mitigation	High	High	HIGH	- 've	High
	With mitigation – without offset/compensation	Medium	High	MEDIUM	- 've	High
	With mitigation – with offset/compensation	Low	High	LOW	- 've	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Normal operations						
Construction (cont.)	**Impact 3d: Impacts of elevated turbidity on light penetration**					
	Before mitigation	Very Low	Low	NEGLIGIBLE	- 've	High
	With mitigation	Very Low	Low	NEGLIGIBLE	- 've	High
	Impact 4: Drilling noise impacts on marine megafauna, fish, turtles and avifauna.					
	Before mitigation – 24-hr exposure	Low	High	LOW	-'ve	High
	Before mitigation – 30-min exposure	Very Low	High	LOW	-'ve	High
	With mitigation	Low	High	LOW	-'ve	High
	Impact 5a: General construction noise impacts on marine megafauna and avifauna — helicopters					
	Before mitigation	Low	High	LOW	-'ve	High
	With mitigation	Very Low	High	LOW	-'ve	High
	Impact 5b: General construction noise impacts on marine megafauna and avifauna — vessels					
	Before mitigation	Low	Medium	LOW	-'ve	High
	With mitigation	Very Low	Medium	VERY LOW	-'ve	High
	Impact 6: Light and water pollution impacts of well testing and flaring					
	Before mitigation — Flaring lighting	Low	Medium	LOW	-'ve	High
	With mitigation — Flaring lighting	Very Low	Medium	VERY LOW	-ve	High
	Before mitigation — Hydrocarbon 'drop-out'	Low	Medium	LOW	-ve	High
	With mitigation — Hydrocarbon 'drop-out'.	Very Low	Medium	VERY LOW	-ve	High
	Before mitigation — Produced water discharge	Very Low	Medium	VERY LOW	-ve	High
	With mitigation — Produced water discharge	Very Low	Medium	VERY LOW	-ve	High
	Impact 7: Impacts of light pollution from construction activities on pelagic marine fauna					
	Before mitigation	Very Low	High	LOW	-'ve	High
	With mitigation	Very Low	High	LOW	-'ve	High
	Impact 8: Impacts of the introduction of alien and invasive species					
	Before mitigation	Very High	Low	HIGH	-'ve	High
	With mitigation	High	Low	MEDIUM	-'ve	High
	Impact 9: Impacts on fisheries as a result of construction related exclusion zones					
	Before mitigation — Deepsea trawl	Very Low	Medium	VERY LOW	-ve	High
	With mitigation — Deepsea trawl	Very Low	Medium	VERY LOW	-ve	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Normal operations						
Construction (cont.)	Before mitigation — Hake longline	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Mid-water trawl	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Line fishery	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Large pelagics	Low	High	LOW	-ve	High
	With mitigation — Large pelagics	Low	High	LOW	-ve	High
	Before mitigation — Small pelagics	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Rock lobster	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Squid jig	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Small-scale,	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Recreational	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Mariculture	Very Low	Low	NEGLIGIBLE	-ve	High
Production	**Impact 10: Impacts to water quality and marine systems resulting from production facilities operational discharges**					
	Before mitigation	Medium	Medium	MEDIUM	-'ve	High
	With mitigation	Low	Medium	LOW	-'ve	High
	Impact 11a: Impacts on the local benthic environments from presence of subsea infrastructure — infrastructure not buried					
	Before mitigation	Very Low	High	VERY LOW	-'ve	High
	With mitigation	Very Low	High	VERY LOW	-'ve	High
	Impact 11b: Impacts on the local benthic environments from presence of subsea infrastructure — infrastructure buried					
	Before mitigation	Very Low	Low	NEGLIGIBLE	-'ve	High
	Impact 12: Impacts of physical presence of above water infrastructure on avifauna					
	Before mitigation	Low	Medium	LOW	-'ve	High
	With mitigation	Low	Medium	LOW	-'ve	High
	Impact 13: Impacts of operational artificial lighting on the marine environment.					
	Before mitigation	Medium	High	MEDIUM	-'ve	High
	With mitigation	Low	High	LOW	-'ve	Medium
	Impact 14: Impacts on fisheries as a result of production related exclusion zones					
	Before mitigation — Deepsea trawl	Low	Medium	VERY LOW	-ve	High
	With mitigation — Deepsea trawl	Low	Medium	VERY LOW	-ve	High
	Before mitigation — Hake longline	Very Low	Low	NEGLIGIBLE	-ve	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Normal operations						
Production (Cont.)	Before mitigation — Mid-water trawl	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Line fishery	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Large pelagics	Low	High	LOW	-ve	High
	With mitigation — Large pelagics	Low	High	LOW	-ve	High
	Before mitigation — Small pelagics	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Rock lobster	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Squid jig	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Small-scale,	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — Recreational	Very Low	Low	NEGLIGIBLE	-ve	High
	Before mitigation — mariculture	Very Low	Low	NEGLIGIBLE	-ve	High
Exploration	**Impact 15: Biochemical and toxicity water quality and benthic impacts associated with the discharge of drilling fluid and cuttings.**					
	Before mitigation — WBMs	Low	High	LOW	-'ve	High
	Before mitigation — Cement	Very Low	High	LOW	-'ve	High
	With mitigation	Low	High	LOW	-'ve	High
	Impact 16a: Benthic impacts on infauna associated with exploratory drilling discharges.					
	Before mitigation	Low	Medium	LOW	- 've	High
	With mitigation	Low	Medium	LOW	- 've	High
	Impact 16b: Impacts of elevated turbidity on pelagic marina biota due to exploratory drilling discharges					
	Before mitigation	Very Low	Medium	VERY LOW	- 've	High
	With mitigation	Very Low	Medium	VERY LOW	- 've	High
	Impact 16c: Benthic impacts on epifauna associated with exploratory drilling discharges					
	Before mitigation	High	High	HIGH	- 've	High
	With mitigation – without offset/compensation	Medium	High	MEDIUM	- 've	High
	With mitigation – with offset/compensation	Very Low	High	LOW	- 've	High
	Impact 16d: Impacts of elevated turbidity on light penetration					
	Before mitigation	Very Low	Low	NEGLIGIBLE	- 've	High
	With mitigation	Very Low	Low	NEGLIGIBLE	- 've	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Normal operations						
Exploration (Cont.)	**Impact 17: Light and water pollution impacts of exploratory well testing and flaring**					
	Before mitigation — Flaring lighting	Low	Medium	LOW	-'ve	High
	With mitigation — Flaring lighting	Very Low	Medium	VERY LOW	-ve	High
	Before mitigation — Hydrocarbon 'drop-out'.	Low	Medium	LOW	-ve	High
	With mitigation — Hydrocarbon 'drop-out'.	Very Low	Medium	VERY LOW	-ve	High
	Before mitigation — Produced water discharge	Very Low	Medium	VERY LOW	-ve	High
	With mitigation — Produced water discharge	Very Low	Medium	VERY LOW	-ve	High
	Impact 18: Exploratory drilling noise impacts on marine megafauna, fish, turtles and avifauna					
	Before mitigation – 24-hr exposure	Low	High	LOW	-'ve	High
	Before mitigation – 30-min exposure	Very Low	High	LOW	-'ve	High
	With mitigation	Low	High	LOW	-'ve	High
	Impact 19: Noise pollution impacts for exploratory VSP activities on marine megafauna and avifauna.					
	Before mitigation	Very Low	High	LOW	-'ve	High
	With mitigation	Very Low	High	LOW	-'ve	High
	Impact 20a: General exploratory activity noise impacts on marine megafauna and avifauna — helicopters					
	Before mitigation	Low	High	LOW	-'ve	High
	With mitigation	Very Low	High	LOW	-'ve	High
	Impact 20b: General exploratory activity noise impacts on marine megafauna and avifauna — vessels					
	Before mitigation	Low	Medium	LOW	-'ve	High
	With mitigation	Very Low	Medium	VERY LOW	-'ve	High
	Impact 21: Impacts on fisheries as a result of exploratory exclusion zones					
	Before mitigation — Deepsea trawl	Low	Medium	LOW	-ve	High
	With mitigation — Deepsea trawl	Low	Low	VERY LOW	-ve	High
	Before mitigation — Hake longline	Low	Low	VERY LOW	-ve	High
	With mitigation — Hake longline	Low	Low	VERY LOW	-ve	High
	Before mitigation — Mid-water trawl	Low	Low	VERY LOW	-ve	High
	With mitigation — Mid-water trawl	Low	Low	VERY LOW	-ve	High
	Before mitigation — Line fishery	Low	Low	VERY LOW	-ve	High
	With mitigation — Line fishery	Low	Low	VERY LOW	-ve	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Normal operations						
Exploration (Cont.)	Before mitigation — Large pelagics	Medium	Medium	**MEDIUM**	-ve	High
	With mitigation — Large pelagics	Medium	Medium	**MEDIUM**	-ve	High
	Before mitigation — Small pelagics	Low	Low	**VERY LOW**	-ve	High
	With mitigation — Small pelagics	Low	Low	**VERY LOW**	-ve	High
	Before mitigation — Rock lobster	Low	Low	**VERY LOW**	-ve	High
	With mitigation — Rock lobster	Low	Low	**VERY LOW**	-ve	High
	Before mitigation — Squid jig	Medium	Medium	**MEDIUM**	-ve	High
	With mitigation — Squid jig	Medium	Medium	**MEDIUM**	-ve	High
	Before mitigation — Small-scale,	Medium	Medium	**MEDIUM**	-ve	High
	With mitigation — Small-scale	Medium	Medium	**MEDIUM**	-ve	High
	Before mitigation — Recreational	Low	Low	**VERY LOW**	-ve	High
	With mitigation — Recreational	Low	Low	**VERY LOW**	-ve	High
	Before mitigation — Mariculture	Very Low	Low	**NEGLIGIBLE**	-ve	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Surveys across all project phases						
Exploration and production wells, and pipeline siting	**Impact 22: Disturbance to sediments, seabed and benthic communities as result of exploratory marine surveys (ROV, metocean, sediment sampling)**					
	Before mitigation	Very Low	High	**LOW**	-ve	High
	With mitigation	Very Low	Medium	**VERY LOW**	-ve	High
	Impact 23: Noise pollution impacts for exploratory sonar profiling activities					
	Before mitigation	Low	High	**LOW**	-'ve	High
	With mitigation	Very Low	High	**LOW**	-'ve	High
	Impact 24: Impacts of increased vessel traffic across all project phases on marine ecosystems and fishers					
	Before mitigation	Very Low	High	**LOW**	-'ve	High
	With mitigation	Very Low	Medium	**VERY LOW**	-'ve	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Unplanned events						
Unplanned events	**Impact 25: Impacts of pollution generated through littering, fuel leaks, refuelling (bunkering), or collision during construction on the marine environment**					
	Before mitigation	Medium	Medium	MEDIUM	-ve	High
	With mitigation	Low	Medium	LOW	-ve	High
	Impact 26: Faunal strikes as a result of increased vessel traffic					
	Before mitigation	Very Low	High	LOW	-'ve	High
	With mitigation	Very Low	Medium	VERY LOW	-'ve	High
	Impact 27a: Impacts on marine ecological systems and communities as a result of oil/fuel spillage, including a blowout (Discharge-4 and Discharge-5; condensate)					
	Before mitigation — Plankton	High	High	HIGH	-ve	High
	With mitigation — Plankton	Medium	High	MEDIUM	-ve	High
	Before mitigation — Benthic fauna	High	High	HIGH	-ve	Medium
	With mitigation — Benthic fauna	Medium	High	MEDIUM	-ve	Medium
	Before mitigation — Fish	High	High	HIGH	-ve	High
	With mitigation — Fish	Medium	High	MEDIUM	-ve	High
	Before mitigation — Seabirds	Very High	High	VERY HIGH	-ve	High
	With mitigation — Seabirds	High	High	HIGH	-ve	High
	Before mitigation — Turtles	Very High	High	VERY HIGH	-ve	High
	With mitigation — Turtles	High	High	HIGH	-ve	High
	Before mitigation — Marine mammals	Very High	High	VERY HIGH	-ve	High
	With mitigation — Marine mammals	High	High	HIGH	-ve	High
	Before mitigation — Coastal environment	Very High	High	VERY HIGH	-ve	High
	With mitigation — Coastal environment	High	High	HIGH	-ve	High
	Impact 27b: Impacts on marine ecological systems and communities as a result of oil/fuel spillage, including a blowout (Discharge-1 and Discharge-2; crude)					
	Before mitigation — Plankton	Very High	High	VERY HIGH	-ve	High
	With mitigation — Plankton	High	High	HIGH	-ve	High
	Before mitigation — Benthic fauna	Very High	High	VERY HIGH	-ve	Medium
	With mitigation — Benthic fauna	High	High	HIGH	-ve	Medium
	Before mitigation — Fish	Very High	High	VERY HIGH	-ve	High
	With mitigation — Fish	High	High	HIGH	-ve	High

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Unplanned events						
Unplanned events (cont.)	Before mitigation — Seabirds	Very High	High	VERY HIGH	-ve	High
	With mitigation — Seabirds	High	High	HIGH	-ve	High
	Before mitigation — Turtles	Very High	High	VERY HIGH	-ve	High
	With mitigation — Turtles	High	High	HIGH	-ve	High
	Before mitigation — Marine mammals	Very High	High	VERY HIGH	-ve	High
	With mitigation — Marine mammals	Very High	High	HIGH	-ve	High
	Before mitigation — Coastal environment	Very High	High	VERY HIGH	-ve	High
	With mitigation — Coastal environment	High	High	HIGH	-ve	High
	Impact 28a: Impacts on commercial and recreational fishing as a result of oil/fuel spillage, including a blowout (Discharge-4 and Discharge-5; condensate)					
	Before mitigation — Deepsea trawl	High	High	HIGH	-ve	High
	With mitigation — Deepsea trawl	Medium	High	MEDIUM	-ve	High
	Before mitigation — Hake longline	High	High	HIGH	-ve	High
	With mitigation — Hake longline	Medium	High	MEDIUM	-ve	High
	Before mitigation — Mid-water trawl	High	High	HIGH	-ve	High
	With mitigation — Mid-water trawl	Medium	High	MEDIUM	-ve	High
	Before mitigation — Line fishery	High	High	HIGH	-ve	High
	With mitigation — Line fishery	Medium	High	MEDIUM	-ve	High
	Before mitigation — Large pelagics	High	High	HIGH	-ve	High
	With mitigation — Large pelagics	Medium	High	MEDIUM	-ve	High
	Before mitigation — Small pelagics	High	High	HIGH	-ve	High
	With mitigation — Small pelagics	Medium	High	MEDIUM	-ve	High
	Before mitigation — Rock lobster	High	High	HIGH	-ve	High
	With mitigation — Rock lobster	Medium	High	MEDIUM	-ve	High
	Before mitigation — Squid jig	High	High	HIGH	-ve	High
	With mitigation — Squid jig	Medium	High	MEDIUM	-ve	High
	Before mitigation — Small-scale	High	High	HIGH	-ve	Medium
	With mitigation — Small-scale	Medium	High	MEDIUM	-ve	High
	Before mitigation — Recreational	High	High	HIGH	-ve	Medium

Phase	Impact	Magnitude	Sensitivity	Significance	Status	Confidence
Unplanned events						
Unplanned events (cont.)	With mitigation — Recreational	Medium	High	**MEDIUM**	-ve	High
	Before mitigation — Mariculture	High	High	**HIGH**	-ve	High
	With mitigation — Mariculture	Medium	High	**MEDIUM**	-ve	High
	Impact 28b: Impacts on commercial and recreational fishing and mariculture as a result of oil/fuel spillage, including a blowout (Discharge-1 and Discharge-2; crude)					
	Before mitigation — Deepsea trawl	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Deepsea trawl	High	High	**HIGH**	-ve	High
	Before mitigation — Hake longline	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Hake longline	High	High	**HIGH**	-ve	High
	Before mitigation — Mid-water trawl	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Mid-water trawl	High	High	**HIGH**	-ve	High
	Before mitigation — Line fishery	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Line fishery	High	High	**HIGH**	-ve	High
	Before mitigation — Large pelagics	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Large pelagics	High	High	**HIGH**	-ve	High
	Before mitigation — Small pelagics	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Small pelagics	High	High	**HIGH**	-ve	High
	Before mitigation — Rock lobster	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Rock lobster	High	High	**HIGH**	-ve	High
	Before mitigation — Squid jig	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Squid jig	High	High	**HIGH**	-ve	High
	Before mitigation — Small-scale	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Small-scale	High	High	**HIGH**	-ve	High
	Before mitigation — Recreational	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Recreational	High	High	**HIGH**	-ve	High
	Before mitigation — Mariculture	Very High	High	**VERY HIGH**	-ve	High
	With mitigation — Mariculture	High	High	**HIGH**	-ve	High

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 IMPACT ASSESSMENT

Under normal operations, four impacts were rated as of high significance prior to mitigation, (Table 8.37). Six impacts were rated as medium, and 25 were rated as of low significance, and 13 were rated as of very low significance prior to mitigation. Twenty-three impacts were rated as of negligible significance, and no mitigation is therefore required (Table 8.37).

Of the activities that are anticipated to occur across all project phases, three were rated as of low significance prior to mitigation, with two impacts remining low and the other being reduced to very low significance after the implementation of mitigation.

Impacts related to unplanned events are all rated a high to very high before mitigation.

The high impacts are reduced to either medium or low significance with the introduction of suitable mitigation measures, and while the significance of the very high impacts are reduced with the successful implementation of suitable mitigation, these impacts remain of high significance (Table 8.37). The two construction phase impacts that were assessed as of high significance are only reduced to low with the implementation of suitable offsets, otherwise they remain as impacts of medium significance (Table 8.37).

The primary impacts of concern under normal operating conditions are:

- The loss of benthic habitat and disturbance/mortality of epifauna within CBA Natural/ Biodiversity Conservation Areas as defined by the Draft Marine Biodiversity Sector Plan (2023). This impact is considered to be of high significance prior to mitigation (Table 8.37). Indeed, the development of the subsea pipelines associated with oil and gas processes are considered **non-compatible** within the CBA Natural areas (i.e., Biodiversity Conservation Areas). While the environmentally preferable option is to reroute the pipeline to avoid CBA areas, as complete avoidance mitigation is not possible, an offset or compensatory mechanism needs to be developed as part of a Biodiversity Action Plan (BAP) (Section 9.2.1).

- Benthic impacts associated with the discharge of drilling muds and cuttings on epifauna, for both proposed production and exploratory drilling. This impact is considered to be of high significance (Table 8.37). While environmental effects in the lower water column are expected to ensure for a very short duration, up to 2.5 days maximum, benthic effects (i.e., impacts on the sediment) are modelled to endure for up to five years (Section 6). There is evidence that, depending on the discharge location, a plume of significant impact can extend beyond the confines of the 11B/12B Production Right Application Area. In particular, there is intersection with the Southwest Indian Seamounts Marine Protected Area to the southwest of Block 11B/12B. The area where cumulative environmental risks are expected within the modelled plume covers ~2.5% of the bottom water area of the MPA. Should this impact plume (PEC/PNEC > 1) overlap with vulnerable communities on hard ground, there is potential for an impact of substantial consequence (given the high sensitivity of the receptors), and recovery would only be expected over the medium- to long-term (>10 years) due to their long generation times. Except for not drilling at sites where this overlap can occur, mitigation to fully avert this impact is not possible, and therefore an offset or compensatory mechanism needs to be developed as part of a BAP (Section 9.2.1).

- While the final position of the proposed wells has not been finalised, these modelling studies focused on worst-case scenarios. However, should the drilling methodology change from what has been modelled in these studies, additional modelling will need to be conducted prior to the commencement drilling to assess whether the impact plume (PEC/PNEC > 1) in the bottom water column is expected to intersect with any sensitive species (VME indicators), areas (such as MPAs or EBSAs), habitats or structures.

- The introduction of alien invasive marine species has a high impact significance prior to mitigation (Table 8.37). However, the risk of this impact is considered to be very low to improbable, which serves to reduce the significance the impact further (note however that probability is not accounted for in the ESIA methodology used,). This impact is also not unique to oil and gas exploration and production activities, but rather a threat which is common to the South African marine environment given the numerous vessels that pass through South African coastal waters on a daily basis (Biccard *et al.* 2018).

The primary impacts of concern for unplanned events are related exclusively to the impacts of oil and condensate on marine systems and resources:

- While it is noted that the probability of a major spill happening via a well blowout or a pipe rupture is considered to be extremely small, the impacts on marine ecological systems and communities as a result of oil/fuel spillage, including a blowout and pipeline rupture, are assessed as high to very high (Table 8.37). Any release of liquid hydrocarbons has the potential for direct, indirect and cumulative effects on marine fauna (and associated habitats), with knock-on effects on ecosystem form and function in the offshore, nearshore and coastal environment. Impacts derive from toxic and/or smothering effects on organisms in the path of a spill (with estuaries being particularly vulnerable), physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton (particularly copepods), pelagic eggs and fish larvae, and habitat loss or contamination (CSIR 1998b; Perry 2005). Groups at particular risk include seabirds (because they are long-lived and impacted by surface oiling through their use of habitat and feeding) as well as turtles and cetaceans (as they are long lived, and breath at the surface).

  While model results from the Project Development Area wells (Discharge-4 and 5) indicate a very small probability (0.5-1%) that a pipeline rupture would result in oil shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) entering the Knysna Estuary, the impacts of oil entering this system would be of high intensity. Model results for a blowout from the Exploratory Priority Area indicate that a crude oil spill from Discharge-2 in particular results if a significantly greater probability shoreline oiling, with a maximum shoreline impact probability of 100% from George to Gqeberha in winter (July to September), and 98% between Knysna and Gqeberha in autumn (April to June). For Discharge-1, there is a 42% probability of the oil reaching shore from Knysna to St. Francis Bay area in spring (Oct-Dec).

  The Knysna Estuary is one of only three large, permanently-open estuarine bays along the South African coastline. The estuary is considered to be the most ecologically significant estuary in South Africa, representing 42.8 % of all estuarine biodiversity. Knysna is home to a number of critically endangered species, the most famous of which being the Knysna seahorse *Hippocampus capensis* While model results indicate a very small probability (0.5-1%) that a pipeline rupture would result in oil shore in concentrations that result in sublethal effects threshold for birds on the shoreline (> 10 g/m^2) entering the Knysna Estuary, the impacts of oil entering this system would be of high intensity (Section 7). The Knysna Estuary is one of only three large, permanently-open estuarine bays along the South African coastline. The estuary is considered to be the most ecologically significant estuary in South Africa, representing 42.8 % of all estuarine biodiversity (Turpie *et al.* 2002) Knysna is home to a number of critically endangered species, the most famous of which being the Knysna seahorse *Hippocampus capensis*, which is endemic to the Knysna Estuary and wilderness lakes and relies on the survival of the local eelgrass species *Zostera capensis*.

There is also concern that model results show that there is a relatively high probability (30-50% for Discharge-1, and 50-70% for Discharge-2) that a crude oil spill from a blowout at wells in the Exploratory Priority Area may reach the Addo Elephant National Park MPA (Algoa Bay), which will have direct impacts on important breeding islands for the endangered Cape gannet and African penguin (Section 3.3.6).

Therefore, while the risk of occurrence of a blowout at these exploratory wells is low, the implications of a crude oil spill of the magnitude modelled are nothing short of catastrophic — the impacts across all aspects of the marine environment are rated as very high prior to mitigation, and high after mitigation.

- The impacts of an uncontrolled spillage of oil from Discharge-4 and 5 are assessed to be of high significance for a number of fishing sectors. Impacts derive from the displacement of species from normal feeding areas, physical contamination of animals (including eggs and larvae) resulting in mortality and/or physiological effects such as clogging of gills, the exclusion of fisheries from polluted areas and gear damage due to oil contamination. Of particular concern are the impacts of shoreline oiling (especially that of crude oil from Dischage-1 and Discharge-2) on small-scale and recreational fisheries that operate in the intertidal and typically from the shoreline. The direct effects and vulnerability of many shoreline species, harvested by small-scale recreational fishers means impacts associated with an uncontrolled spill are higher for this sector. These sectors also have reduced flexibility in terms of redistribution of effort, considering the extent of coastline potentially impacts by an oil spill. Other sectors of particular concern include the large pelagic fishery (with which there is a significant operational overlap with the 70% spill probability mapping for a Discharge-4/5 blowout). In the event of an oil spill, fishing may have to be temporarily suspended in oiled waters.

- The impacts of crude oil in the marine system on the direct fishing activities and on the key fishery resources and benthic environment are considered to be of very high ignorance across all sectors prior to mitigation. In general, the impact of crude oil spillage will be significant, overlapping with the fishing grounds of most major fisheries of South Africa (demersal trawl, midwater trawl, commercial linefishing, large pelagic longline, small pelagic purse seine, squid jig, south coast rock lobster) and recreational fisheries. In terms of the most affected fisheries, hake longline, midwater trawl and south coast rock lobster fisheries will have significant direct impacts with over 20% of their fishing grounds >50% likely to be covered by crude oil in the event of a spillage from Discharege-l, while spillage from Discharge-2 would cover over 20% of grounds of these three fisheries, plus the squid fishery. This would result in significant disruption to fishery operations in those areas in the short term but impacts of crude oil persisting in the marine system would impact the resource for much longer than this.

9.2 Recommended mitigation

9.2.1 Offset and/or compensation requirements

As per the Draft Marine Biodiversity Sector Plan (2023), the development of the subsea pipelines associated with oil and gas processes are considered **non-compatible** with CBA Natural areas (i.e., Biodiversity Conservation Areas) (Table 4.2). The environmentally preferable option is to reroute the pipeline to avoid CBA areas. However, avoidance may not be feasible, because all routing options from the Project Development Area to the existing F-A gas platform pass through CBA areas. There is provision in Harris *et al.* (2022) that, should significant mineral or petroleum resources be identified within a CBA area, alternative CBAs and/or biodiversity offsets are to be identified to meet targets for the same biodiversity features that are found at the site. This provision would be potentially applicable to the development of pipeline infrastructure critical to the production phase of this project.

As per the National Biodiversity Offset Guidelines (2021), a biodiversity offset is defined as a "*measurable outcome of compliance with a formal requirement contained in an environmental authorisation to implement an intervention that has the purpose of counterbalancing the residual negative impacts of an activity, or activities, on biodiversity, through increased protection and appropriate management, after every effort has been made to avoid and minimise impacts, and rehabilitate affected".* However, the guideline is noted to only be applicable in the terrestrial and freshwater realms and is not applicable in the offshore marine realm and estuarine ecosystems. (No explanation is provided in the gazette notice as to why this is the case. The gazette notice does, however, state that this does not mean that biodiversity offsetting is not required for residual negative impacts on biodiversity in estuarine ecosystems and the marine realm). Therefore, the IFC biodiversity offset requirements are applied to this assessment.

As per the mitigation hierarchy specified in IFC Performance Standard 1, it is required that an "offset" be designated to compensate for direct impacts on delineated "Natural habitat[16]" as a result of the proposed development activities that cannot be abated or reduced at the source. As per IFC Performance Standard 6, *"biodiversity offsets are a set of actions with on-the-ground 'measurable conservation outcomes' that can balance significant residual biodiversity losses caused by the client's project only after appropriate avoidance, minimization and restoration measures have been applied, with equivalent biodiversity gains in terms of ecological characteristics ("like-for-like or better") and size of expected gains*". In other words, the decision to undertake a

[16] According to the IFC standards, "Natural habitats" are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition. This aligns well with the definition of CBA Natural areas which are defined as areas which must be safeguarded in their natural or near-natural state because they are critical for conserving biodiversity and maintaining ecosystem functioning.

biodiversity offset cannot act as a replacement for mitigation and management measures to avoid significant impact.

The IFC Performance Standard 6 GN31 stipulates that two general types of offsets can be used to compensate for significant residual impacts:

- Restoration offsets, which are designed to remediate past damage to biodiversity (due to factors unrelated to the client's project) via rehabilitation or enhancement of biodiversity components (or even re-creation of ecosystems and their associated biodiversity values) at suitable offset sites; and,
- Protection or averted loss offsets protect biodiversity in an area demonstrated to be under threat of imminent or projected loss (due to factors unrelated to the client's project). Projections of the losses of biodiversity that will be averted by an offset require credible analysis of those trends. In some cases, this type of offset may not be appropriate where there is great uncertainty or there is a lack of stakeholder support for the analysis supporting those projections.

The main biodiversity offset design steps include:

1. Scoping, in consultation with relevant stakeholders, of potential conservation activities or offset sites within the landscape that could benefit the biodiversity values potentially impacted by the project (i.e., "like-for-like or better").
2. Assessing if the loss of biodiversity at the project site can be compensated by gains at the offset site.
3. Identifying means for securing offset activities over the long term, including, for example, legal protections.
4. Establishing an effective process for communities affected by the offset to participate in the design and implementation of the biodiversity offset.
5. Defining the specific offset activities and how they will be implemented in a biodiversity offset management plan, including the roles, responsibilities, and budget projections for the involved parties.
6. Establishing a funding mechanism to support the offset for as long as project impacts persist.
7. Designing a system for monitoring, evaluation, and adaptive management.
8. Ensuring that the project meets all applicable laws, regulations, and policies pertaining to biodiversity offsets.

The CBA Natural habitat (defined as Critical Habitat) lost as per the proposed development activities, specifically the development of the pipeline infrastructure, predominantly falls across the Eastern Agulhas Outer Shelf Mosaic (Figure 3-5). As this habitat mostly occurs outside the Application Area, it is not possible to offset exactly like-for-like. Most of the available habitat within the Block is classified as Agulhas Rocky Shelf Edge and Southwest Indian Upper Slope (Figure 3-5).

While not explicitly catered for in the IFC Guidelines, the concept of "out-of-kind" offset has received some attention in the international literature in recent years (see for example Habib *et al*. 2013, Bull *et al.* 2015, Moilanen & Kotiaho 2018). Out-of-kind offsets are generally applied in instances where it is recognised that the more conventional "in kind" (i.e., restoration or averted loss) offsets are not feasible. Out-of-kind offsets include measures such research, education and financial compensation and are sometimes referred to as "substitution in kind" (Pope *et al*. 2021). According to Pope *et al*. (2021), under this definition, research can include taxonomic research into particular species, ecological studies or management studies, or research into ecological restoration as a necessary precursor to undertaking restoration activities, while education could include providing interpretative information in protected areas, or informing visitors to such areas about the ways to minimise impacts on the environment, and financial could include contributions made into a strategic offset fund, or directly to conservation agencies for management of conservation initiatives.

Each of these is a substitution in kind between different forms of capital, i.e., natural capital for human capital in the form of knowledge, or financial capital, but none is strictly consistent with the principles of "no net loss" or the principle of "Like-for-Like" that has been adopted as the gold standard by the IFC. However, these measures can be seen as stepping stones or can serve to benefit an actual offset if there is an appropriate 'line of sight' from the measure to biodiversity outcomes. Pope *et al*. (2021), provide an example of this where they suggest that if developers are required to first conduct research into the best way to eliminate feral pests from an offset site, or into ecological restoration techniques and then implement the findings of this research, this could then inform an improvement offset. Similarly, if funds are provided to a conservation agency for the express purpose of managing an offset site donated by the developer to the conservation estate, then this could benefit a habitat protection offset. They do acknowledge though, that taxonomic or ecological research is often not directly implementable in the short term by a developer. If funding for such research is provided by a developer this can indirectly contribute to better conservation practices in the long term, however, there is no direct 'line of sight' from such a research contribution to a specific biodiversity outcome, and as such it cannot strictly be considered an offset. It can, nonetheless, be an important part of an overall offset package.

In the case of this project, where there is no equivalent habitat available within the concession area allocated to TEEPSA that can be restored or protected, and there is limited knowledge regarding the distribution of such habitat elsewhere, we are forced to consider adopting an 'out-of-kind' offset. Knowledge regarding the distribution of habitat affected by project actions, and more particularly, the species associated with these habitat types, in the environment remains poor. One of the primary reasons for this is the challenges associated with undertaking scientific research in these deep-water environments and the paucity of funds required to do this. We propose therefore that an out-of-kind offset be considered and that this take the form of research conducted directly by TEEPSA (over and above any monitoring work that may be required to assess efficacy of any avoidance or mitigation measures implemented in terms of the EMP) or a funding allocation by TEEPSA to an appropriate government, parastatal or non-government agency for research that can contribute towards a better understanding of the distribution of deep water habitats and associated fauna off South African coast. Such a proposal would need to be further unpacked in the Biodiversity Action Plan for this study and would need to consider very carefully how "line of sight" from such research can contribute directly towards the kinds of concrete biodiversity outcomes required by the IFC and others.

9.2.2 Construction phase mitigation requirements

In addition to Project Controls, mitigation requirements (excluding offsets) identified for the construction phase include the following:

MITIGATION MEASURES — AVOID AT SOURCE

- Technical studies must be undertaken to inform the pipe laying method to inform if trenching will be required and if so, to minimise the amount of trenching required. This will minimise the unavoidable impacts of increased suspended sediment and sedimentation rates in the vicinity of pipelaying activities.

- Pre-installation site EBS ROV surveys must be untaken to ensure construction activities do not disturb or destroy the sensitive and significant VME indicator epifaunal communities, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops). These surveys must make use of suitable expertise to identify areas of particular sensitivity on site.

- While the final position of the proposed wells has not been finalised, these modelling studies focused on worst-case scenarios. However, should the drilling methodology change from what has been modelled in these studies, additional modelling will need to be conducted prior to the commencement drilling to assess whether the impact plume (PEC/PNEC > 1) in the bottom water column is expected to intersect with any sensitive species (VME indicators), areas (such as MPAs or EBSAs), habitats or structures.

- Ensure that the installation of pipelines and manifolds locations are not located within a one km radius of any species, areas (such as MPAs or EBSAs), habitats or structures.

MITIGATION MEASURES — ABATE AT SOURCE

- Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected.

- All process areas on board operational vessels should be bunded to ensure drainage water flows into the closed drainage system.

- Drip trays should be used to collect run-off from equipment that is not contained within bunded areas, and the contents routed to the closed drainage system.

- Anchors and chains should be laid prior to rig arrival to minimize risk of impact to sensitive benthic components by increasing accuracy of positioning in accordance with the anchor-spread and mooring analysis, as optimal placement is ensured by monitoring anchor handling operations by ROV (DNV 2013, cited in Oak 2020).

- Anchor chains should be given buoyancy by partly replacing chains with fibre (nylon) wire and attaching buoys to reduce the risk of damage to fragile species by extending the point of anchor chain touchdown and reducing the potential horizontal footprint (as sideways movement decreases further from the rig) (DNV 2013, cited in Oak 2020).

- The impact is regarded as permanent but may be mitigated to some extent by the choice of pipeline material, as some sessile rocky shore and reef organisms are predicted to recolonize the concrete and pipeline surface in time. Further mitigation measures include minimising the surface area impacted by cementing. Alternatively bolting the pipeline directly to the rocky substratum or to concrete bases would minimize the area impacted.

- Cement spillage to the marine environment must be minimised.

- Ensure only low-toxicity, low bioaccumulation potential and partially biodegradable additives are used in drilling fluid and cement.
- Avoid excess cement usage by using a ROV to monitor discharges to the seafloor around the drill casing.
- Inform and empower all staff about sensitive marine species & suitable disposal of waste.
- Low-toxicity biodegradable detergents should be used in the cleaning of deck spillage
- Innovative technologies and operational procedures for drilling solids discharges should be considered to minimise the impacts when drilling tophole sections to limit the extent of dispersion.
- An independent Marine Mammal Observer must accompany the pre-drilling survey to undertake validation of cetacean migration and distribution models.
- In the unlikely event of a cetacean sighting within the Permanent Threshold Shift (PTS) threshold distance for the most sensitive species (400 m) immediately prior to drilling commencement, drilling may not start until the independent MMO aboard a drilling support vessel confirms that no cetaceans are present within this PTS radius.

MITIGATION MEASURES — AVOID/ABATE AT SOURCE

- Reduce the lighting to a minimum compatible with safe operations whenever and wherever possible to reduce nocturnal faunal attraction.
- Position light sources, if possible and consistent with safe working practices, in places where emissions to the surrounding environment can be minimised i.e., aim lighting downward rather than out to sea.
- Include procedures in the EMPr for how to care for downed seabirds and ensure that personnel are adequately trained in this regard.
- Monitor the presence of seabirds and identify mortalities, even when birds do not land on the vessel, especially in foggy conditions and at night.
- Report ringed/banded birds to the appropriate ringing/banding scheme (details are provided on the ring).
- Infrastructure (e.g. wellheads, BOPs and guide bases) used in other locations must be thoroughly cleaned before deployment.
- Avoid siting well infrastructure in areas of higher fishing intensity if feasible. This particularly relates to the Large Pelagic Longline sector.
- Prior to commencement, key stakeholders should be consulted and informed of the proposed activities (including navigational co-ordinates of the area, timing and duration of proposed activities) and the likely implications thereof.
- Maintain adequate safety clearance between fishing vessels and construction phase vessels and equipment through at-sea communications with vessels in the vicinity of the survey area.

- Ensure that all flight paths avoid the Mossel Bay (Seal Island seal colony) and Robberg Peninsula (seabird and seal colonies).
- Maintain a flight altitude of at least 1 000 m during flight, except when taking off and landing or in a medical emergency.
- Avoid extensive low altitude (<762 m or 2 500 ft) coastal flights by ensuring that the flight path is perpendicular to the coast, as far as possible.
- Brief of all pilots on the ecological risks associated with flying at a low altitude along the coast or above marine mammals.
- No hovering or circling over whales, dolphins, sharks, turtles or aggregations of sea birds.
- Implement a maintenance plan to ensure all diesel motors and generators receive adequate maintenance to minimise noise emissions.
- Ensure vessel transit speed between the survey / drill area and port is a maximum of 12 knots (22 km/hr), except within 25 km of the coast where it is reduced further to 10 knots (18 km/hr).
- All the noise abatement measures shall be taken to ensure an adequate acoustic insulation of the engines, compressors, turbines (enclose engines) and gas flow lines and valves (lagging, in-line silencers, etc.).
- Optimise well test programme to reduce flaring as much as possible during the test.
- As far as possible, conduct flaring during daylight hours.
- If disorientated, but otherwise unharmed seabirds are found/caught, they must be kept in a dark space and be released during daylight hours.
- Use a high-efficiency burner for flaring to maximise combustion of the hydrocarbons and minimise hydrocarbon ‘drop-out’ during well testing.
- Monitor flare (continuous) for any malfunctioning, etc. (including any drop-out).
- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station.
- Include training on how to care for downed seabirds as part of induction and ongoing awareness training.

MITIGATION MEASURES — COMPENSATE/OFFSET

- If complete avoidance mitigation is not possible, an offset or compensatory mechanism needs to be developed as part of a Biodiversity Action Plan (BAP) is required (see Section 9.2.1).

9.2.3 PRODUCTION PHASE MITIGATION REQUIREMENTS

In addition to Project Controls, mitigation requirements identified for the production phase include the following:

MITIGATION MEASURES — AVOID/ABATE AT SOURCE

- Prohibit discharges within MPAs and EBSAs (and up current when in close proximity) during surveying or transit to and from the operations site.
- TEEPSA will continue to engage with PetroSA regarding the use of good international industry practice in the operation and maintenance of the F-A Platform.
- Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected.
- All process areas should be bunded to ensure drainage water flows into the closed drainage system.
- Drip trays should be used to collect run-off from equipment that is not contained within bunded areas, and the contents routed to the closed drainage system.
- In consultation with PetroSA the following are required:
    - Include procedures in the EMPr for how to care for downed seabirds and ensure that personnel are adequately trained in this regard.
    - Monitor the presence of seabirds and identify mortalities, even when birds do not land on the vessel, especially in foggy conditions and at night.
    - Report ringed/banded birds to the appropriate ringing/banding scheme (details are provided on the ring).
    - Reduce the lighting to a minimum compatible with safe operations whenever and wherever possible to reduce nocturnal faunal attraction.
    - Position light sources, if possible and consistent with safe working practices, in places where emissions to the surrounding environment can be minimised i.e., aim lighting downward rather than out to sea.
    - Monitor the presence of seabirds and identify mortalities, even when birds do not land on the vessel, especially in foggy conditions and at night.
- Avoidance of siting well infrastructure in areas of higher fishing intensity if feasible. This particularly relates to the Large Pelagic Longline sector.

MITIGATION MEASURES — ABATE AT SOURCE

- Low-toxicity biodegradable detergents should be used in the cleaning of deck spillages.
- Post-construction/drilling ROV surveys should be undertaken to scan seafloor for any dropped equipment and other removable features (e.g., excess cement) around the well site. Thes must be retrieved/removed, where practicable, after assessing the safety and metocean conditions.
- The impact may be mitigated to some extent by the choice of pipeline material, as some sessile rocky shore and reef organisms are predicted to recolonize the concrete and pipeline surface in time. Further mitigation measures include minimising the surface

area impacted by cementing. Alternatively bolting the pipeline directly to the rocky substratum or to concrete bases would minimize the area impacted.

- Once the pipeline is installed, it is recommended that further disturbance along the route is minimised to allow the new (novel) community to stabilise with time. Given the long-term nature of the pipeline and the anticipated community that will establish, it should not be removed during ultimate decommissioning.

- Post-construction/drilling ROV surveys should be undertaken to scan the seafloor for any dropped equipment and other removable features (e.g. excess cement) around the well site. This must be retrieved/removed, where practicable, after assessing the safety and metocean conditions.

9.2.4 EXPLORATION PHASE MITIGATION REQUIREMENTS

In addition to Project Controls, and in addition to the mitigation identified for the Construction phase (Section 9.2.2), the following mitigation requirements are identified for the Exploratory Phase:

MITIGATION MEASURES — AVOID AT SOURCE

- Prohibit VSP surveys in declared MPAs and EBSAs.

MITIGATION MEASURES — AVOID/ABATE AT SOURCE.

- Pre-borehole site ROV surveys must be undertaken to ensure construction activities do not disturb or destroy the sensitive and significant VME epifaunal communities identified in Section 3.3.2, vulnerable habitats (e.g., hard grounds), and structural features (e.g., rocky outcrops). These surveys must make use of suitable expertise to identify areas of particular sensitivity on site. The results of these surveys must be used to inform drill site location planning.

- Ensure a buffer of a one km radius of any sensitive species, areas (such as MPAs or EBSAs), habitats or structures.

MITIGATION MEASURES — ABATE AT SOURCE

- For VSPS
    - A minimum of two dedicated Marine Mammal Observer (MMO), with a recognised MMO training course, must be on board for marine fauna observation (360 degrees around drilling unit), distance estimation and reporting. One MMO should also have Passive Acoustic Monitoring (PAM) training, should a risk assessment, undertaken ahead of the VSP operation, indicate that the PAM equipment can be safely deployed considering the metocean conditions (specifically current). MMOs should arrive five days prior to VSP commencement to make preliminary observations.
    - Ensure a VSP support vessel is fitted with PAM technology (one or more hydrophones), which detects animals through their vocalisations, should it be possible to safely deploy PAM equipment
    - VSP profiling should, as far as possible, only commence during daylight hours with good visibility. However, if this is not possible due to prolonged periods of poor

visibility (e.g. thick fog) or unforeseen technical issue which results in a night-time start, refer to "periods of low visibility" below.

- Undertake a one-hour (at water depths > 200 m) pre-shoot visual and possible acoustic scan (prior to soft-starts / airgun tests) within the 500 m radius mitigation zone to confirm there is no cetaceans, turtles, penguins and shoaling large pelagic fish activity close to the source.

- Implement a "soft-start" procedure of a minimum of 20 minutes' duration when initiating the acoustic source (except if testing a single airgun on lowest power). This requires that the sound source be ramped from low to full power rather than initiated at full power, thus allowing a flight response by marine fauna to outside the zone of injury or avoidance. Delay "soft-starts" if cetaceans, turtles and shoaling large pelagic fish are observed / detected within the mitigation zone during the pre-shoot visual / acoustic scan. A "soft-start" should not begin until 20 minutes after cetaceans depart the mitigation zone or 20 minutes after they are last seen or acoustically detected by PAM in the mitigation zone. In the case of penguins, shoaling large pelagic fish and turtles, delay the "soft-start" until animals are outside the 500 m mitigation zone.

- Maintain visual observations and possibly acoustic detections within the 500 m mitigation zone continuously during VSP operation to identify if there are any cetaceans present.

- Should a shutdown or break of more than 20 minutes occurs, a full pre-watch and soft-start process should be carried out before the survey re-commences. If an MMO/PAM operator has been monitoring during the breakdown period, this time can contribute to the 60-minute pre-watch time. If a cetacean is detected in the mitigation zone during the breakdown period, there must be a minimum of a 20-minute delay from the time of the last detection within the mitigation zone and a soft-start must then be undertaken. In the case of penguins, shoaling large pelagic fish or turtles, the animals are outside the 500 m mitigation zone within the 20 minutes period.

- Ensure that during periods of low visibility (where the mitigation zone cannot be clearly viewed out to 500 m), including night-time, the VSP source is only used if PAM technology is in place to detect vocalisations (subject to a risk assessment indicating that the PAM equipment can be safely deployed considering the metocean conditions) or:

    - there have not been three or more occasions where cetaceans, penguins, shoaling large pelagic fish or turtles have been sighted within the 500 m mitigation zone during the preceding 24-hour period;

    - a two-hour period of continual observation of the mitigation zone was undertaken (during a period of good visibility) prior to the period of low visibility and no cetaceans, penguins, shoaling large pelagic fish or turtles were sighted within the 500 m mitigation zone.

- For exploratory drilling:

- An independent Marine Mammal Observer must accompany the pre-drilling survey to undertake validation of cetacean migration/distribution models.

  - In the unlikely event of a cetacean sighting within the Permanent Threshold Shift (PTS) threshold distance for the most sensitive species (400 m) immediately prior to drilling commencement, drilling may not commence until an independent MMO aboard a drilling support vessel confirms that no cetaceans are present within this PTS radius.

- Notify the operators of pelagic long-line vessels of the timing, area and safety clearance requirements prior to the commencement of the exploratory activities through the SATLA.

- Maintain adequate safety clearance between fishing vessels and exploratory vessels and equipment through at-sea communications with vessels in the vicinity of the survey area.

- Appoint an on-board fisheries liaison officer (FLO) on survey vessels to facilitate communication with fishing vessels whilst on location. The FLO should report daily on vessel activity and respond and advise on action to be taken in the event of encountering fishing gear in the survey area.

9.2.5 MITIGATION REQUIREMENTS FOR ACTIVITIES THAT FALL ACROSS ALL PROJECT PHASES

There are three identified impacts related to activities that fall across all phases of the project. In addition to Project Controls, mitigation requirements for these are identified below.

MITIGATION MEASURES — AVOID AT SOURCE

- Prohibit the placement of receivers or metocean buoys in declared MPAs and EBSAs.

- Prohibit sonar surveys in declared MPAs and EBSAs

MITIGATION MEASURES — AVOID/ABATE AT SOURCE

- Limit the area directly affected by physical contact with infrastructure to the smallest area required.

- Ensure vessel transit speed between the survey / drill area and port is a maximum of 12 knots (22 km/hr), except within 25 km of the coast where it is reduced further to 10 knots (18 km/hr).

- Ensure that all vessel paths avoid breeding areas or migration routes during peak migration or breeding times of year, if possible.

- Placing a trained, dedicated observer onboard a vessel to help increase the detection rate of cetaceans or turtles along a vessel's route during day-light hours.

- No hovering or circling over whales, or other marine megafauna.

- Educate and create awareness with mariners about collision risks

MITIGATION MEASURES — ABATE AT SOURCE

- Ensure the ROV does not land or rest on the seabed as part of normal operations.

- For sonar surveys:

- A minimum of two dedicated Marine Mammal Observer (MMO), with a recognised MMO training course, must be on board for marine fauna observation (360 degrees around drilling unit), distance estimation and reporting. One MMO should also have Passive Acoustic Monitoring (PAM) training, should a risk assessment, undertaken ahead of the sonar operation, indicate that the PAM equipment can be safely deployed considering the metocean conditions (specifically current). MMOs should arrive five days prior to sonar survey commencement to make preliminary observations.

- Ensure drilling unit vessel is fitted with PAM technology (one or more hydrophones), which detects animals through their vocalisations, should it be possible to safely deploy PAM equipment.

- Sonar surveys should, as far as possible, only commence during daylight hours with good visibility. However, if this is not possible due to prolonged periods of poor visibility (e.g. thick fog) or unforeseen technical issue which results in a night-time start, refer to "periods of low visibility" below.

- Undertake a one hour (as water depths > 200 m) pre-shoot visual and possible acoustic scan (prior to soft-starts / airgun tests) within the 500 m radius mitigation zone in order to confirm there is no cetaceans, turtles, penguins and shoaling large pelagic fish activity close to the source.

- Implement a "soft-start" procedure of a minimum of 20 minutes' duration when initiating the acoustic source (except if testing a single airgun on lowest power). This requires that the sound source be ramped from low to full power rather than initiated at full power, thus allowing a flight response by marine fauna to outside the zone of injury or avoidance. Delay "soft-starts" if cetaceans, turtles and shoaling large pelagic fish are observed / detected within the mitigation zone during the pre-shoot visual / acoustic scan. A "soft-start" should not begin until 20 minutes after cetaceans depart the mitigation zone or 20 minutes after they are last seen or acoustically detected by PAM in the mitigation zone. In the case of penguins, shoaling large pelagic fish and turtles, delay the "soft-start" until animals are outside the 500 m mitigation zone.

- Maintain visual observations and possibly acoustic detections within the 500 m mitigation zone continuously during sonar survey operation to identify if there are any cetaceans present.

- Should a shutdown or break of more than 20 minutes occurs, a full pre-watch and soft-start process should be carried out before the survey re-commences. If an MMO/PAM operator has been monitoring during the breakdown period, this time can contribute to the 60-minute pre-watch time. If a cetacean is detected in the mitigation zone during the breakdown period, there must be a minimum of a 20-minute delay from the time of the last detection within the mitigation zone and a soft-start must then be undertaken. In the case of penguins, shoaling large pelagic fish or turtles, the animals are outside the 500 m mitigation zone within the 20 minutes period.

- Ensure that during periods of low visibility (where the mitigation zone cannot be clearly viewed out to 500 m), including night-time, the sonar source is only used if PAM technology is in place to detect vocalisations (subject to a risk assessment indicating that the PAM equipment can be safely deployed considering the metocean conditions) or:

- there have not been three or more occasions where cetaceans, penguins, shoaling large pelagic fish or turtles have been sighted within the 500 m mitigation zone during the preceding 24-hour period;
- a two-hour period of continual observation of the mitigation zone was undertaken (during a period of good visibility) prior to the period of low visibility and no cetaceans, penguins, shoaling large pelagic fish or turtles were sighted within the 500 m mitigation zone.

9.2.6 UNFORESEEN EVENT (POLLUTION EVENT, WELL BLOWOUT, PIPE RUPTURE) MITIGATION REQUIREMENTS

In addition to Project Controls, mitigation for unforeseen events includes the following:

MITIGATION MEASURES – AVOID/ABATE

- Implement leak detection and maintenance programmes for valves, flanges, fittings, seals, hydraulic systems, hoses, etc. All hydraulic systems should be adequately maintained, and hydraulic hoses should be frequently inspected.
- Use breakaway couplings with shut-off valves during refuelling. As a result, any spill during refuelling is likely to be of a relatively small volume before it will be detected and stopped.
- Give preference to vessels using marine gas oil (MGO), which (if spilled) is less persistent in the marine environment than heavy fuel oil (HFO).
- As far as possible, and whenever the sea state permits, attempt to control and contain the condensate spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill.
- In the case of small operational diesel spills offshore, no action would be required unless large numbers of pelagic seabirds are present, in which case the spill should be sprayed with dispersants (if sea conditions permit and permission has been obtained from the relative authority).
- Ensure adequate resources are available to collect and transport oiled birds to a cleaning station.
- All process areas should be bunded to ensure drainage water flows into the closed drainage system.
- Drip trays should be used to collect run-off from equipment that is not contained within bunded areas, and the contents routed to the closed drainage system.
- Ensure offshore bunkering is not undertake in the following circumstances:
  - Wind force and sea state conditions of ≥6 on the Beaufort Wind Scale;
  - During any workboat or mobilisation boat operations;
  - During helicopter operations;
  - During the transfer of in-sea equipment; and

  - At night or times of low visibility.

- Avoid scheduling drilling operations during the periods when weather and metocean conditions make drilling safe operations less than optimal, when the likelihood of shoreline oiling for a blowout is highest.

MITIGATION MEASURES – ABATE

- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station.

- Low-toxicity biodegradable detergents should be used in the cleaning of all deck spillages.

- Obtain permission from DFFE to use low toxicity dispersants. Use cautiously.

- Use low toxicity dispersants that rapidly dilute to concentrations below most acute toxicity thresholds (refer to DFFE Oil Dispersant Policy and SAMSA Marine Notice on dispersants). Dispersants should be used cautiously and only with the authorisation of DFFE.

- Ensure a standby vessel is within 30 minutes of the drilling unit and equipped for dispersant spraying and can be used for mechanical dispersion (using the propellers of the ship and/or firefighting equipment). It should have at least 5 m^3 of dispersant onboard for initial response.

- As far as possible, and whenever the sea state permits, attempt to control and contain the spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill.

- In the event of a large spill, use drifter buoys and satellite-borne Synthetic Aperture Radar (SAR)-based oil pollution monitoring to track the behaviour and size of the spill and optimise available response resources.

- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station. Include training on how to care for downed seabirds as part of induction and ongoing awareness training.

MITIGATION MEASURES – AVOID/ABATE/RESTORE

- Develop a well-specific response strategy and plans (OSCP and BOCP), aligned with the National OSCP, for each well location that specifies the resources and response required to minimise the risk and impact of oiling (shoreline and offshore). This response strategy and associated plans must take cognisance to the local oceanographic and meteorological seasonal conditions, local environmental receptors and local spill response resources. The development of the site-specific response strategy and plans must include the following:

  - Assessment of response resources (equipment and people) and capabilities at time of drilling, location of such resources (in-country or international), and associated mobilisation / response timeframes.

  - Selection of response strategies that reduce the mobilisation / response timeframes as far as is practicable. Use the best combination of local and international resources to facilitate the fastest response.

  - Well-specific oil spill modelling for planning purposes taking into consideration site- and temporal-specific information, the planned response strategy, and associated resources.

  - Considering the well-specific modelling, map environmentally or socio-economically sensitive and priority protection areas, in collaboration with an independent Marine Ecologist and Social Scientist.

  - Develop intervention plans for the most sensitive areas to minimise risks and impacts and integrate these into the well-specific response strategy and associated plans.

  - If modelling and intervention planning indicates that the well-specific response strategy and plans cannot reduce the response times to less than the time it would take oil to reach the shore, additional proactive measures must be committed to. For example:

    - Implement measures to reduce surface response times (e.g., pre-mobilise a portion of the dispersant stock on the support vessels, contract additional response vessels and aircrafts, minimise the time it takes to install the SSDI kit, improve dispersant spray capability, etc.).

    - Deploy and/or pre-mobilise shoreline response equipment (e.g., response trailers, shoreline flushing equipment, shoreline skimmers, storage tanks, shoreline booms, skirt booms, shore sealing booms, etc.) to key localities for the full duration of drilling operation phase to proactively protect sensitive coastal habitats and areas.

- Schedule joint oil spill exercises including TEEPSA and local departments/organisations to test the oil spill response readiness.

- Ensure contract arrangements and service agreements are in place to implement the OSCP, e.g., capping stack in Saldanha Bay and other international locations, SSDI kit, surface response equipment (e.g., booms, dispersant spraying system, skimmers, etc.), dispersants, response vessels, etc.

MITIGATION MEASURES – RESTORE

- In the event of a large blowout or loss of control of the well, an oil spill response plan must be implemented taking the following factors into consideration:

  - Designated personnel to manage the situation;

  - Spill response, containment and clean-up equipment on standby with sufficient training provided to the personnel responsible for its maintenance and effective use; and,

    - Well control, capping and containment equipment on standby with sufficient training provided to the personnel responsible for its maintenance and effective use.

- Ensure that the following aspects are included in insurance cover to financially manage the consequences of any unplanned event:

    - Control of Well.
    - Damages and compensation to Third-Parties.
    - Decommissioning & Abandonment.
    - Evidence to be provided to PASA.

9.3 Monitoring

Monitoring requirements for the project across all phases include, but are not limited to, the following:

- Benthic monitoring of communities (infauna and epifauna) must be undertaken after the construction phase in alignment with the baseline surveys undertaken in 2022 to quantify the impacts and validate the dispersion models.
- Drilling cuttings must be tested for toxicity and barite contamination and oil content to ensure the specified discharge standards are maintained.
- Continuous monitoring during flaring must be implemented for any malfunctioning, etc. (including any drop-out).
- An ROV must be used to monitor discharges to the seafloor around the drill casing to minimise cement usage.
- As per MARPOL 73/78 Annex I, vessels must have an onboard oil discharge monitoring and control system to ensure that any discharge of oily mixtures is stopped when the oil content of the effluent exceeds 15 ppm.
- Monitoring and management measures during drilling must be implemented in accordance with standard well control practices to assist in detection and control of uncontrolled releases.
- The presence of seabirds must be monitored, and mortalities identified, even when birds do not land on the vessel, especially in foggy conditions and at night.
- For VSP and sonar activities, a minimum of two dedicated Marine Mammal Observer (MMO), with a recognised MMO training course, must be on board for marine fauna observation (360 degrees around drilling unit), distance estimation and reporting. One MMO should also have Passive Acoustic Monitoring (PAM) training, should a risk assessment, undertaken ahead of the sonar operation, indicate that the PAM equipment can be safely deployed considering the metocean conditions (specifically current). All MMO observational reports must be submitted to the Competent Authority.

- For production and exploratory drilling, a certified, independent MMO must accompany the pre-drilling survey to undertake validation of cetacean migration/distribution models. The MMO is also required to make observations immediately prior to drilling commencement to confirms that no cetaceans are present within the PTS radius. All MMO observational reports must be submitted to the Competent Authority.

- In the event of a large spill, use drifter buoys and satellite-borne Synthetic Aperture Radar (SAR)-based oil pollution monitoring to track the behaviour and size of the spill and optimise available response resources.

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APPENDIX 1: FISHERIES DATA PROCESSING

Table A2-1. Processing steps for commercial fisheries spatial data provided by DFFE and the NBA (Sink *et al.* 2019)

Fishery	Data Source	Data provided	Processing steps
Inshore demersal trawl	DFFE PAIA request	Raw data were received for the period 2009-2019 with start and end positions for each trawl event, species and total catch in kilograms.	• First data we separated by bottom/twin trawl & midwater trawl as all trawl data were provided together. • All vessels labelled as 'inshore' included • Joined start and end points • All trawls >45 km removed (Currie unpublished data (but in NBA) trawls = 1-6 hours 3-4knots. Maximum = 44.4km) • All trawls that were over land removed • All records with whole integer latitude and longitudes were removed (e.g., N 54 – lacking coordinate/spatial resolution) • Records outside of 20E and Great Kei removed (including lines that crossed) as per permit conditions • An 18m buffer applied to each trawl (based on gear configuration from 'Description and evaluation of hake-description and evaluation of hake-directed trawling intensity on benthic habitat trawling intensity on benthic habitat in South Africa) trawl area calculated • Summed total catch per trawl • Species with no catch records removed • Species recorded in ladings data were cross referenced with SA buyers and sellers handbook • Very low total catches (<10 kg) of individual species removed • 'Teleostei' and 'Teleostei demersal' grouped as 'Demersal teleosts' • 1km grid created • Spatial join for join count between trawls and grid. Zero counts and <10th percentile removed to eliminate remaining very low density and likely a areas. • Values then ranked (raw value/80th percentile value) and mapped • Clipped by all MPAs and clipped portion of trawl removed. Also clipped by restricted areas as defined by the permit conditions • Then separated by hake target and sole targeted • Hake and sole catches <50kg removed • Values then ranked (raw value/80th percentile value) and mapped Bycatch: • Steps outlined above plus: • First landings data were split by hake directed and sole directed fisheries • 1km grid, joined with cleaned raw trawl data • Output summed by each 1km square • All bycatch values were summed per km plus total catch was summed for each grid cell

Fishery	Data Source	Data provided	Processing steps
Commercial Linefish	DFFE PAIA request	Point data were received for the period 2010-2020. Points related to a linefishing reporting grid so Grid ID was also supplied. Data were recorded by species with weight landed (kg) for each species.	• National Marine Linefish System reporting grid overlayed • Summarised point data for GridID crew, hours and weight (kg) • CPUE = (weight/(crew)). CPUE kg per person per hour fishing • Some cells had no hours fishing reported and were removed • Errors in reporting were removed (e.g., no data entered for crew numbers) • 1km grid overlaid on top of NMLS grid to summarized by 1km grid cells to be able to compare with other fisheries • 'effort' = frequency of trips was expressed per cell as quantiles. • Low hours fishing (under 10 hrs per grid) removed • CPUE = catch per km2 per fisher • Effort mapped • Catch per unit effort for each species mapped
Squid fishery	DFFE PAIA request	Data were received for the period 2012-2019. Point data were only given for 2014 onwards. These were correspond to a 'Block'. Catch for each data recorded was provided (kg).	• Records with only coordinates mapped and matched to squid grid Block code • Records outside of grid removed (both on GIS and manually) • Gaps in data removed • Grid Block IDs that don't make sense removed, those with also coordinates were mapped and new Block id code generated • Data codes expanded • Time (hours)trawling calculated in excel (subtracting) • USE_SquidJig_cleaned_forspatialanalysis • Joined • Summed by Block (manually) • CPUE calculated (summed catch per Block/(summed fishing hours*crew) CPUE = kg squid per fisher per hr • Spatial join with 1km – centre points of 1km grid • Join count of 0 removed. Nulls removed
Hake Longline	DFFE PAIA request	Point data of start and end positions was received from DFFE for the period 2010-2022, alongside number of hooks per line and the total catch in kilograms.	• All points were joined by trip ID and hake lone 'lines' were mapped. • All records outside EEZ and on land removed • NBA –'lines are generally 30 km in length • and are deployed around depths of 200-400 m' • Longline sets >45km were therefore removed • Records where hooks = 0 were removed and also strange numbers e.g. 14 hooks = likely errors, so were removed • Records with total catch of 0kg removed • Records with lengths less than 0.01km removed • Hooks per km calculated for each long line set • Green weights and total (green weight) for Hake and Kingklip calculated plus other bycatch species with a conversion factor -conversion factor provided by DFFE • Sets were cleaned by MPAs overlaps and permit conditions outlining restricted areas • Summarized number of hooksper Km by 1km grid • Summarized total hake and kingklip green weight by fishnet 1km grid • Bycatch summarized on the same grid

Fishery	Data Source	Data provided	Processing steps
Midwater trawl	DFFE PAIA request	Raw data were received for the period 2009-2019 with start and end positions for each trawl event, alongside data for hours of trawling and total catch in kilograms.	• Start and end points extracted and merged, trawl lines were connected and drawn • Midwater trawls operate at speeds of approximately 5 knots with trawl durations ranging between 1 and 9 hours and averaging 2.5 hours = Max trawl length= 83,34003997 km. Trawls above this threshold were removed • Nulls (zero catch data) were removed • Lines that intersect land removed • Species landings with no catch were removed • Total catch calculated – totals under 50kg removed. Also individual catches of target species • (mackerel) under 50kg were removed • The trawl doors (3.5 t each) maintain the net opening which ranges from 120 to 130 m in width and from 40 m to 80 m in height(https://cdn.slrconsulting.com/uploads/2021-10/CGG_Appendix6_Fisheries.pdf). A 62.5m buffer therefore applied • Trawls overlapping MPAs were clipped and trawl potion inside MPA removed • Trawl less than 100m depths removed as were trawls < 20 nm from the coast as per permit conditions • 1km grid was overlaid (same size and extent used for the inshore trawl analysis) • Spatial join for join count. Zero joins removed. <10th percentile removed • Strange lines representing reporting errors removed • Mapped by quantiles of highest effort 0-1. Anything over 1 = 1 • Mapped in the same way by just Trachurus capensis landings - Mapped by quantiles of highest effort 0-1. Anything over 1 = 1 • Data, where necessary, were summarized by 1 km grid cells.
Small pelagic purse seine	National Biodiversity assessment Fishery Intensity Layer (Holness S, 2018, Sink *et al.* 2019)	Data for the period 2000-2016 and calculated to a 5 min grid by CAPFISH (DAFF/CAPFISH/SANBI)	• A centroid was used for each grid square, with total catch values for the square being allocated to this centroid. A zero value was allocated to non-fished areas. • A natural neighbours interpolation was undertaken for marine areas. • Extremely low values with under 200kg catch over the record period were excluded. • Reclassified into 10 quantiles (given values from 10-100). • Values were modified using MPA boundaries (where there are activity exclusions). • The ecosystem map and pressure matrix were applied to produce an impact layer.
Pelagic longline	National Biodiversity assessment Fishery Intensity Layer (Holness S, 2018, Sink *et al.* 2019)	Point data of start and end positions from DFFE for the period 2000-2016, alongside number of hooks per line and the total catch in kilograms.	• Base data with line hook numbers (effort) values associated with start and end points • A point density approach was used to add up all effort around an area. A 120m grid was used, with areas within 10 000m of a point being evaluated. • The effort was calculated in hooks/km2 . Low values of under 100 hooks/km2 were removed to deal with scatter of inaccurate points and very low use areas. • Reclassified into 10 quantiles (given values from 10-100). • Values were modified using MPA boundaries (where there are activity exclusions). • The ecosystem map and pressure matrix were applied to produce an impact layer

Fishery	Data Source	Data provided	Processing steps
South Coast Rock Lobster	National Biodiversity assessment Fishery Intensity Layer (Holness S, 2018, Sink *et al.* 2019)	South Coast Rock Lobster harvesting data were collated by for each concession area for the period 2007 to 2016.	• A centroid was developed from the summary grid of total catch. A zero value was allocated to all nonfished grid cells. • A natural neighbours interpolation was undertaken for marine areas. • Extremely low values with under 713kg catch over the record period were excluded. • A 100*n/n90 method used to deal with the skewed distribution of values, with n90 = 33 420. We reclassified any resulting values over 100 as 100. • Values were modified using MPA boundaries (where there are activity exclusions). • The ecosystem map and pressure matrix were applied to produce an impact layer. Squid Harvesting Total catch values for the period 2012 - 2016 were collated and calculated into a 5min grid

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