ZIRCO ROODE HEUWEL (PTY) LTD, NORTHERN CAPE

KAMIESBERG PROJECT, NAMAQUALAND, SOUTH AFRICA

MARINE SPECIALIST STUDY AND IMPACT ASSESSMENT

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EXECUTIVE SUMMARY

Zirco Roode Heuwel (Pty) Ltd (Zirco) require seawater to extract heavy mineral concentrate from mined material at the Roode Heuwel deposit which is situated approximately 20 km inland of Groensriviersmond in Namaqualand. Zirco, in consultation with Bergstan Africa Development Engineers, have agreed that a gully seawater intake (Figure 1) would be the most cost-effective solution and would carry the least amount of project risk pertaining to both installation processes and storm sea conditions (Bergstan Africa, 2013). Six gully sites were proposed by the engineers as possible options – three of which are preferred sites. The proposed gully site located within the National Park was omitted from the survey due to legal complications.

Anchor Environmental Consultants (AEC) were appointed by Coastal and Environmental Services to undertake a marine specialist study which describes the rocky shore biota in and around the area likely to be impacted by the marine intake pipeline, including an assessment of the impact significance and mitigation measures. The findings would be used to facilitate the decision making process to select an appropriate gully and way forward.

A field survey was conducted in which intertidal rocky shore community composition at a series of open coast sites and sheltered gully sites was surveyed. A brief subtidal snorkel survey was also conducted and the maximum depth recorded at each of the sites. A bird list was compiled and additional fauna utilising the intertidal zone were noted. The sites were then compared for significant differences in intertidal rocky shore community composition using multivariate techniques in PRIMER.

The results showed that that there was no significant difference in intertidal rocky shore community composition between the three preferred (potentially impacted) and the lesser preferred (control) sites. However, the open coast sites were significantly dissimilar from the sheltered gully sites, both in terms of number of species and species composition. This was largely because of the difference in the prevailing physical conditions at each of the survey sites. The sheltered gully sites were situated higher up the shore and hence significantly fewer species were recorded there.

The following impacts were identified, assessed and mitigated for:

Construction phase

Impact 1: Direct losses of intertidal and infratidal biota in development footprint

Mitigation and Management

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.

Impact 2: Barotrauma of marine fauna as a result of blasting

Mitigation measures

All blasting should be conducted using a rock breaking technology known as NoneX (www.nonex.co.za). This is a non-explosive technology. It is propellant compound encased in a cartridge which reacts very quickly to produce high volumes of harmless gas (nitrogen, carbon dioxide and steam). The cartridge is sealed inside a drilled hole and ignited. High pressure gas is released and enters into the fractures caused by drilling and natural fractures or planes of weakness in the rock. The gas pressure causes the fractures to expand and the rock to split apart. The cartridges do produce a high pressure over a short time frame and so will produce noise. It is recommended that blasting activities be limited to one detonation series per day to avoid or reduce the mortality of predators and seabirds attracted to fish kills from previous blasts.

Impact 3: Impaired water quality and its effects on marine fauna

Mitigation measures

Nonex should be used for all blasting. The NoneX rock breaking process produces a much courser fragmentation when compared to the smaller particles produced by explosives. Furthermore, NoneX detonations on land have been reported to produce negligible dust and fumes. The use of NoneX blasting technology will result in the release of gases into the water column. None of the gases produced will be noxious given that the cartridge is oxygen balanced and sufficient oxygen is available to achieve optimal oxidation to produce gases consisting of carbon dioxide, nitrogen and steam.

All fuel and oil is to be adequately stored and no leaking vehicles are to be permitted on site. Contingency plans in the event of an accident must be prepared. Containment of storm water from construction areas is also important.

The casting of cement for attachment of the pipeline should take place within watertight plastic canvas bags supported and shaped within metal frames with shuttering beams.

Impact 4: Litter during construction

Mitigation measures

The following mitigation measures must be taken to avoid or reduce the risk of litter and debris entering the marine environment:

- Inform & empower all staff about sensitive marine species & suitable disposal of construction waste.

- Filter effluent on start-up of plant to remove plastic particles.

Operational Phase

Impact 1: Impingement of organisms

Mitigation measures

It is recommended that the following mitigation measures be taken to avoid or reduce the impingement of mobile organisms at the intake:

- The velocity of the intake flow be maintained below 0.2 m/s through the installation of an appropriate sized intake structure on the base of the foot valve. The intake structure should be directed such that water flows in in a ‘horizontal’ rather than vertical direction;

- the intake pipes be positioned at least 0.5 m off the seabed to reduce the intake of sediment and benthic organisms (Fredorenko 1991);

- the intake pipes be positioned at least 1.4 m below the Mean Low Water Spring to reduce entrainment of larvae and most other planktonic marine organisms as these are generally concentrated at or near the surface.

Decommissioning Phase

It is anticipated that impacts 2, 3 and 4 outlined in the construction phase are likely to be repeated during the decommissioning phase. The same mitigation procedures should be adhered to in order to mitigate as far as possible impacts discussed above.

Based on the results of the field survey, it is apparent that the sheltered gully sites displayed significantly lower biodiversity and abundance of intertidal rocky shore biota in comparison to the open water (exposed) sites. Furthermore the benthic biota at these sites is not of great significance in terms of conservation status. This would suggest that impacts of the construction and decommissioning phases of the intake point would be fairly low within any of the proposed sheltered gully sites.

Site KMM4 was regarded as the most suitable for abstraction of seawater because of its greater depth and least amount of blasting required. Site KMM6 was regarded as an environmentally sensitive area, as many birds and seals were observed utilising the intertidal zone. The site is also adjacent to a sandy beach (regarded a rare habitat in the region) and vegetated sand dunes, increasing its sensitivity.

A biological monitoring survey is proposed, with a repeat survey six months after abstraction has gone online.

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ACRONYMS AND ABBREVIATIONS

AEC	Anchor Environmental Consultants
ANOSIM	Analysis of Similarities
ANOVA	Analysis of Variance
ASCE	American Society of Civil Engineers
HMC	Heavy Mineral Concentrate
HWM	High Water Mark
IUCN	International Union for the Conservation of Nature
MDS	Multi-Dimensional Scaling
MPA	Marine Protected Area
MSP	Mineral Separation Plant
NEMBA	National Environmental Management Biodiversity Act of 2004
PCP	Primary Concentrator Plant
PRIMER	Plymouth Routines in Multivariate Ecological Research
SANBI	South African National Biodiversity Institute
SIMPER	Similarity Percentages
TAC	Total Allowable Catch
UNEP	United Nations Environment Programme
WCRL	West Coast Rock Lobster

1. INTRODUCTION

Zirco Roode Heuwel (Pty) Ltd (hereafter referred to as Zirco) currently holds the prospecting right to the Roode Heuwel and Leeuvlei heavy mineral deposits, located approximately 500 km north of Cape Town in the Northern Cape Province of South Africa. Based on the drilling programme and mining studies completed at the Roode Heuwel deposit, there is an estimated mineral reserve of 270 million tons (at 4.8% total heavy mineral grade) which could support 20 years of mining at a rate of 1 500 to 2 300 tons per hour.

Dry mining using front end loaders is the most likely scenario. The mineralised sand will first be concentrated in a Primary Concentrator Plant (PCP) to produce a Heavy Mineral Concentrate (HMC). The HMC will then be processed in a Mineral Separation Plant (MSP) where the final products - ilmenite, monazite, zircon and rutile - will be produced. Mineral sands mining and processing plants require substantial quantities of water and energy (both in the form of fuel and electricity) to operate. Seawater has been selected as the most viable option for the wet separation of HMC from sand in the PCP.

The amount of seawater required for the PCP is estimated at 12 million m^3 per annum. In addition, an estimated 690 000 m^3 of freshwater per annum is required for potable water and to remove salt from the HMC prior to it going into the MSP. In order to meet the freshwater requirement, a reverse osmosis desalination plant is planned to be constructed at the mine site. The desalination plant will either treat brackish groundwater or seawater brought to the mine site for processing purposes - a small quantity of this seawater will be bled off to supply the desalination plant. The freshwater produced from the desalination plant will be used to wash salt from the HMC prior to separation in the MSP. Water used to wash HMC will be recycled into the process water. Three types of seawater intake works have been proposed as a source of water for the mine, these include:

- Gully Intakes (various location options)
- Open Water Intake in Khnyp Bay as a stand-alone installation
- Open Water Intake in Khnyp Bay as part of the new envisaged harbour development

Zirco, in consultation with Bergstan Africa Development Engineers have estimated that a Gully Seawater Intake (Figure 1) would be the most cost-effective solution and would carry the least amount of project risk pertaining to both installation processes and storm sea conditions (Bergstan Africa, 2013). Anchor Environmental Consultants (AEC) were appointed by Coastal and Environmental Services to conduct a marine specialist study which describes the rocky shore biota in and around the area likely to be impacted by the marine intake pipeline, including an assessment of the impact significance and mitigation measures.

Alternative locations for a Gully Seawater Intake, identified by Bergstan Africa Development Engineers (Figure 2), were surveyed during a site visit which took place during February/March 2014. Baseline data collected during this survey were used together with available scientific literature to describe and rank the importance of the various biota at each of the study sites and to describe the general marine ecology of the area. For the purposes of the assessment, the study area was considered to include the coastline and adjacent surf zone to a distance of approximately 500 m offshore. The upper limit of the study area was set as the maximum height reached by the high water spring tides. This is the portion of the marine environment that is likely to be most impacted by the proposed Gully Seawater Intake. Various impacts identified during the construction, operational and decommissioning phases of the seawater intake were assessed in the general context of the rocky shore and immediate subtidal gully habitats found in the area. Recommendations for the selection of a suitable abstraction site and mitigation measures are provided.

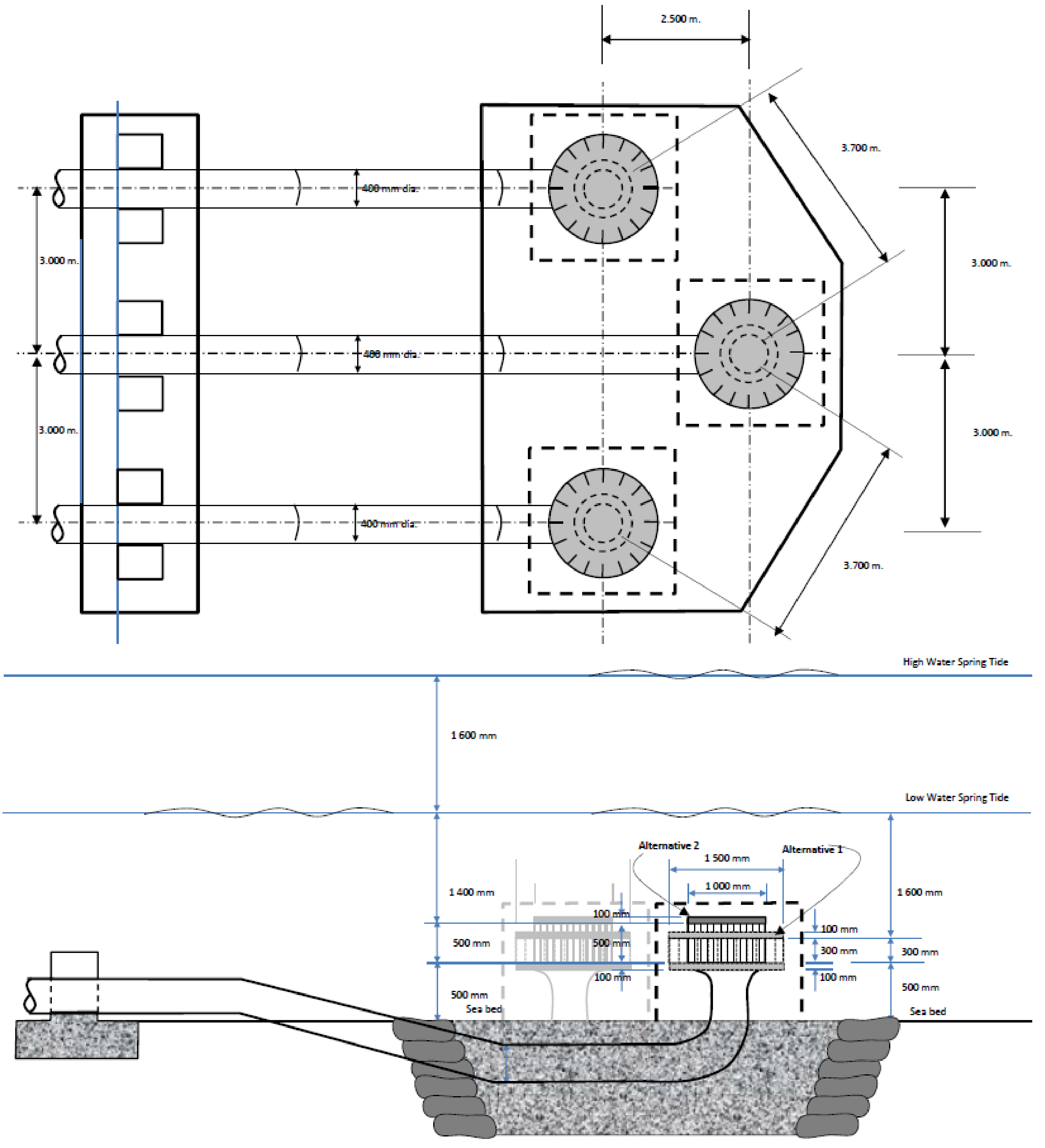

Figure 1: Top – longitudinal section of concept Gully Intake Works. Bottom – cross section through concept Gully Intake Works (Source: Bergstan Africa, 2013).

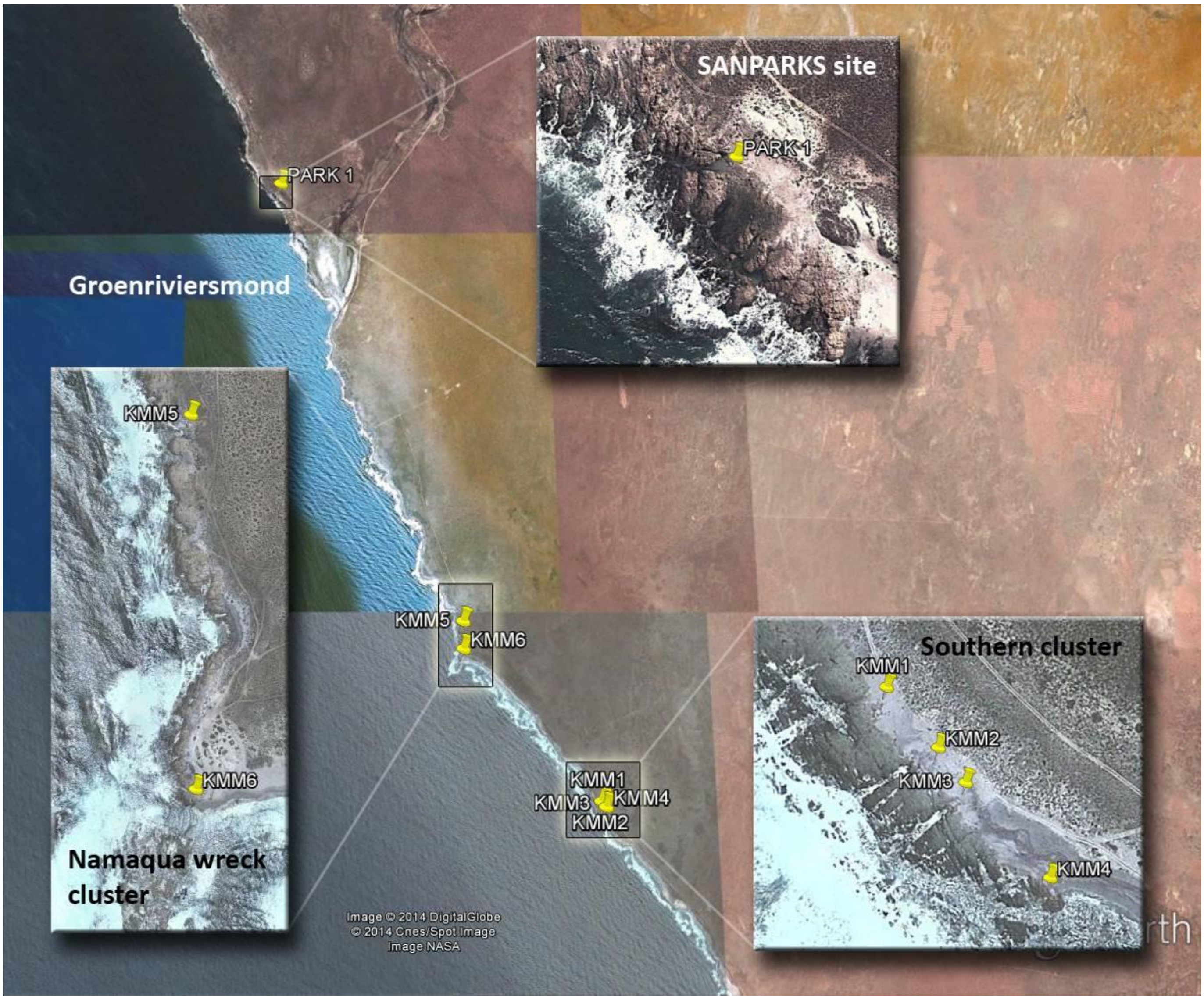

Figure 2: Alternative locations for the Gully Seawater Intake identified by Bergstan Africa Development Engineers. Gully site PARK 1 was omitted from this particular study due to legal complications pertaining to section 43 of the Marine Living Resources Act (1998).

2. DECRIPTION OF THE MARINE ENVIRONMENT

Oceanography

2.1. Regional oceanography

The physical oceanography of an area, particularly water temperature, nutrient and oxygen levels, and wave exposure are the principal driving forces that shape marine communities. The broader oceanography of the Groenriviersmond region is influenced by the cold Benguela upwelling system of the west coast (Figure 3). The Benguela Current originates from the South Atlantic Circulation, which circles just north of the Arctic Circumpolar Current.

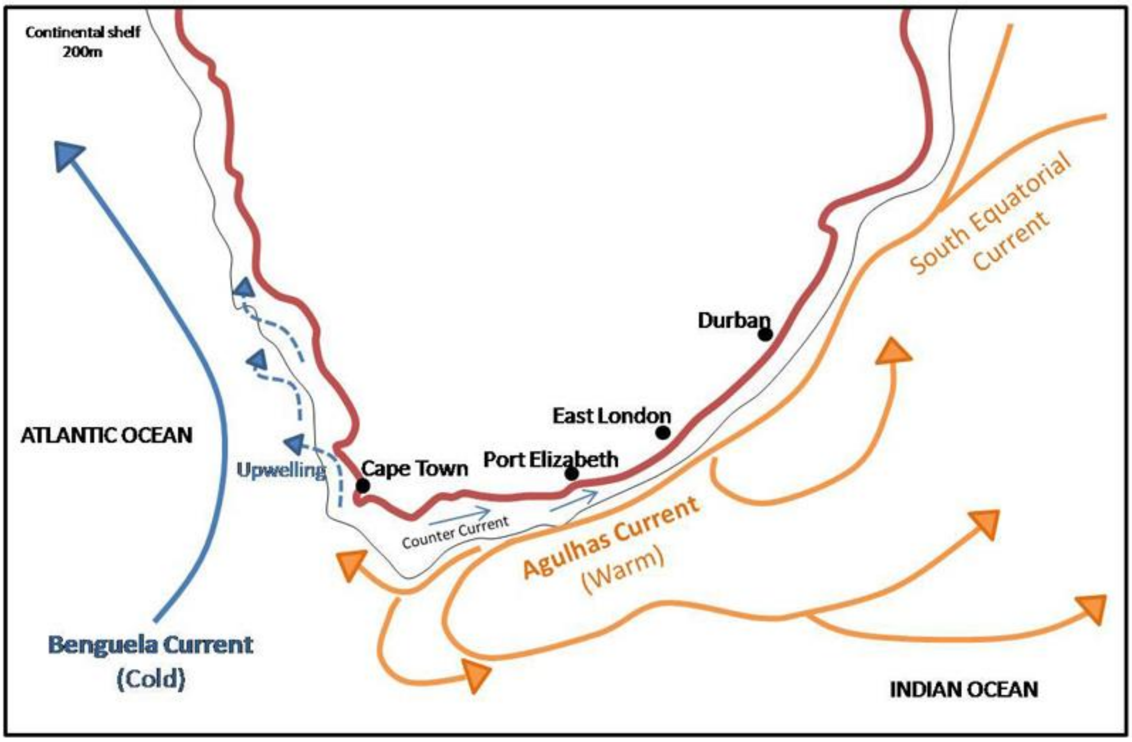

Figure 3: Southern Africa showing Agulhas and Benguela currents.

The naturally cool temperature of the Benguela current (average temperature 10-14^{o}C) is enhanced by the upwelling of colder nutrient-rich deep water (Branch 1981). The area experiences strong southerly and south-easterly winds which are deflected by the Coriolis force (rotational force of the earth which causes objects in the southern hemisphere to spin anticlockwise). These prevailing conditions deflect the surface waters offshore and draws cold, nutrient rich water upwards to replace it (Figure 4). Phytoplankton bloom when the nutrients reach the surface waters where plenty of light is available for photosynthesis. The phytoplankton is then preyed upon by zooplankton, which is in turn eaten by filter feeding fish such as anchovy or sardine. This makes the west coast one of the richest fishing grounds in the world and also attracts large colonies of birds and seals (Branch 1981). The areas that experience the most intense upwelling activity in the southern Benguela are situated off Cape Columbine, approximately 80 km South of Lamberts Bay, and the Cape Peninsula. The water temperature and nutrient levels are strongly influenced by wind with minimum temperatures and maximum nutrient levels occurring in conjunction with upwelling events (Branch and Griffiths 1988).

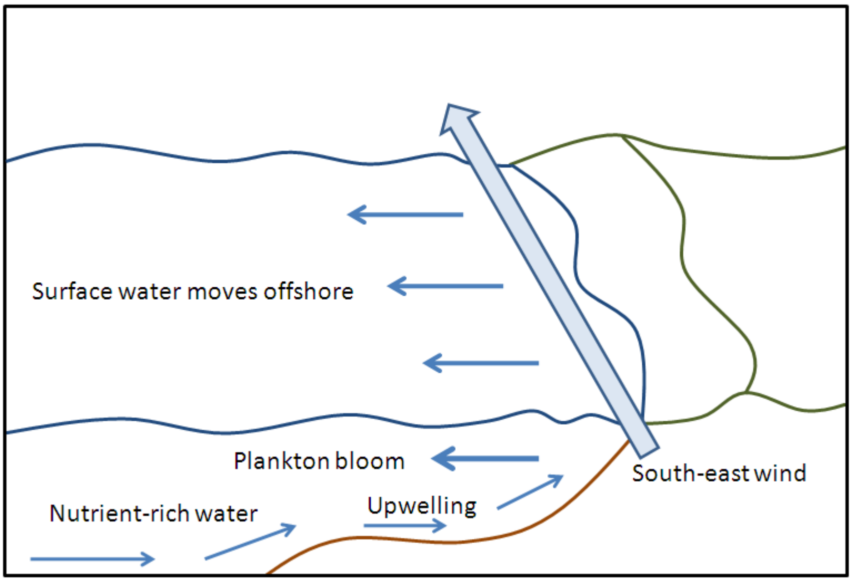

Figure 4: Wind-driven upwelling that occurs on the west and south west coasts of South Africa.

2.2. Local oceanography

The study site is subject to semi-diurnal tides, with each successive high (and low) tide separated by 12 hours. Each high tide occurs approximately 25 minutes later every day, which is due to the 28-day rotational cycle of the moon around the earth. Spring tides occur once a fortnight during full and new moons. Tidal activity greatly influences the biological cycles (feeding, breeding and movement) of intertidal marine organisms, and has an influence on when people visit the coastline to partake in various activities (e.g. relax, bathe, harvest marine resources). The tidal variation in the vicinity of Groenriviersmond usually ranges between 0.28 m (relative to the chart datum) at mean low water springs to 1.91m at mean high water springs with the highest and lowest astronomical tide being 2.25m and 0.056m respectively.

Another factor which greatly influences marine ecology and human activities along the coastline is wave energy. Wave size is determined by wind strength and fetch (distance over which it blows) and determines the degree to which breaking waves at the shore will shift sand and erode rock. The west coast of South Africa typically experiences high wave energy and is dominated by south-westerly swells with a long fetch and a period of 10-15+ seconds (Branch and Griffiths 1988).

2.3. Regional Biogeography

Numerous attempts have been made to understand and map marine biogeographic patterns around the coast of South Africa (e.g. Stephenson and Stephenson 1972; Brown and Jarman 1978; Emanuel *et al.* 1992; Engledow *et al*. 1992; Stegenga and Bolton 1992; Bustamante and Branch 1996; Bolton and Anderson 1997; Turpie *et al*. 2000; Sink 2001; Bolton *et al*. 2004; Lombard *et al.* 2004). Most of these studies recognised three coastal regions – a cool temperate west coast, a warm temperate south coast and a subtropical east coast region, with the main points of argument relating to the position of the boundaries. Marine biogeographic patterns around the South African coast were recently reviewed and several new ecoregions were described (Sink *et al.* 2011). According to these divisions, Groenriviersmond and the study sites described in this report, fall in the Namaqua inshore ecozone, which is nested within the Southern Benguela Ecoregion (Figure 5).

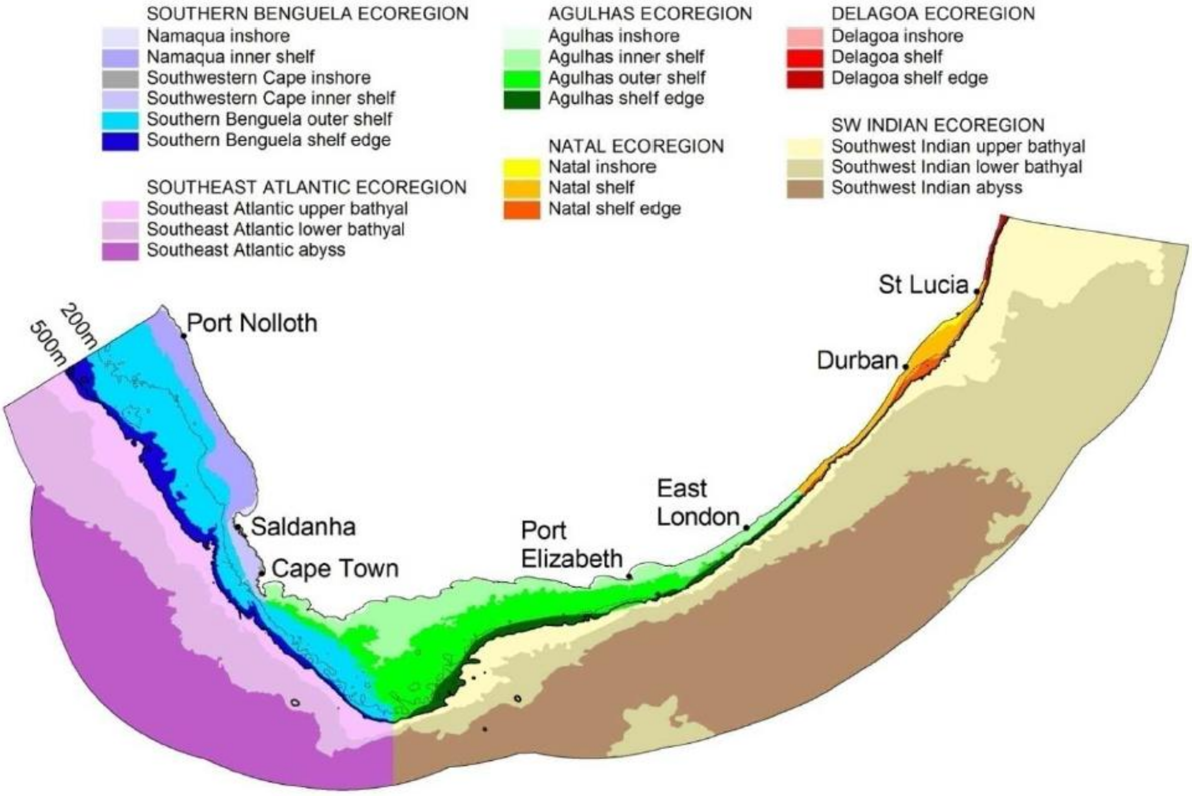

Figure 5: Six marine ecoregions with 22 ecozones incorporating biogeographic and depth divisions in the South African marine environment as defined by Sink et al. (2011).

Ecology

2.4. Sandy beaches

Intertidal sandy beaches are very dynamic environments. The faunal community composition is largely dependent on the interaction of wave energy, beach slope and sand particle size (beach morphodynamics). Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993). Dissipative beaches are wide and flat with fine sands and high wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy along a broad surf zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches have low wave energy, and are coarse grained (>500 µm sand) with have narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch and Griffiths 1988; Field and Griffiths 1991).

The sandy beaches of the Southern Benguela Ecoregion are exposed to high energy waves with the exception of a few small sheltered bays (Bally 1987). The main inputs of food to the sandy beaches in this system are upwelling-related coastal phytoplankton and kelp detritus (Bally 1987). The biomass values reported for beaches along the southern Benguela coast are some of the highest in the world (Bally 1987).

Sandy beaches have no hard substratum onto which animals and plants can attach. Organisms living here rely on a nutrient source in the form of seaweed detritus which is constantly deposited on the beach together with organic rich froth, or spume (Branch 1981). Sandy beaches are highly dynamic; strong waves scour and erode beaches while gentle waves deposit sand. Sand is typically deposited with offshore winds, and eroded with onshore winds. Relatively few species occur on sandy beaches due to their unstable and harsh nature, but those that do occur are hardy, and well adapted to life in these environments (Branch 1981). Animals living here are, however, offered some degree of protection by being able to burrow into the layers of sand to escape desiccation, overheating and strong waves (Branch 1981). Five groups of organisms are typically found on sandy beaches: aquatic scavengers, aquatic particle feeders, air breathing scavengers, meiofauna (smaller than 1 mm in size), and higher predators (Branch 1981).

Aquatic scavengers feed on dead or dying animals that wash up on the beach and their activity is largely regulated by tides. This group includes species such as *Bullia* (the plough snail), that emerge from the sand as the tide rises and are deposited in the same area in which the waves drop debris and decaying matter. Later they follow the tide down the shore as it recedes to avoid being eaten by terrestrial predators. **Aquatic particle feeders**, such as the sand hopper, occur mostly on the low-shore and feed on small organic particles. The majority of these species migrate up and down the beach with each tidal cycle, such that they remain in the surf zone and can escape avian and terrestrial predators. Sand hoppers are important for the breakdown of washed up seaweed, and are also a major food source for sanderlings and other birds. **Air breathing scavengers** live high on the shore and feed on kelp and other seaweeds that have been washed up, as well as dead and decaying animal matter. These species complete their life cycles out of water, emerge from the sand during low tide when there is less risk of being washed away, and are almost strictly nocturnal to avoid desiccation and predation. **Meiofauna** (organisms < 1mm in size) are by far the most abundant of the animals found on sandy beaches, as their small size enables them to live between sand grains. The two most common groups are nematode worms and harpacticoid copepods. Meiofauna play an important role in breaking down organic matter which is then colonised by bacteria. **Higher predators** which feed on sandy beach organisms include birds, such as African black oystercatchers, White fronted plovers and sanderlings, and fish such as galjoen and white Steenbras (Branch 1981).

Beaches typically comprise three functional zones, namely the surf zone, the beach (intertidal and backshore zones) and the dunes. The diversity and abundance of species has been shown to increase with depth in the **surf zone** of beaches along the Benguela system. A rich outer turbulent zone (10-33m from the shore) supports delicate cnidarians (anemones), tube building polychaetes and amphipods, while the less diverse offshore turbulent zone (3m-5m from the shore) is typified by deep burrowing polychaetes and crustaceans. The poor species diversity and abundance, as well as the presence of the cumacean *Cumopsis robusta* (small crustacean), characterise the inner turbulent zone (0-1m from the shore) of the surf zone. Fish such as galjoen and white steenbras frequent turbulent surf zone waters off the west coast where they swim over submerged beaches at high tide and feed on small crustaceans (Branch 1981). Surf zone habitats, particularly medium to low energy beaches, are in fact widely recognised as important nursery areas for fish, and is even thought to rival that of estuaries in some areas (Clark *et al*. 1996, Lenanton *et al*. 1982, Bennett 1989). The **intertidal zone** of sandy beaches along the coast of the Benguela system can be divided into three zones; the zone of saturation (or the sublittoral fringe), the midshore and the upper drift line (or supralittoral zone). The sublittoral fringe is typified by mysids (*Gastrosaccus* spp.) and scavenging gastropods (*Bullia* spp.), while the midshore region is characterised by isopods (*Eurydice longicornis* and *Pontogeloides latipes*) and a polychaete (*Scolelepis squamata*). The upper drift line is typified by air-breathing amphipods (*Talorchestia*) and giant isopods (*Tylos* spp.), as well as a rich diversity of insects (mostly Coleoptera and Diptera) where large quantities of kelp have been deposited on the drift line.

Sandy beaches are important for the filtering and decomposition of organic matter in sea water. As water percolates down through the sand the organic particles are trapped and decomposed by bacteria, which in turn release nitrates and phosphates that are returned to the sea. Continual flow of water through the sand maintains oxygen levels and aids bacterial decomposition, and thus sandy beaches act as water purifiers (Branch 1981).

2.5. Sandy benthic habitat

The primary food source in near-shore sediments is plankton and detritus, brought in by currents from rocky shores and reefs, and other more productive coastal communities. Faeces, dead individuals and debris from plankton and nekton in the water column as well as detritus, generated by the bottom dwellers themselves as they die, is also present. Bacteria play a major role in decomposition and are an important source of protein on soft-bottom habitats.

Fauna and flora that inhabit the surfaces of subtidal sand are called benthic epifauna, while those that burrow or dig into the soft sediments are called benthic infauna. Soft-bottom subtidal communities are dominated by benthic infauna, with some epifauna present, however sessile or attached forms are virtually absent as there is nothing to attach to (Castro and Huber 1997). The distribution of infauna and the depth at which organisms can live in the substrate is largely dependent on sediment particle size. More porous, larger grained substrates allow greater water circulation through the sediment thereby replenishing the oxygen which is used up during decomposition processes.

Much of the benthic infauna are deposit feeders which either ingest sediments and extract organic matter trapped between the grains or actively collect organic matter and detritus (Castro and Huber 1997). Many species of polychaetes and worms are deposit feeders. Peanut worms (Sipunculida) gather detritus using tentacles at the mouth of an elongate, tubular anterior process that can be squeezed out by muscular contraction and then retracted (Branch *et. al*. 1994).

Suspension feeders eat drifting detritus and plankton from the water column (Castro and Huber 1997). Some suspension feeders are filter feeders which actively pump and filter water to obtain suspended particles. These include clams as well as species of amphipods and polychaetes. Other suspension feeders lift arms, tubes, branches or polyps vertically into the water column to catch suspended particles.

Predators in soft bottom habitats may burrow through sediments to get to their prey or catch it on the surface (Castro and Huber 1997). Predators such as crabs, hermit crabs, lobsters and octopuses, which inhabit rocky areas, may move to sandy benthos to feed (Castro and Huber 1997). Most bottom-dwelling fish in soft bottom habitats are predators. Rays and skates scoop up clams, crabs and other infauna and epifauna, while flat fishes, such as flounders and soles, lie camouflaged or covered on the bottom and forage for a wide variety of prey.

2.6. Rocky reefs and kelp forests

Temperate rocky reefs are found below the low water mark (i.e. are always completely submerged) and are known to support diverse assemblages of life. Disturbance from wave action and sedimentation result in a high turnover of competitors in these habitats. Many large predators such as fish and sharks are attracted to rocky reefs, and thus form an important component of these ecosystems (Barros *et al*. 2001). Rocky reef communities also influence the abundance and distribution of benthic macrofauna in adjacent soft bottom habitats, and it has been found that more benthic species occur close to rocky reefs (Barros *et al.* 2001). Thus many reef-associated fish and crustaceans not only forage directly on the reef but also on the adjacent sandy bottom areas.

The following generic description of subtidal, west coast rocky reef is largely based on information provided by Branch *et al*. (2010) and Meyer and Clark (1999). Rocky reefs provide substratum to which kelp (*Ecklonia*) can attach, and these large kelp forests provide food and shelter for many organisms. Light is the limiting factor for plant growth, and thus kelp beds only extend down to approximately 10 m depth. Many other algal species live underneath the floating canopy of kelp, especially inshore where the light is abundant and the water shallow. A sub-canopy of *Lamanaria* grows beneath the *Ecklonia* in deeper waters (Figure 6), and dense communities of mussels, sea urchins, and rock lobster live between the *Lamanaria*. Growing epiphytically on these kelps are the algae *Carradoria virgata*, *Suhria vittata* and *Carpoblepharis flaccida*. Representative under-storey algae include *Botyrocarpa prolifera*, *Neuroglossum binderianum*, *Botryoglossum platycarpum*, *Hymena venosa* and *Epymenia obtusa*, various coralline algae. The dominant grazer is the sea urchin *Parechinus angulosus*, with lesser grazing pressure from limpets, the isopod *Paridotea reticulata* and the amphipod *Ampithoe humeralis*. Herbivores occurring in the kelp forests include the kelp limpet *Patella compressa* which lives on the stipes of the kelp (Branch 1981). West coast rock lobster, *Jasus lalandii*, and *Octopus vulgaris* are two of the most important carnivores that occur within kelp forests in the Groenriviersmond area. Other kelp forest predators include the starfish *Henricia ornata*, various feather and brittle stars (Crinoidea & Ophiuroidea, Echinodermata), *Nucella* spp. and *Burnupena* spp. gastropods. Fish species likely to be found in the kelp beds off Lamberts Bay include hottentot *Pachymetopon blochii* (Figure 6), two-tone fingerfin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis,* milk fish *Parascorpis typus*, rock suckers *Chorisochismus dentex* and the catshark *Haploblepharus pictus* (Branch *et al*. 2010).


Figure 6: Left – *E. maxima* kelp forest with *L. pallida* sub-canopy and Hottentot (*Pachymetopon blochii*). Right – sandy anemones (*Bunodactis reynaudi*), a typical west coast shallow reef species.

Kelp washed ashore forms an important food source for scavengers and provides shelter for numerous isopods (sea lice), which are in turn preyed upon by birds. Filter feeders such as mussels, red bait and sea cucumbers comprise 70-90% of the faunal community on rocky shores and their principal food source is kelp (Branch et al. 2010). Kelp thus forms an integral part of the rocky shore and sandy beach ecosystems. Kelp also produces large quantities of mucus, which encourages bacterial growth upon which protozoa feed.

Figure 7: Horned isopods, *Deto echinata*, feeding on drift cast kelp *Ecklonia maxima.*

2.7. Rocky shore

Rocky shores can be divided into distinct bands according to the amount of time each is exposed to the air, which in turn influences the organisms that inhabit each section of the shore. Species that are more tolerant to desiccation (drying out) are found near the high-water mark, while those that cannot tolerate long periods of water recession are found near the low-water mark. There are five distinct zones that are typically found on rocky shores. These zones (moving in a landward direction) are named the Infratidal zone, the Cochlear zone, the Lower Balanoid zone, the Upper Balanoid zone and the Littorina zone. A further influencing factor on the distribution of organisms on the rocky shore is the degree of exposure to wave action, with significant differences noted between sheltered and exposed areas (Bustamante et al. 1997).

The Infratidal zone is inhabited by species which cannot withstand long periods of exposure and includes thick algal beds of kelp, *Gigartina, Champia lumbricalis* and articulated corallines interspersed with sea urchins (*Parechinus*) and the invasive black mussel, *Mytilis galloprovincialis*. The large limpets, *Scutellastra argenvillei* and *Cymbula granatina*, form dense stands which extend up into the cochlear zone effectively replacing *S. cochlear* which are somewhat rare in the region. *Octopus vulgaris*, and various species of fish, known as “klipvis” in South Africa, are found in subtidal rock pools where they prey upon bivalves and other invertebrates.

Above the Cochlear zone is the Lower Balanoid, where the limpet *S. granularis*, winkles (*Oxystele tigrina* and *O. variegata*) and whelks (*Burnupena spp.*) are found. The black mussel, *M. galloprovincialis*, also extends into this zone and competes for space with *Gunnarea gaimardi*, the Cape reef worm. Little seaweed occurs within this zone, however some sea lettuce (*Ulva*) is present and there are scattered patches of the encrusting brown alga, *Ralfsia verrucosa*. The upper Balanoid zone is dominated by animals, in particular limpets and barnacles. The harshest of all is the Littorina zone, which is dominated by the snail *Afrolittorina knysnaensis* and the flat-bladed alga *Porphyra capensis* (Branch 1981).

The diversity of intertidal macroalgal species is relatively low in the region (Bustamante et al. 1997). Filter feeders such as mussels and the Cape reef worm comprise ~70% of the faunal community on rocky shores and their principal food source is kelp particulates together with various microorganisms, kelp spores, phytoplankton and other fragments of organic matter (du Toit & Attwood 2008). An ecological assessment of the rocky shore at each of the proposed gully intake sites was conducted in order to assess the importance of the area for rocky intertidal biodiversity conservation.

3. METHODOLOGY

Field Survey

3.1. Survey methods

The six proposed gully seawater intake sites (Figure 2) were divided into preferred sites, i.e. potentially impacted, and lesser preferred sites, i.e. controls. This prioritisation was undertaken during the field survey in consultation with Bergstan Africa Development Engineers. The preferred sites included KMM1, KMM4 and KMM6. The lesser preferred sites included KMM2, KMM3 and KMM5. At each of the proposed gully seawater intake sites, intertidal biota were surveyed within the gully itself (sheltered) and on the adjacent open coast (exposed). The presence and relative abundance of each species was noted. Estimates of relative abundance for mobile fauna (numbers of individuals) and sessile fauna and flora (percentage primary cover) were made according to the following categories:

- Mobile fauna (numbers of individuals): 1 = Rare, 1-10 = Common, 10-100 = Abdundant, >100 = Very Abundant.

- Sessile fauna and flora (percentage primary cover): 1% = Rare, 5-10% = Common, 10-50% = Abdundant, >50% = Very Abundant.

This method is non-destructive (no biota were removed from the shore) and small infaunal species living in the complex matrix of dense mussel beds (e.g. polychaetes, amphipods, isopods) are thus not recorded. Each study site was photographed at spring high tide and spring low tide in order to assess the amount of sea water available for abstraction (Figure 16 and Figure 17). A brief subtidal assessment of each gully was made on snorkel – observational notes were made on the presence and relative abundance of west coast rock lobster (WCRL) *Jasus lalandii*, and any other subtidal organisms not detected in the intertidal survey (Figure 8). The maximum depth at spring low tide was also recorded.

A bird list was compiled at each of the gully clusters surveyed and any terrestrial animals utilising the intertidal zone were noted.

Figure 8: The author taking notes after a subtidal survey on snorkel.

3.2. Data analysis

Understanding changes in benthic diversity is important because increasing levels of environmental stress are generally associated with lower diversity. The presence/absence and relative abundance data collected only allowed for the most basic diversity index to be reported – total number of species (N). A t-test was conducted to test for a statistically significant difference in the mean total number of species observed at the sheltered gully sites versus the mean total number of species observed at the exposed open coast sites.

Similarities or dissimilarities among the intertidal communities surveyed at each of the proposed gully sites were analysed using multivariate analyses with PRIMER 6 (Plymouth Routines in Multivariate Ecological Research). These methods are useful for graphical presentation of the results from data collected during ecological sampling. The principle aim of these techniques is to discern the most obvious patterns in community data. Comparisons between intertidal communities are based on the extent to which they share particular species. Patterns in the data are represented graphically through hierarchical clustering (dendrogram) and multi-dimensional scaling (MDS) ordination techniques. The former produces a dendrogram in which samples with the greatest similarity are fused into groups, and these are successively grouped into clusters as the similarity criteria defining the groups are gradually reduced. MDS techniques compliment hierarchical clustering methods by 'mapping' the sample groupings two-dimensionally in such a way that the distances between samples represent their relative similarities or dissimilarities.

An analysis of similarities (ANOSIM) is carried out on the data to test the statistical significance of differences in community structure among the study sites. The ANOSIM test is a non-parametric test for use on multivariate data based on the principles of permutation and randomization, and is analogous to the parametric analysis of variance test (ANOVA), for univariate data. It tests whether inter-group differences are significantly greater than the variability within groups. In a one-way layout (one-way ANOSIM), the test examines first whether there are differences somewhere among the sites, which is termed a global test. The R-value produced by the ANOSIM test gives an absolute measure of how separated the groups are, on a scale of 0 (indistinguishable) to 1 (all similarities within groups are less than any similarity between groups) (Clarke and Warwick 2001). The R-statistic indicates significant differences among sites where the percentage probability is less than 5% (=0.05). In cases of more than two groups, the global test is followed by pair-wise testing, comparing specific pairs of sites (or groups) to determine where exactly these differences occur.

The contributions of each species to the average dissimilarity between two sites, and to the average similarity within a site, were assessed using a SIMPER (Similarity Percentages) analysis. The taxa were identified, on the basis of which appear to be principally responsible for differences detected in community structure between sites or groups.

Impact Assessment Methodology

Five factors need to be considered when assessing the significance of impacts, namely:

1. Relationship of the impact to **temporal** scales - the temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.
2. Relationship of the impact to **spatial** scales - the spatial scale defines the physical extent of the impact.
3. The severity of the impact - the **severity/beneficial** scale is used in order to scientifically evaluate how severe negative impacts would be, or how beneficial positive impacts would be on a particular affected system (for ecological impacts) or a particular affected party.
   The severity of impacts was evaluated with and without mitigation in order to demonstrate how serious the impact is when nothing is done about it. The word 'mitigation' means not just 'compensation', but includes concepts of containment and remedy. For beneficial impacts, optimization means anything that can enhance the benefits. However, mitigation or optimization must be practical, technically feasible and economically viable.

4. The **likelihood** of the impact occurring - the likelihood of impacts taking place as a result of project actions differs between potential impacts. There is no doubt that some impacts would occur (e.g. loss of vegetation), but other impacts are not as likely to occur (e.g. vehicle accident), and may or may not result from the proposed development. Although some impacts may have a severe effect, the likelihood of them occurring may affect their overall significance.

Each criterion is ranked with scores assigned as presented in Table 1 to determine the overall **significance** of an activity. The criterion is then considered in two categories, viz. effect of the activity and the likelihood of the impact. The total scores recorded for the effect and likelihood are then read off the matrix presented in Table 2, to determine the overall significance of the impact. The overall significance is either negative or positive.

The ***environmental significance*** scale is an attempt to evaluate the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both. The evaluation of the significance of an impact relies heavily on the values of the person making the judgment. For this reason, impacts of especially a social nature need to reflect the values of the affected society.

Table 1: Ranking of Evaluation Criteria

EFFECT	**Temporal Scale**			**Score**
	Short term	Less than 5 years		1
	Medium term	Between 5-20 years		2
	Long term	Between 20 and 40 years (a generation) and from a human perspective also permanent		3
	Permanent	Over 40 years and resulting in a permanent and lasting change that will always be there		4
	Spatial Scale			
	Localised	At localised scale and a few hectares in extent		1
	Study Area	The proposed site and its immediate environs		2
	Regional	District and Provincial level		3
	National	Country		3
	International	Internationally		4
	Severity	**Severity**	**Benefit**	
	Slight	Slight impacts on the affected system(s) or party(ies)	Slightly beneficial to the affected system(s) and party(ies)	1
	Moderate	Moderate impacts on the affected system(s) or party(ies)	Moderately beneficial to the affected system(s) and party(ies)	2
	Severe/ Beneficial	Severe impacts on the affected system(s) or party(ies)	A substantial benefit to the affected system(s) and party(ies)	4
	Very Severe/ Beneficial	Very severe change to the affected system(s) or party(ies)	A very substantial benefit to the affected system(s) and party(ies)	8
LIKELIHOOD	**Likelihood**			
	Unlikely	The likelihood of these impacts occurring is slight		1
	May Occur	The likelihood of these impacts occurring is possible		2
	Probable	The likelihood of these impacts occurring is probable		3
	Definite	The likelihood is that this impact will definitely occur		4

** In certain cases it may not be possible to determine the severity of an impact thus it may be determined: Don't know/Can't know*

Table 2: Matrix used to determine the overall significance of the impact based on the likelihood and effect of the impact.

Likelihood		Effect													
		3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
	1	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	2	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	3	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Prioritising

The evaluation of the impacts, as described above is used to prioritise which impacts require mitigation measures.

Negative impacts that are ranked as being of "**VERY HIGH**" and "**HIGH**" significance will be investigated further to determine how the impact can be minimised or what alternative activities or mitigation measures can be implemented. These impacts may also assist decision makers i.e. numerous **HIGH** negative impacts may bring about a negative decision.

For impacts identified as having a negative impact of "**MODERATE**" significance, it is standard practice to investigate alternate activities and/or mitigation measures. The most effective and practical mitigations measures will then be proposed.

For impacts ranked as "**LOW**" significance, no investigations or alternatives will be considered. Possible management measures will be investigated to ensure that the impacts remain of low significance.

Table 3: Description of Environmental Significance Ratings and associated range of scores.

Significance Rate	**Description**	**Score**
Low	An acceptable impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in either positive or negative medium to short term effects on the social and/or natural environment.	4-8
Moderate	An important impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in either a positive or negative medium to long-term effect on the social and/or natural environment.	9-12
High	A serious impact, if not mitigated, may prevent the implementation of the project (if it is a negative impact). These impacts would be considered by society as constituting a major and usually a long-term change to the (natural &/or social) environment and result in severe effects or beneficial effects.	13-16
Very High	A very serious impact which, if negative, may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts cannot be mitigated and usually result in very severe effects, or very beneficial effects.	17-20

4. RESULTS

4.1. Rocky shore

A total of 43 different taxa were observed during the intertidal survey on the rocky shore – 24 of which are fauna and 19 flora (Table 4). In all cases, except site KMM4, the total number of species recorded was greater on the open coast sites in comparison to the gully sites (Figure 9) with the greatest number of species recorded on the open coast at site KMM5 (31) and the lowest number of species at gully site KMM3 (14). This is supported by the results of a t-test which showed that the mean total number of species recorded at the open coast sites (25) was significantly greater than that recorded at the gully sites (19) - ($t = -3.078$, $df = 10$, $p < 0.05$). However, there appears to be no difference between the preferred (potentially impacted) and lesser preferred (control) gully seawater intake sites in terms of total number of species.

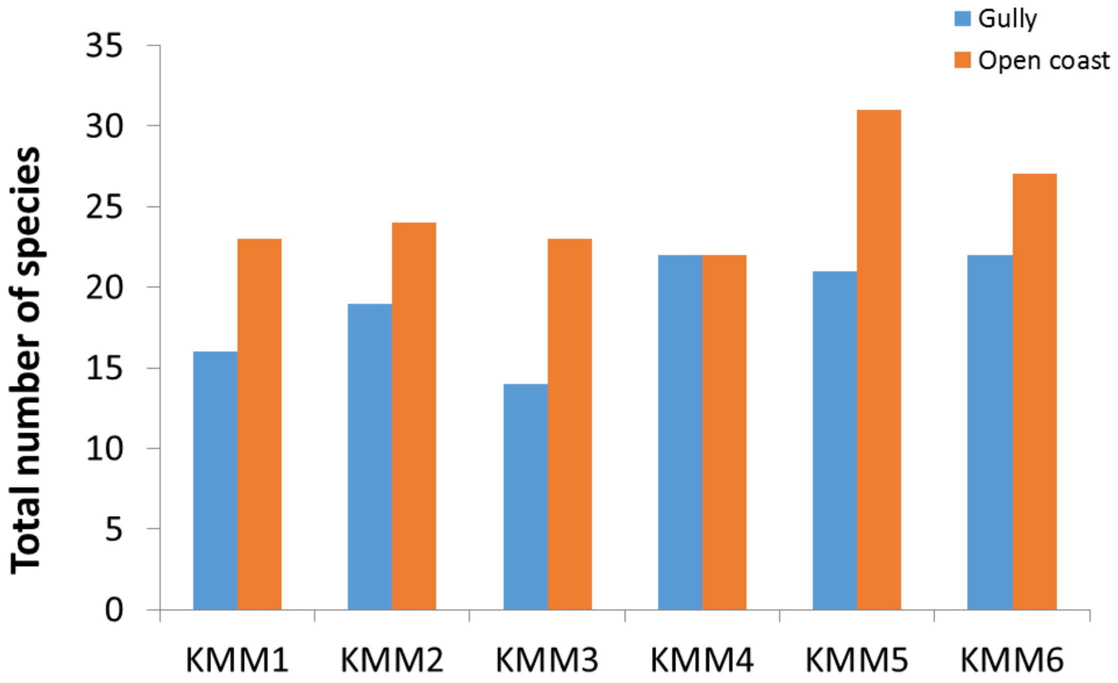

Figure 9: Total number of species recorded at each of the proposed gully seawater intake sites. Note the lower total number of species recorded within the gullies in comparison to that recorded on the open coast sites.

Taking both total number of species and species composition into account, the cluster analysis and dendrogram revealed that indeed there is no significant difference between the potentially impacted and control sites (Figure 10). However, the dendrogram and MDS plot (Figure 11) shows that the study sites are divided into two significant clusters. All the open coast (exposed) sites, apart from KMM5, are clustered together and all the sheltered gully sites, including KMM5, form a separate cluster. Therefore it can be said that the open coast sites are significantly dissimilar from the sheltered gully sites, both in terms of number of species and species composition.

ANOSIM revealed further support for the observed differences between open coast exposed and sheltered gully sites (Global R: 0.781, sig. level 0.2%). SIMPER results show that the average similarity of the open coast sites is 76.57% with a number of species unique to these sites driving this similarity e.g. *S. argenvillei, E. maxima* and *C. lumbricalis* (see Table 4). The other significant cluster, consisting of the sheltered gully sites and KMM5, share an average similarity of 68.52% with their own unique set of species driving similarity e.g. *A. knysnaensis, H. pectunculus* and *O. variegata* (see Table 4).

Table 4: Presence and relative abundance of intertidal fauna (blue text) and flora (green text) at each of the proposed gully seawater intake survey sites – site numbers in red text are those which are considered preferred (potentially impacted), those in black text are lesser preferred (control sites). Key: R = rare, C = common, A = abundant, VA = very abundant.

Species	KMM1		KMM2		KMM3		KMM4		KMM5		KMM6	
	Gully	Open	Gully	Open	Gully	Open	Gully	Open	Gully	Open	Gully	Open
Helcion dunkeri									R	R		
Helcion pectunculus	C		C		C		C		VA	R	A	C
Scutellastra cochlear		R		A			A					
Scutellastra granularis	VA	VA	VA	VA	C	VA	A	VA	VA	VA	VA	VA
Scutellastra argenvillei		A		A		VA		VA		A		A
Siphonaria capensis										A	C	
Oxystele variegata	VA	VA	VA	VA	VA	R	C	R	A	A	C	A
Oxystele tigrina	R		A		R				A	A		
Cymbula granatina	C	A	C	C		C	C	R	A	A	A	A
Parechinus angulosus				R		R				R		
Burnupena spp.	A		C	R	C		R	C	VA	C	A	C
Burnupena papyracea								R				
Octomeris angulosa				A						R		
Tetraclita serrata						R						R
Aulacomya atra		R	R			R	R			R		
Mytilus galloprovincialis		VA	A	VA		VA		VA	C	VA	VA	VA
Choromytilus meridionalis	C				A		C		C		VA	VA
Gunnarea gaimardi	C	VA	A	A		VA	VA	VA	A			A
Sponge		C		R		C		R				R
Affrolittorina knysnaensis	VA		VA		VA		VA		VA	VA	VA	
Anthothoe chilensis			R									C
Aulactinia reynaudi				A			C	R	A	A	A	A
Encrusting bryzoan						R						
Parvulastra exigua					R				C	VA	C	
Ecklonia maxima		VA	R	VA		A	R	C		VA		VA
Laminaria pallida		VA		VA		A				VA	A	VA
Chordariopsis capensis					R		R		R	R	R	R
Porphyra capensis	R				R		R			R	A	C
Aeodes orbitosa	R	R	R	C		C	C	C	A	A	VA	A
Mazaella capensis		R	R	C		C	C	C		A	A	A
Champia lumbricalis		A		VA		A		A		VA		A
Ralfsia verrucosa	R	R	R	R			R		R	VA	R	VA
Splachnidium rugosum		R					C	R		R	R	
Hildenbrandia lecannellieri						R					C	
Pachymenia carnosa												R
Cladophora spp.	R	R	R	R	R	R	R	R	R	R	C	R
Ulva spp.	R	R	C	R	A	R	R	R	A	R	A	C
Encrusting corralline spp.	R	R	C	A	C	A		R	A	A		A
Red foliose algae	R	A			R	C		C	A	A	R	A
Brown foliose algae							C	C				
Cochlear garden		R		R				R				
Upright coralline spp.		R	C	C		R		C		R		R
Red turf		R		R		R	R		R	R		
Number of species	**16**	**23**	**19**	**24**	**14**	**23**	**22**	**22**	**21**	**31**	**22**	**27**

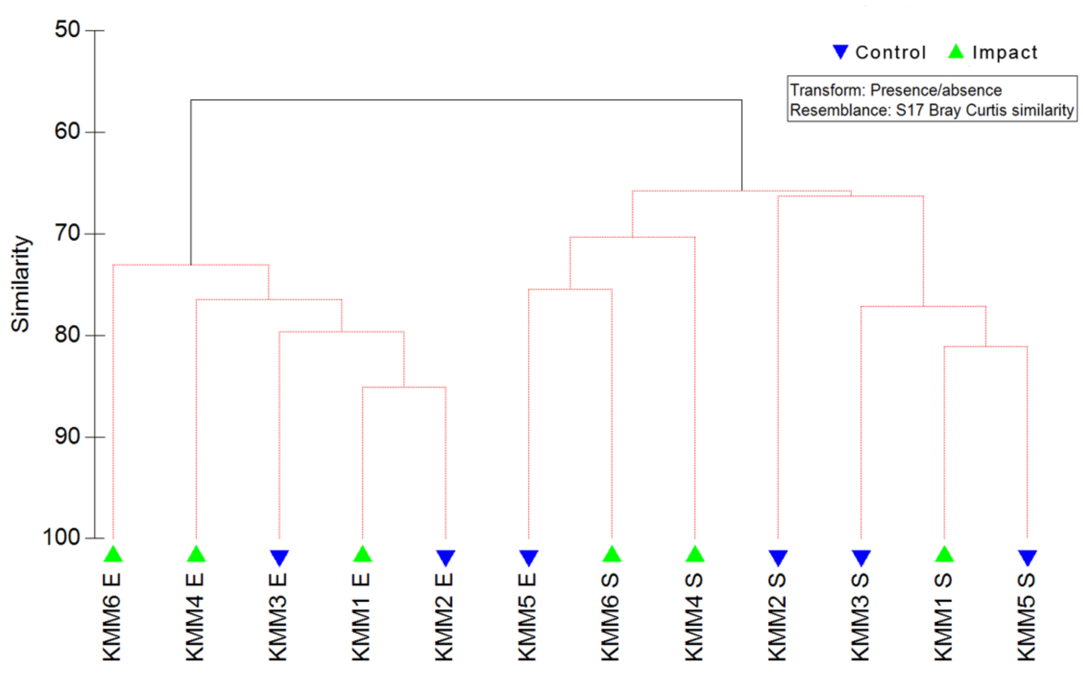

Figure 10: Dendrogram representing the similarity of sites (Bray Curtis Similarity) based on the presence/absence of intertidal rocky shore fauna and flora sampled at gully sites (sheltered – denoted "S") and at open coast sites (exposed – denoted "E"). Preferred (impact) and lesser preferred (control) sites are distinguished with the use of symbols. Clusters of sites significantly similar are represented by the red dotted lines.

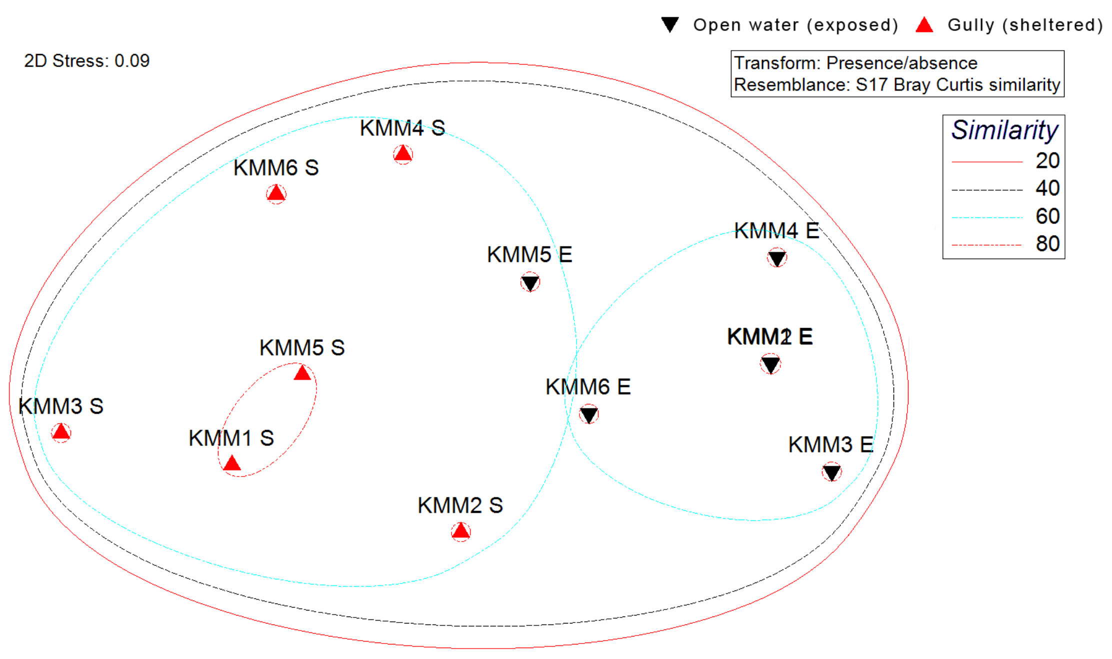

Figure 11: Multidimensional Scaling (MDS) plot based on the presence/absence of intertidal rocky shore fauna and flora sampled at gully sites (sheltered – denoted "S") and at open coast sites (exposed – denoted "E") – also distinguished with the use of symbols. Lines indicate levels of similarity.

The intertidal rocky shore community structure and species composition agrees well with previous findings by Bustamante *et al.* (1997). A large proportion of the biomass present on the low shore, particularly at the open coast sites, was contributed by the kelps *E. maxima* and *L. pallida* and the limpets *C. granatina* and *S. argenvillei*. Large colonies of the polychaete *G. gaimardi* and the alien invasive European black mussel, *M. galloprovincialis*, were also present low down on the shore and extended up into the mid-shore zones. High on the shore *P. capensis* formed dense patches. *B. reynaudii* and *Burnupena spp.* were most frequently encountered in the crevices and gullies. The species most frequently encountered throughout all the zones and at both the gully and open coast sites was *S. granularis*.

The significantly lower mean number of species recorded at the sheltered gully sites can be attributed to the different prevailing physical conditions. These sites are inherently located higher up the shore where organisms are exposed to the air for greater periods of time and have thus adapted to cope with desiccation. In doing so, these organisms have managed to escape the high levels of interspecific competition for resources and space. Therefore a unique suite of organisms characteristic to these high zones on the shore were only present at these sheltered gully sites. They included, *A. knysnaensis, H. pectunculus, O. variegata* and *P. capensis*.

All the taxa recorded in the intertidal zone on the rocky shore (Table 4) are ubiquitous throughout the Namaqua Inshore Ecozone (Branch *et al*. 2010) and are not restricted to this particular area. None of the intertidal rocky shore species observed are considered to be rare or endangered. The subtidal snorkel survey did reveal a few additional species namely; the west coast rock lobster *J. lalandii* (abundant mature adults and recruits observed at every site - Figure 12), various klipvis species (Clinidae), the false plum sea anemone *Pseudactinia flagellifera*, juvenile haarders *Liza spp.*, the starfish *Henricia ornata* and the rocksucker fish *Chorisochismus dentex*.

Figure 12: Mature adult west coast rock lobster, *Jasus lalandii*, were abundant at every gully seawater intake site.

Of the subtidal organisms observed on snorkel, *J. lalandii* is the only species listed on NEMBA (the National Environmental Management Biodiversity Act of 2004) as a threatened and protected species. This means that it is a species of high conservation value or national importance that requires national protection. WCRL are a commercially exploited species and are slow-growing, long-lived animals. Currently the stock is not being adequately managed as the 2012/13 total allowable catch (TAC) was not set in accordance with recommended recovery targets. This is cause for concern in terms of conservation of this important species.

Three bird species were observed at the southern cluster of gully sites in the intertidal zone. These included cormorants (feeding), kelp gull *Larus dominicanu* and white fronted plover *Charadrius marginatus*. A black backed jackal, *Canis mesomelas*, was also sighted in the intertidal zone upon our arrival at the southern cluster.

Eight bird species were observed at the Namaqua wreck cluster. These included *L. dominicanu* (Figure 13), *C. marginatus,* African Black Oystercatcher *Haematopus moquini* (Figure 13), Cape wagtail *Motacilla capensis*, Sanderling *Calidris alba*, Swift tern *Sterna bergii*, White breasted cormorant *Phalacrocorax lucidus* and Cape cormorant *P. capensis*. Cape fur seals, *Arctocephalus pusillus*, were also observed hauling out on the rocks nearby.

Of these species observed, The African Black Oystercatcher, can be highlighted as an important species in terms of its conservation status. It is endemic to southern Africa and is listed as near threatened on the IUCN Red list (Birdlife International 2011). Their range extends from the coastal areas of Namibia to the Transkei (Branch *et al.* 2010). This species forages exclusively in the intertidal zone and they can be found on both rocky and sandy shores throughout the year (Birdlife International 2011). Breeding occurs from September to April, with a peak from November to February. The favoured breeding habitats are offshore islands and sandy beaches; however they do occasionally breed on mainland rocky shores (Birdlife International 2011). Oystercatcher nests are simple scrapes in the sand where possible, but on rocky substrata shells are built up to form a lip or eggs are laid on bare rock. The birds build their nests just above the high water mark (usually within 30 m) and sometimes even below it. Besides being susceptible to high storm or spring tides the nests are situated in the path of vehicles travelling on or just above the HWM (Branch *et al*. 2010). Numerous breeding pairs were observed along the Groenriviersmond coastline, which would suggest that it is an important stronghold for this species.

Figure 13: Birdlife observed at site KMM6. Top: kelp gull, *Larus dominicanus*. Bottom: breeding pair of oystercatchers, *Haematopus moquini* (near-threatened conservation status). Note the beds of the alien invasive black mussel, *Mytilus galloprovincialis* in the foreground.

4.2. Detailed description of proposed gully seawater intake sites

PARK 1

This site is located within the Namaqua National Park and the proposed Namaqua Marine Protected Area (MPA). Development at this site is in contravention of the law (the relevant sections are underlined below). In light of discussions surrounding these issues, it was understood prior to the site visit, that this gully option be omitted from the survey.

Section 4 of the National Parks Act 57 of 1976:

"Object of a Park
The object of the constitution of a park is the establishment, preservation and study therein of wild animals, marine and plant life and objects of geological, archaeological, historical, ethnological, oceanographic, educational and other scientific interests and objects relating to the said life or the first-mentioned objects or to events in or the history of the park, in such a manner that the area which constitutes the park shall, as far as may be and for the benefit and enjoyment of visitors, be retained in its natural state."

Section 43 of the Marine Living Resources Act:

"Marine protected areas
43. (1) The Minister may, by notice published in the Gazette, declare an area to be a marine protected area—
(a) for the protection of fauna and flora or a particular species of fauna or flora and the physical features on which they depend;
(b) to facilitate fishery management by protecting spawning stock, allowing stock recovery, enhancing stock abundance in adjacent areas, and providing pristine communities for research; or
(c) to diminish any conflict that may arise from competing uses in that area.

(2) No person shall in any marine protected area, without permission in terms of subsection (3)—
(a) fish or attempt to fish;
(b) take or destroy any fauna and flora other than fish;
(c) dredge, extract sand or gravel, discharge or deposit waste or any other polluting matter, or in any way disturb, alter or destroy the natural environment;
(d) construct or erect any building or other structure on or over any land or water within such a marine protected area; or
(e) carry on any activity which may adversely impact on the ecosystems of that area.

(3) The Minister may, after consultation with the Forum, give permission in writing that any activity prohibited in terms of this section may be undertaken, where such activity is required for the proper management of the marine protected area."

Proclamation of the Namaqualand MPA is on the Department of Environmental Affairs' workplan agenda for 2014 (pers. comm. Dr. Kerry Sink, SANBI). Furthermore the Systematic Marine Biodiversity Plan for the West Coast of South Africa (Majiedt et al. 2013) shows that the proposed MPA falls within a high priority conservation area and is regarded as a Primary Focus Area for Protection. Further findings within this publication state that Namaqualand Inshore Reef, Inshore hard Grounds and Inshore Sandy areas are critically endangered habitat types. Selection of this site for a seawater intake is likely to invoke significant resistance from South African National Parks and the Department of Environmental Affairs and is therefore strongly discouraged.

KMM1

Gully KMM1 a preferred (potentially impacted) site, is favoured because it offers good protection from wave action. However, the maximum depth recorded during low tide was measured at only 1.3m and an extensive rock shelf closes it off to open water during spring low tide, reducing it to a shallow pool (Figure 16 and Figure 18). A significant amount of blasting would be required to deepen this gully and remove the rock barriers to ensure a constant supply of seawater. There is no adjacent sandy beach or sand dunes which would be impacted at this site.

KMM2

Gully KMM2 is a lesser preferred (control) site with maximum depth measured at 1.7 m at spring low tide. It is blocked off to the sea during spring low tide and reduced to a small puddle (Figure 16 and Figure 18). Significant blasting would be required to both deepen it and to ensure a continuous flow of seawater for abstraction. There is no adjacent sandy beach or sand dunes which would be impacted at this site.

KMM3

Gully KMM3 is a lesser preferred (control) site with maximum depth measured at 1.5 m during spring low tide. A rocky barrier closes the mouth off to the sea during spring low tide and it too is reduced to a small puddle (Figure 16 and Figure 18). Significant blasting would be required to both deepen it and to ensure a continuous flow of seawater for abstraction. Given the close proximity to KMM2, it also has no adjacent sandy beach or sand dunes likely to be impacted.

KMM4

Site KMM4 is a preferred (potentially impacted) site with a maximum depth of 2.4 m during spring low tide. This site is favoured because there are no rocky barriers which cut off flow to the open sea during spring low tide (Figure 17 and Figure 19) and therefore a good flow of seawater is maintained throughout the gully. It is also the deepest gully out of all the proposed sites and would be well suited for seawater abstraction. However, some blasting would be required towards the beach-end of the gully as there are some large rocks between the deepest part of the gully and the beach – visible in the background of Figure 19 (top left photograph). A steep reflective beach is adjacent to the south and is largely composed of coarse sediment and dead mussel shells, an environment largely devoid of infauna.

KMM5

Gully KMM5 is a lesser preferred site with a maximum depth of 1.7 m recorded at spring low tide. It is well protected by an outer rock shelf behind which a deep extensive pool exists with good supply of water from the open sea. Shoreward, this leads into a very shallow and well barricaded gully (Figure 17 and Figure 19). The sheltered environment described above is echoed in the community structure of the intertidal biota – the open coast (exposed) survey site being more similar and clustering with the sheltered gully sites (Figure 10). Significant blasting would be required to run a pipeline through this gully to reach the deep outer pool. There is no adjacent sandy beach or sand dunes which would be impacted at this site.

KMM6

Gully KMM6 is a preferred site with a maximum depth of 1.6 m recorded at spring low tide. It is a shallow channel which runs inside of the point of the Namaqua Wreck (Figure 2). At spring low tide the channel dries out completely with only a small trickle connecting the two sides of the point (Figure 14, Figure 17 and Figure 19).

A sandy beach adjoins this proposed site where numerous holes indicate presence of the giant isopod, *Tylos* (Figure 15). As mentioned earlier, many species were utilising the area; eight different species of bird in the vicinity of the Namaqua wreck and Cape fur seals hauling out on the rocks.

Figure 14: Panoramic view of site KMM6 photographed during spring high tide (top) and spring low tide (bottom). Note the disappearance of the channel during spring low tide, the sandy beach in the foreground and in the background the Namaqua Wreck where Cape fur seals were observed hauling out and where many cormorants and kelp gulls were observed roosting.

Figure 15: *Tylos* holes photographed on the sandy beach adjacent to site KMM6 – size AA battery included for purposes of a scale.

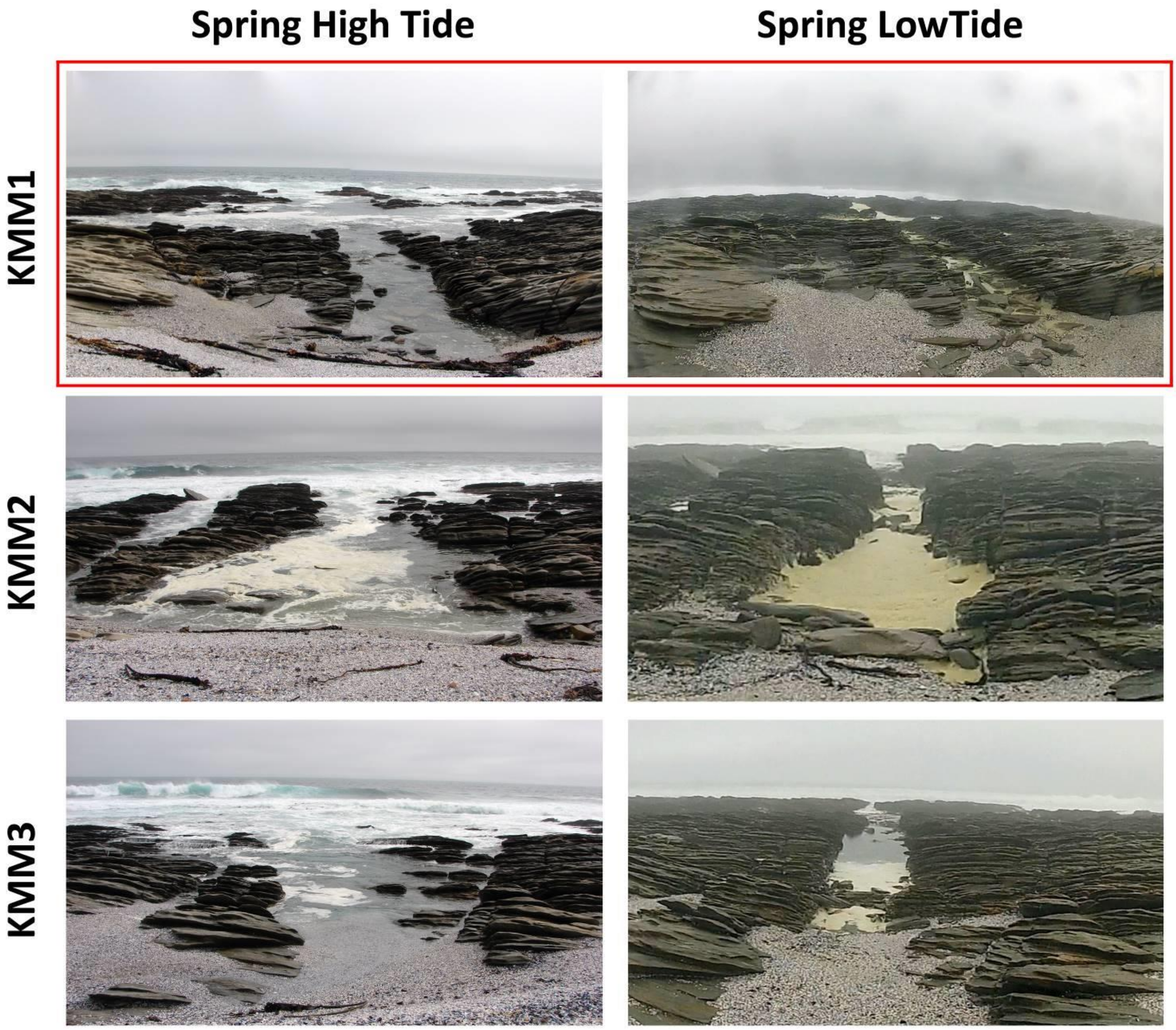

Figure 16: Proposed Gully Seawater Intake Sites KMM1-3 photographed at spring high tide (left) and spring low tide (right). The red box indicates that gully KMM1 is a preferred (potentially impacted) site.

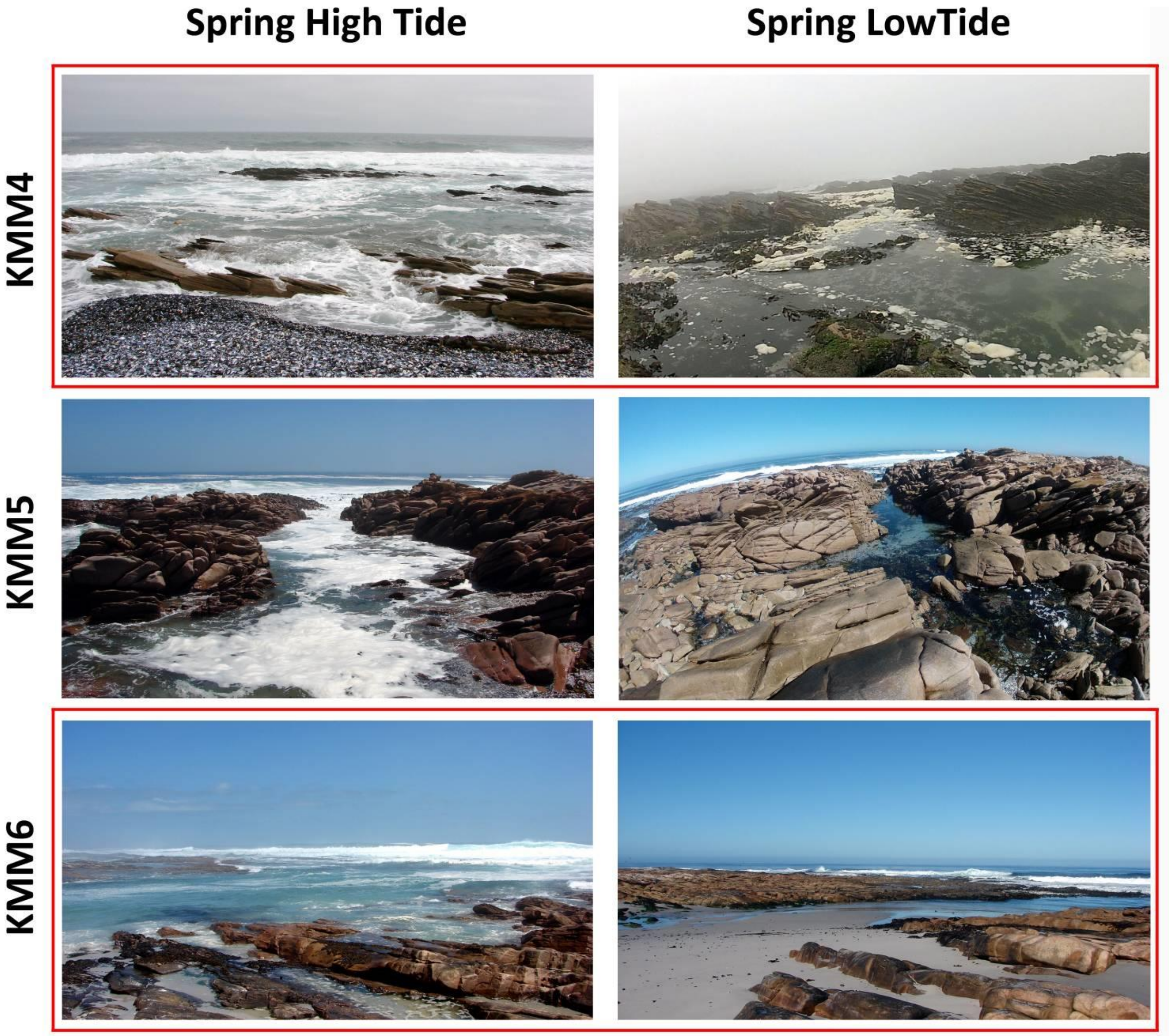

Figure 17: Proposed Gully Seawater Intake Sites KMM4-6 photographed at spring high tide (left) and spring low tide (right). The red box indicates the gullies which are preferred (potentially impacted) sites.

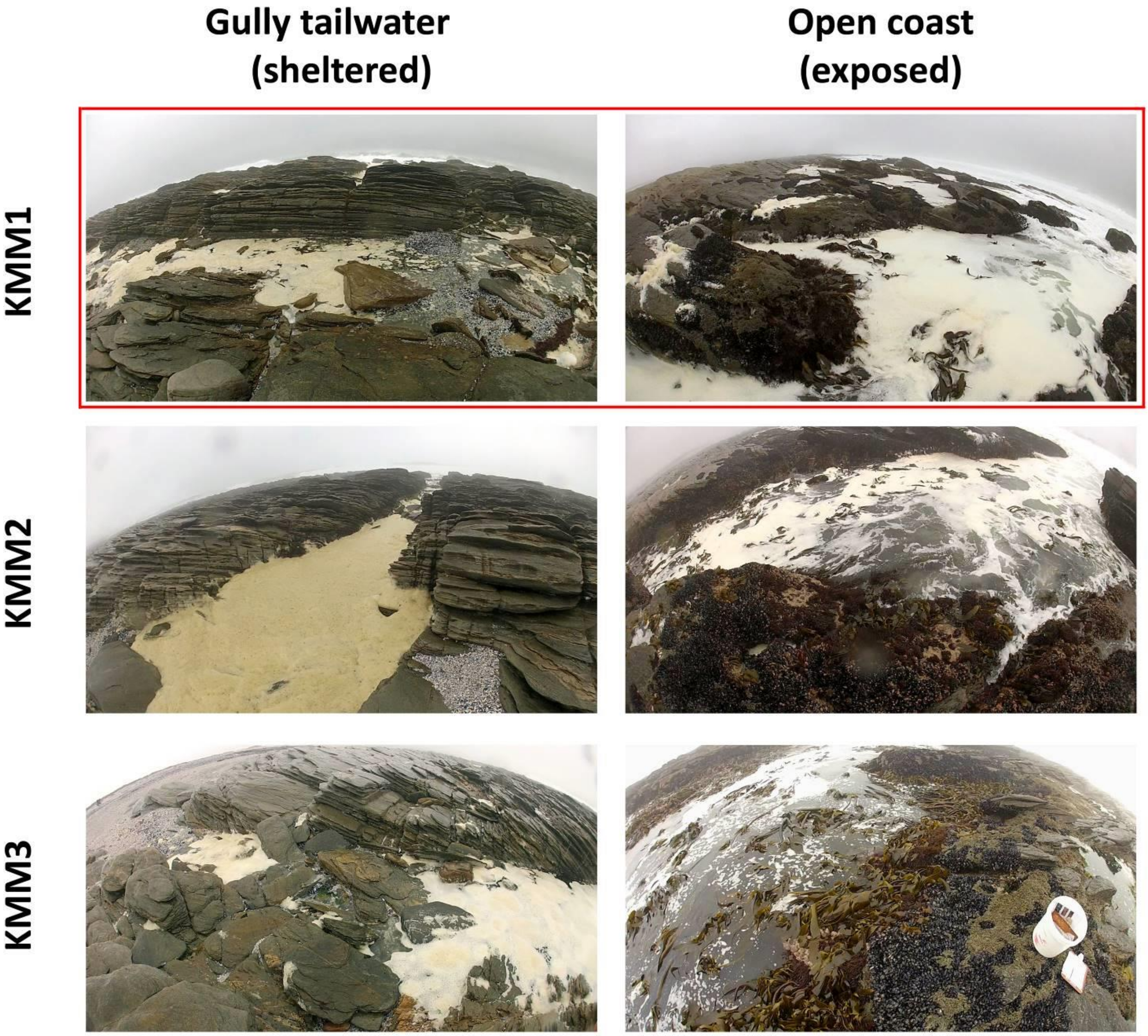

Figure 18: Rocky shore intertidal community composition survey sites KMM1-3. Abundance and diversity of biota is visually lower at sites located within the gullies (left) in comparison to those sites on the open coast (right). The red box indicates those gullies which are preferred (potentially impacted) sites.

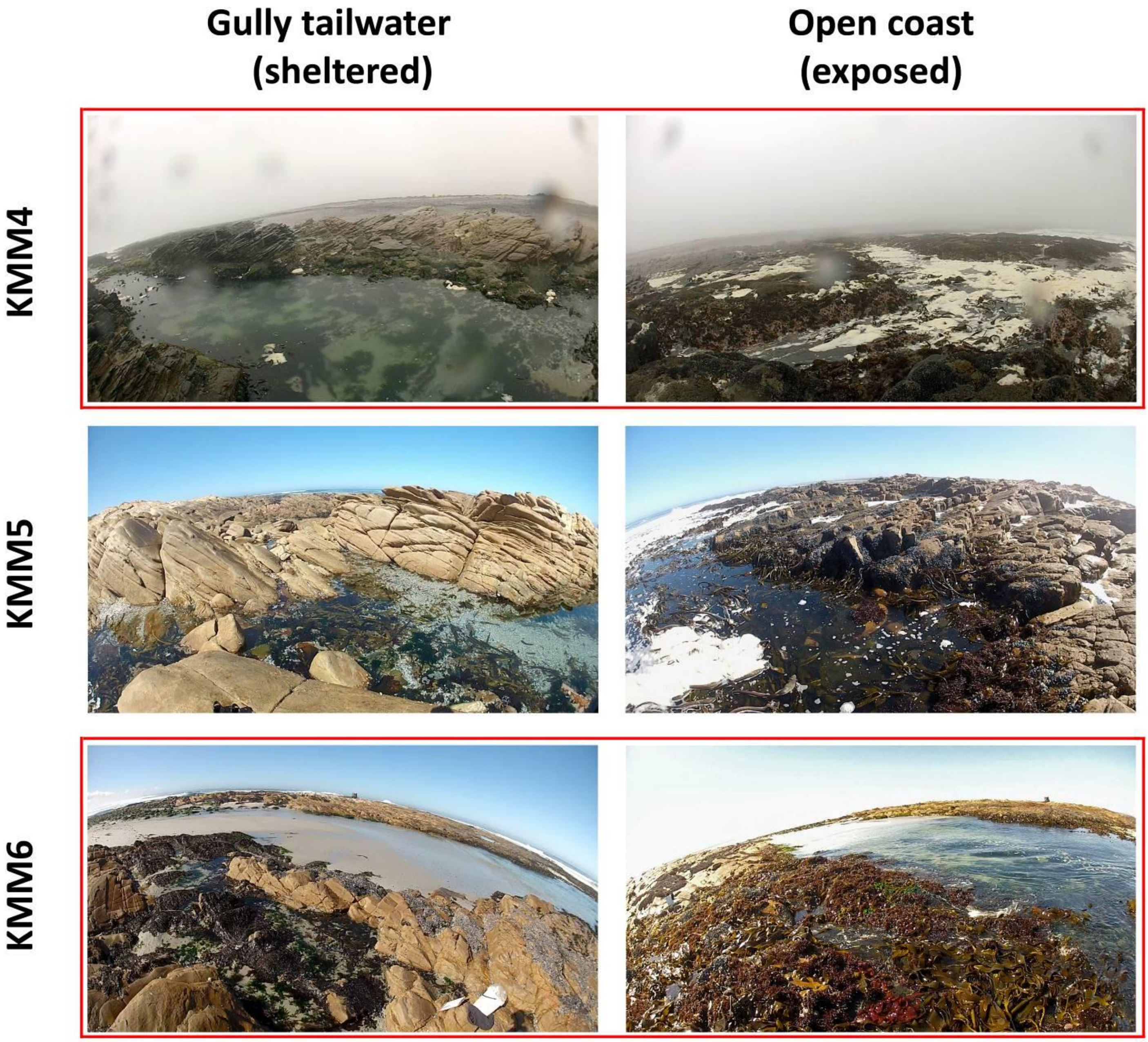

Figure 19: Rocky shore intertidal community composition survey sites KMM4-6. Abundance and diversity of biota is visually lower at sites located within the gullies (left) in comparison to those sites on the open coast (right). The red box indicates those gullies which are preferred (potentially impacted) sites.

5. ASSESSMENT OF POTENTIAL IMPACTS

5.1. Construction phase Marine Environmental Impacts

This chapter details the marine environmental impacts identified by the specialist consultant. For each issue identified, details are provided, followed by the mitigation measures required to minimise the negative impacts associated with the issue. The impact rating methodology used to determine the impacts below is presented in Chapter 3 of this report.

Construction phase

Impact 1: Direct losses of intertidal and infratidal biota in development footprint

Cause and Comment

Constructing an intake pipeline across sub tidal reefs and the intertidal rocky shore will require permanently attaching the pipeline to the substratum in a manner that is sufficiently strong to resist the action of the sea. The use of concrete to cement the pipeline in place is the most feasible option. This will result in the death of all sessile (attached) biota along the pipeline path or in the areas where concrete is placed, disturbance of mobile fauna and habitat alteration.

Significance of Impact

Impact	Effect						**Risk or Likelihood**		**Total Score**	**Overall Significance**
	Temporal Scale		Spatial Scale		Severity of Impact					
Without Mitigation	Medium term	2	Localised	1	Moderate	2	Definite	4	9	MODERATE
With Mitigation	Medium term	2	Localised	1	Slight	1	Definite	4	8	LOW

Mitigation and Management

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.

Impact 2: Barotrauma of marine fauna as a result of blasting

Cause and Comment

The energy of detonating an explosive is released as physical, thermal and gaseous products. The thermal and detonation impacts associated with an explosion are only important to consider near the blast (3 m to 10 m) while the impacts of shockwaves, noise and gaseous chemical products are likely to be experienced at greater distances from the blast. Explosive charges in, adjacent to or beneath a water column produce pressure waves or shockwaves which pass into the water medium. Shockwaves produced by an explosive detonation are "converted suddenly into potential energy of compression and kinetic energy of outward motion in the water medium" (Kramer *et al*. 1968). Shockwaves have harmful and often fatal impacts on organisms with gas cavities, for example swim bladders in fish and sinus cavities and lungs in birds and mammals.

Results of several experiments have shown that underwater blasts can cause lung haemorrhages, gastrointestinal lesions and ruptured eardrums in mammals; pulmonary haemorrhages, coronary air embolisms and ruptured airsacs, eardrums, livers and kidneys in birds (Yelverton *et al*. 1973); and air bladder and intestinal and organ ruptures and broken ribs in fish (Aplin 1947, Yelverton *et al*. 1975, Wright 1982). Marine invertebrates do not possess gas filled cavities and the direct impacts of shockwaves produced by blasting are therefore predicted to be negligible and insignificant. The impacts of underwater blasting on marine fauna are related to the size of the explosion, the type of explosive used and water depth.

Fauna likely to be at risk from blasting activities at the proposed sites include coastal fish species, marine birds, sharks and mammals. The marine habitats in the vicinity of the proposed sites are not unique and are relatively well represented along adjacent sections of coast and are soon to be protected within the Namaqualand Marine Protected Area. The fish kills that are likely to result from the blasts will not result in an irreplaceable loss of resources and will be replenished following recruitment from adjacent areas. A potential problem may arise where several blasts are triggered throughout a particular day as predators (birds, fish and mammals) are likely to be attracted to the area to feed on fish killed by the initial blast. This could be mitigated by limiting blasting activities to one detonation series per day.

Significance of Impact

Impact	Effect						**Risk or Likelihood**		**Total Score**	**Overall Significance**
	Temporal Scale		Spatial Scale		Severity of Impact					
Without Mitigation	Short term	1	Regional	3	Severe	4	Probable	3	11	MODERATE
With Mitigation	Short term	1	Regional	3	Slight	1	Probable	3	8	LOW

Mitigation measures

It is recommended that all blasting be conducted using a rock breaking technology known as NoneX (www.nonex.co.za). This is a non-explosive technology. It is propellant compound encased in a cartridge which reacts very quickly to produce high volumes of harmless gas (nitrogen, carbon dioxide and steam). The cartridge is sealed inside a drilled hole and ignited. High pressure gas is released and enters into the fractures caused by drilling and natural fractures or planes of weakness in the rock. The gas pressure causes the fractures to expand and the rock to split apart. The cartridges do produce a high pressure over a short time frame and so will produce noise. Blasting activities must be limited to one detonation series per day to avoid or reduce the mortality of predators and seabirds attracted to fish kills from previous blasts. The use of NoneX reduces impact significance to LOW.

Impact 3: Impaired water quality impacts to marine fauna

Cause and Comment

Construction activities such as drilling and blasting are likely to generate sediment plumes, which will increase the turbidity of the water and settle on the surrounding seafloor. Another potential source of contamination of the water in the vicinity of the construction site is the potential chemical pollution from the casting of concrete.

The area surrounding the construction site is particularly exposed. It is anticipated that sand particles suspended by drilling and blasting will be readily dispersed with no significant impact on the marine biota. Similarly in the event of exposure of cement directly into the marine environment any chemical pollution is expected to be readily dispersed and as such impacts are expected to be of low significance to the marine biota in the area. The construction activities will involve the use of heavy vehicles and machinery in the coastal zone and there is a potential for hydrocarbon spills. Suitable management mechanisms must be implemented to mitigate this risk and contingency plans in the event of accidental spills must be prepared. This should include measures required to ensure that no storm water from the site be allowed to enter the sea.

Significance of Impact

Impact	Effect						Risk or Likelihood		Total Score	Overall Significance
	Temporal Scale		Spatial Scale		Severity of Impact					
Without Mitigation	Short term	1	Localised	1	Moderate	2	Probable	3	7	LOW
With Mitigation	Short term	1	Localised	1	Slight	1	Probable	3	6	LOW

Mitigation measures

NoneX should be used for all blasting. The NoneX rock breaking process produces a much courser fragmentation when compared to the smaller particles produced by explosives. Furthermore NoneX detonations on land have been reported to produce negligible dust and fumes. The use of NoneX blasting technology will result in the release of gases into the water column. None of the gases produced will be noxious given that the cartridge is oxygen balanced and sufficient oxygen is available to achieve optimal oxidation to produce gases consisting of carbon dioxide, nitrogen and steam.

All fuel and oil is to be adequately stored and no leaking vehicles are to be permitted on site. Contingency plans in the event of an accident must be prepared. Containment of storm water from construction areas is also important.

The casting of cement for attachment of the pipeline should take place within water tight plastic canvas bags supported and shaped within metal frames with shuttering beams.

Impact 4: Litter during construction

Cause and Comment

Large numbers of marine organisms, including fish and marine mammals, are killed or injured by becoming entangled in debris (Wallace 1985), while others, including seabirds, are at risk through the ingestion of small plastic particles (Shomura and Yoshida 1985). All reasonable measures must be implemented to ensure there is no littering by construction workers. During the construction phase of the gully seawater intake pipeline, piping off-cuts and other materials used or bought to site during construction, may enter the sea. 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.

South Africa has laws against littering, both on land and in the coastal zone, but these laws are seldom, if ever, rigorously enforced. The fact that this form of pollution can be obviated is clearly demonstrated by the lack of such material in countries where the laws are strictly adhered to (e.g. Germany and Holland). Objects which have a particular impact on marine fauna include plastic bags and bottles, pieces of rope and small plastic particles (Wehle and Coleman 1983). Large numbers of marine organisms, including fish, birds and marine mammals, are killed or injured by becoming entangled in debris (Wallace 1985) while others, including seabirds, are at risk through the ingestion of small plastic particles (Shomura and Yoshida 1985).

A potential source of such pollution associated with the construction of the gully seawater intake pipeline is that small cuttings of material may exist inside the piping and pumps and will be backwashed out upon start-up of the system. These materials, being largely plastics, may be transported by currents for long distances out to sea or around the coast. Thus, unlike fuel or sewage contamination, the extent of the damage is in theory limitless. The impact on certain forms of marine life by floating or submerged solid materials can hardly be overstressed. Most at risk are seabirds and fish, including possibly rare or even endangered species.

Significance of Impact

Impact	Effect						Risk or Likelihood		Total Score	Overall Significance
	Temporal Scale		Spatial Scale		Severity of Impact					
Without Mitigation	Medium term	2	Regional	2	Moderate	2	Probable	3	9	MODERATE
With Mitigation	Medium term	2	Regional	2	Moderate	2	May Occur	2	8	LOW

Mitigation measures

The following mitigation measures must be taken to avoid or reduce the risk of litter and debris entering the marine environment:

- Inform & empower all staff about sensitive marine species & suitable disposal of construction waste.
- Filter effluent on start-up of plant to remove plastic particles.

5.2. Operational phase Marine Environmental Impacts

Impact 1: Impingement of organisms

Cause and Comment

The impacts of seawater extraction on marine life can include entrainment and impingement. Entrainment occurs when organisms pass through intake structures and into the process equipment. These may include holoplanktonic organisms (permanent members of the plankton, such as copepods, diatoms and bacteria) and meroplanktonic organisms (temporary members of the plankton, such as juvenile shrimps and the planktonic eggs and larvae of invertebrates and fish). Impingement occurs when larger marine organisms are trapped against intake screens by the velocity of the water flow. These organisms may suffer mortality due to starvation, suffocation or exhaustion (UNEP 2008). Although some hardy species may survive impingement, the 24 h survival rate of less robust species is probably less than 15%. The significance of these impacts is related to the location of an intake. Intake structures should be positioned away from sensitive environments or areas with high species diversity or abundance, like rocky reefs, and should not draw in water from the upper few cm of the water column, as planktonic organisms tend to concentrate in this zone.

Impingement and entrainment can also be mitigated through optimal designs to open water intakes. The horizontal extraction of water should aid in reducing fish entrainment as fish have been shown to avoid rapid changes in horizontal flow. The number of mobile organisms becoming entrained in the intake structure and the ability of larger organisms to escape impingement is dependent on the intake velocity. There is a broadly accepted rule that water extraction velocities should be capped at 0.15 m/s to minimize debris and marine life impingement (ASCE 1982, Fredorenko 1991). However this mitigation measure is only effective for mobile organisms which can swim away and not planktonic organisms, which have little or no mobility and drift passively with currents, or organisms that are incapable of sustained mobility against water flow.

Fish and invertebrate eggs and larvae, algal spores, phytoplankton and zooplankton in the vicinity of the intake structure are thus expected to suffer mortality by entrainment. Plankton species have rapid reproductive cycles and are likely to be widespread and abundant in the coastal waters, and thus their ability to sustain their populations should not be impacted by one intake structure. Furthermore the reproductive strategy of many fish and invertebrates is to produce many eggs and larvae of which a large percentage will suffer mortality by natural causes and only a small percentage will reach maturity (UNEP 2008).

Extracting sea water directly from the sea using a pipeline means that the sea water would not be filtered through sediment and may still contain high numbers of marine biota (larvae, macro/micro – fauna etc.) that may foul plant equipment. Increased particles in the water will require increased use of chemicals and biocides in pre-treatment, resulting in increased backwash volumes/intervals and increased negative environmental contamination. Predicted impacts therefore remain of moderate significance.

Significance of Impact

Impact	Effect						**Risk or Likelihood**		**Total Score**	**Overall Significance**
	Temporal Scale		Spatial Scale		Severity of Impact					
Without Mitigation	Long term	3	Localised	1	Severe	4	Probable	3	11	MODERATE
With Mitigation	Long term	3	Localised	1	Slight	1	Possible	2	7	LOW

Mitigation measures

It is recommended that the following mitigation measures be taken to avoid or reduce the impingement of mobile organisms at the intake, thus reducing the impact to low significance:

- Having discussed the optimum intake velocity with the engineers it was agreed that the recommended intake flow may not exceed 0.2 m/s through the installation of an appropriate sized intake structure on the base of the foot valve. The intake structure should be directed such that water flows in a 'horizontal' rather than vertical direction;
- the intake pipes must be positioned at least 0.5 m off the seabed to reduce the intake of sediment and benthic organisms (Fredorenko 1991);
- the intake pipes must be positioned at least 1.4 m below the Mean Low Water Spring Tide mark to reduce entrainment of larvae and most other planktonic marine organisms as these are generally concentrated at or near the surface.

The current design considered in this report indicates that no biocides will be discharged into the marine environment. The seawater will be screened and filtered and all materials used in the system will be selected for robustness to avoid the need for biocides. If fouling occurs and biocides are required the potential impacts of these various options on the water quality and biological communities will need to be assessed and compared. Provided it is mitigated properly, this will not constitute a significant issue.

Decommissioning Phase

It is anticipated that impacts 2, 3 and 4 outlined in the construction phase are likely to be repeated during the decommissioning phase. The same mitigation procedures should be adhered to in order to mitigate as far as possible for any of the impacts discussed above.

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations

The construction of a gully seawater intake system for the Zirco Roode Heuwel (Pty) Ltd heavy mineral deposit mine at either of the gully sites proposed in this report will have a variety of impacts on the marine environment. These include the potential release of debris into the marine environment during and immediately following construction, the entrainment and impingement of organisms during the intake of seawater. The proposed mitigation procedures are well known and have been effectively applied in similar circumstances. If followed the overall effect of the perceived impacts will be significantly reduced.

Based on the results of the field survey, it is apparent that the sheltered gully sites displayed significantly lower biodiversity and abundance of intertidal rocky shore biota in comparison to the open water (exposed) sites – which had significantly greater levels of biodiversity and abundance. Furthermore the benthic biota at these sites is not of great significance in terms of conservation status. This would suggest that perceived impacts of the construction and decommissioning phases of the intake point would be fairly low within any of the proposed gully sites.

In terms of intertidal rocky shore biota, no significant differences were observed between the preferred and lesser preferred gully sites. However, we would recommend that the seawater intake pipe be installed ***at gully site KMM4***, provided that the suggested mitigation procedures are followed. This gully was shown to be the deepest of all those surveyed and would therefore not require as much blasting as the other proposed sites. Furthermore, this site demonstrated good connectivity with the open sea during spring low tide, thus ensuring that seawater can be abstracted at the recommended velocity of 0.15 m/s without risk of drying the gully out. In addition to this the southern gully cluster, in which KMM4 is situated, does not have any adjacent sandy beaches or vegetated sand dunes likely to be impacted.

Site KMM6, a preferred site, should not be considered for construction of the gully seawater intake pipe. The area is more sensitive in terms of its utilisation by birds and mammals. Furthermore, the adjacent sandy beach is a rare piece of habitat in the region and is home to a unique group of infauna. For this reason it is utilized by mammals and sea birds as a place of refuge and a foraging area. There are also vegetated sand dunes above the High Water Mark, which is threatened habitat where any disturbance should be discouraged. This is the only site where the substrate is covered in fine sand which would present further complications with abstraction of seawater.

Taking into consideration the ecological sensitivity/significance of the various sites, the suitability of each site for construction of a seawater intake was scored from 10 (most suitable) to 1 (least suitable). Table 5 below summarises the results. We conclude that site KMM4 is the most preferred, followed by sites 1, 2, 3 and 5, with the Park Site least favourable.

Monitoring

A biological monitoring survey for this study should be undertaken approximately six months after seawater abstraction commences. If the results from this study indicate that species richness and abundance of biota at stations in close proximity to the intake pipe are within 80% of those recorded during the baseline, prior to the start of abstraction and that there is no indication that the gully is being sucked dry, then no further surveys are required. However, if the change in the biotic communities exceeds levels specified above and/or significant changes are evident at distances of greater than 50 m from the intake point as specified above, monitoring surveys should be repeated at monthly intervals and consideration should be given to reducing the rate of abstraction.

Table 5: Suitability of each site for construction of a gully seawater intake – 10 (most suitable) to 1 (least suitable) – based on an ecological sensitivity/significance score.

Site number	Ecological score (sensitivity/significance)	Criteria
KMM1	6	Relatively low number of species. No adjacent sandy beach or sand dunes. Significant blasting required. Outside national park and proposed MPA.
KMM2	6	Relatively low number of species. No adjacent sandy beach or sand dunes. Significant blasting required. Outside national park and proposed MPA.
KMM3	6	Relatively low number of species. No adjacent sandy beach or sand dunes. Significant blasting required. Outside national park and proposed MPA.
KMM4	8	Average species richness. No adjacent sandy beach or sand dunes. None/small amount of blasting required. Outside national park and proposed MPA.
KMM5	5	High number of species. No adjacent sandy beach or sand dunes. Significant blasting required. Outside national park and proposed MPA.
KMM6	3	Relatively high species richness. Ecologically sensitive adjacent sandy beach and sand dunes. Eight different bird species utilising intertidal zone. Cape fur seals hauling out on the rocks. Legal implications (wreck site). Outside national park and proposed MPA.
Park 1	1	Legal implications (South African National Park). Proposed MPA. High species richness and habitat types critically endangered (Majiedt *et al.* 2013). Ecologically sensitive adjacent sandy beach and sand dunes. Blasting possibly required

7. REFERENCES

Aplin, J.A., 1947. The effect of explosives on marine life. California Fish and Game 34: 53 – 70.

ASCE. 1982. Design of water intake structures for fish protection. Hydraulics Division. American Society of Civil Engineers, New York : 163 p.

Bally, R. 1987. The ecology of sandy beaches of the Benguela ecosystem. South African Journal of Marine Science. 5, 759-770

Barros, F., A. J. Underwood, et al. (2001). The influence of rocky reefs on structure of benthic macrofauna in nearby soft-sediments. Estuarine, Coastal and Shelf Science 52: 191-199.

Bennett, B. A. (1989). The fish community of a moderately exposed beach on the southwestern Cape coast of South Africa and an assessment of this habitat as a nusery for juvenile fish. Estuarine Coastal and Shelf Science 28: 293-305.

Bergstan Africa Development Engineers. 2013. Zirco Roode Heuwel Mine, Northern Cape, South Africa Khnyp Bay. Seawater Intake, Pump Stations and Pipeline cost estimate. Concept Design Report.

BirdLife International (2011) IUCN Red List for birds. Downloaded from http://www.birdlife.org on 18/01/2011.

Bolton, J.J. & Anderson, R.J. 1997. Marine vegetation. In Vegetation of southern Africa. Cowling, R.M., Richardson, D.M. & Pierce, S.M. (Eds.) Oxford: Cambridge University Press. pp. 348-370.

Bolton, J.J., Leliaert, F., De Clerck, O., Anderson, R.J., Stegenga, H., Angledow, H.E. & Coppejans, E. 2004. Where is the western limit of the tropical Indian Ocean seaweed flora? An analysis of intertidal seaweed biogeography on the east coast of South Africa. Marine Biology 144: 51-59.

Branch, G M. 1981. The living shores of southern Africa. Struik Publishers (Pty) Ltd. Cape Town.

Branch, G.M. & C.L. Griffiths 1988. The Benguela ecosystem part V: the coastal zone. Oceanogr. and Mar. Biol. Ann. Rev. 26, 395-486.

Branch, GM. Griffiths CL., Branch ML. and L.E. Beckley (2010). Two oceans a guide to the marine life of southern Africa. Struik Nature, Cape Town.

Brown, A.C. & Jarman, N. 1978. Coastal Marine Habitats. In: Biogeography and Ecology of southern Africa. Werger, M.J.A. and Van Bruggen, A.C. (Eds.) The Hague: W. Junk. pp. 1239-1277.

Bustamante, R.H. & Branch, G.M. 1996. Large scale patterns and trophic structure of southern African rocky shores: the role of geographic variation and wave exposure. Journal of Biogeography 23: 339-351.

Bustamnante, R. H., G. M. Branch and S. Eekhout. 1997. The influences of physical factors on the distribution and zonation patterns of South African rocky-shore communities. South African Journal of Marine Science 18:1, 119-136.

Castro, P. and Huber, M. 1997. Chapter 12: Life on the Continental Shelf. In Marine Biology Second Edition. McGraw-Hill. P. 260-266.

Clark, B.M., B.A. Bennett & S.J. Lamberth 1996. Factors affecting spatial variability in seine net catches of fish in the surf-zone of False Bay, South Africa. Mar. Ecol. Prog. Ser. 131: 17-34.

Clarke, K.R. and Warwick, R.M. 1994. Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. National Environmental Research Council, UK, 144pp.

Du Toit, J. & Attwood, C. 2008. Management plan for the Betty's Bay Marine Protected Area. Prepared for: World Wildlife Fund & the Department of Environmental Affairs and Tourism, Marine and Coastal Management. Coastal and Marine Eco-Tourism Corporation, Roggebaai, South Africa.

Emanuel, B. P., R. H. Bustamante, et al. 1992. A zoogeographic and functional approach to the selection of marine reserves on the west coast of South Africa. South African Journal of Marine Science 12: 341-354.

Engledow, H.R., Bolton, J. & Stegenga, H. 1992. The biogeography of the seaweed flora of Namibia. In Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa. Mshingeni, K.E., Bolton, J.J., Critchley, A.T. and Kiangi G. (Eds.) Windhoek. pp. 85-97.

Fedorenko , A.Y. 1991. Guidelines for minimizing entrainment and impringement of aquatic organisms at marine intakes in British Columbia. Can. Manuser. Rep. Fish. Aquat. Sci. 2098 E: 86p.

Field, J.G. and C.L. Griffiths 1991. Littoral and sublittoral ecosystems of southern Africa. In: A.C. Mathieson and P.H. Nienhuis (eds). Ecosystems of the World 24. Intertidal and Littoral Ecosystems, Elsevier Science Publishers, Amsterdam.

Lenanton, R.C.J., A.I. Robertson, & J.A. Hansen. 1982. Nearshore accumulations of detached macrophytes as nursery areas for fish. Mar. Ecol. Prog. Ser. 9: 51-57.

Lombard, A.T., Strauss, T. , Harris, J., Sink, K., Attwood, C. & Hutchings, L. 2004. South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 4: Marine Component. Pretoria: South African National Biodiversity Institute. (www.sanbi.org).

Majiedt P, Holness S, Sink K, Oosthuizen A, Chadwick P. 2013. Systematic Marine Biodiversity Plan for the West Coast of South Africa. South African National Biodiversity Institute, Cape Town. Pp 46.

McLachlan, A., Jaramillo, E.., Donn T.E. and F. Wessels. 1993. Sandy beach macrofauna communities and their control by the physical environment: a geographical comparison. J. coastal Res. Spec. Issue 15, 27-38.

Meyer, W and BM Clark 1999. - Description of the environment of the South African west coast marine diamond mining concession 'a'. Anchor Environmental Consultants report compiled for Sue Lane & Associates and Robin Carter for use in the compilation of Environmental Management Programmes, to be instituted by individual concession holders.

Sink, K.J. 2001. A hierarchical analysis of abiotic determinants and harvesting impacts in the rocky intertidal communities of KwaZulu-Natal. Ph.D. Thesis. University of Cape Town.

Shomura, R. S . and H. 0. Yoshida (editors). 1985. Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, Hawaii. U.S. Dep. Comer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC

Stegenga, H. & Bolton, J.J. 1992. Ceramiaceae (Rhodophyta) of the Cape Province, South Africa: Distribution in relation to concepts of marine provinces. Botanica Marina 35: 99-107.

Turpie, J.K., Beckley, L.E. & Katua, S.M. 2000. Biogeography and the selection of priority areas for the conservation of South African coastal fishes. Biological Conservation 92: 59-72.

UNEP 2008. Deslaintion Resources and Guidance Manual for Environmental Impact Assessments. United Nations Environment Programme, Regional Office for West Asia, Manama, and World Health Organisation, Regional Office for the Eastern Mediterranean, Cairo.

Wallace, N. 1985. Debris entanglement in the marine environment: a review. pp. 259-277. *In*: R.S. Shomura and H.O. Yoshida (eds.), Proceedings of the Workshop on the Fate and Impact of Marine Debris. November 27-29, 1984. Honolulu, Hawaii. US Dep. of Comm., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-54.

Wehle, D. H. S . and Coleman, F. C. 1983. Plastics at sea. Natur. Hist. 92(2):20-26.

Wright, D.G. 1982. A disscussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories. Canadian Tech. Rpt Fish. Aquatic Sci. 1052: 1 - 16

Yelverton, J.T., Richmond, D.R., Fletcher, E.R. and Jones, R.K. 1973. Safe distances from underwater explosions for mammals and birds. Defense Nuclear Agency, Washington. DNA 3114 T. (cited by Cooper 1995)

Yelverton, J.T., Richmond, D.R., Hick, W., Sanders, K., Fletcher, E.R. and Royce, E. 1975. The relationship between fish size and their response to underwater blast. Defense Nuclear Agency, Washington. DNA 3677 T. (cited by Cooper 1995)

APPENDIX 1:

Study site co-ordinates:

SITE	Date and time	Co-ordinates
Kmm1	28-FEB-14 7:25:57AM	S30 56.658 E17 37.990
Kmm2	28-FEB-14 7:22:49AM	S30 56.677 E17 38.009
Kmm3	28-FEB-14 7:12:43AM	S30 56.688 E17 38.019
Kmm4	01-MAR-14 12:32:35AM	S30 56.718 E17 38.050
Kmm5	01-MAR-14 5:25:48AM	S30 54.666 E17 36.214
Kmm6	01-MAR-14 4:57:01AM	S30 54.975 E17 36.219
Park1	01-MAR-14 7:16:07AM	S30 49.479 E17 33.722