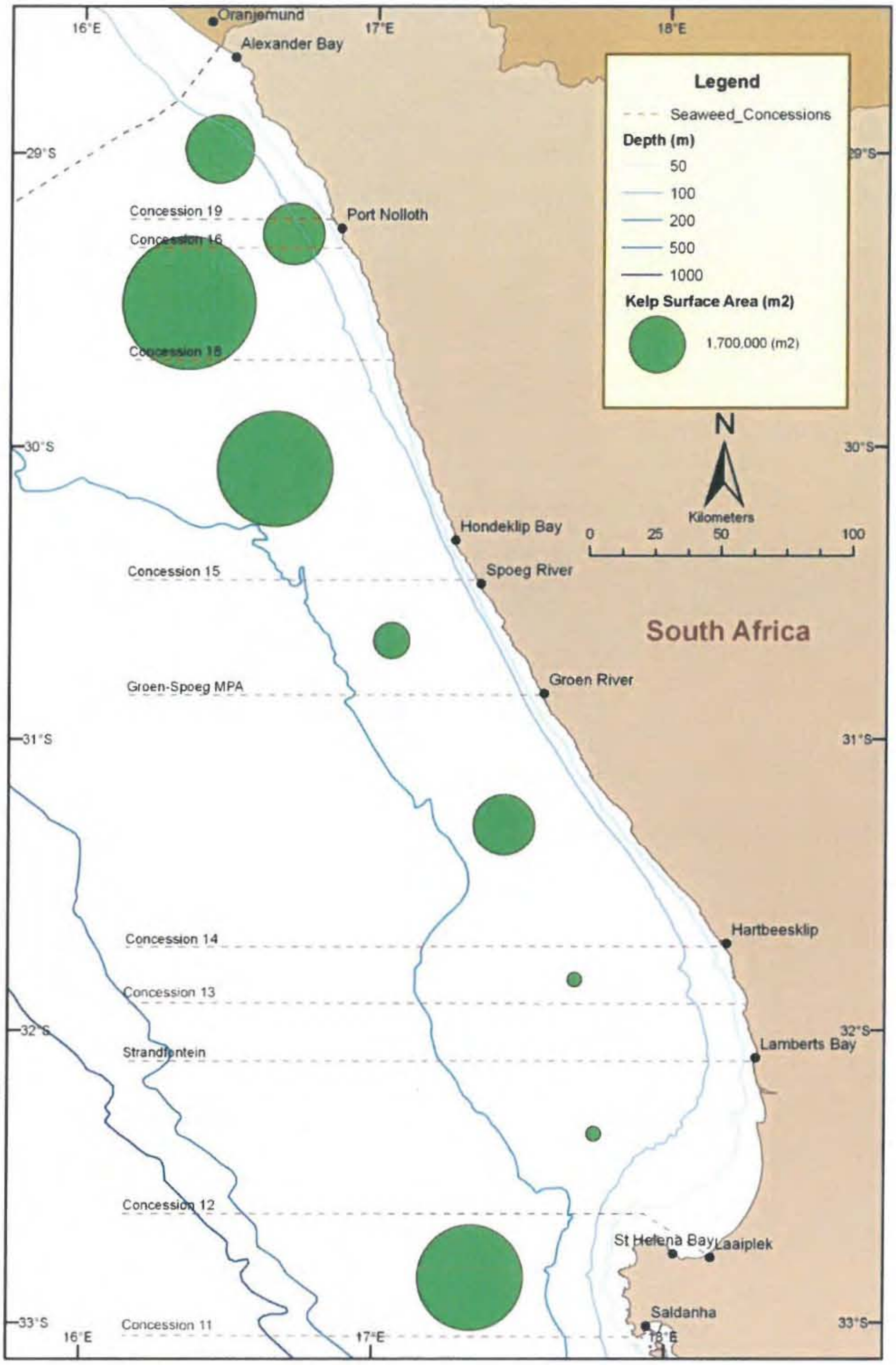

Figure 28: Estimated kelp bed areas in the South African kelp concessions between the Orange River mouth and Cape Columbine (from Penney *et al.* 2007).

Table 4: Beach-cast collections (in kg dry weight) for kelp concessions north of Lamberts Bay. (Data source: Seaweed Section, DAFF).

Concession Number	Concession Holder	2005	2006	2007	2008	2009	2010	2011	2012	2013
13	Eckloweed Industries	65,898	94,914	122,095	61,949	102,925	53,927	40,511	43,297	20,485
14	Eckloweed Industries	165,179	145,670	79,771	204,365	117,136	166,106	72,829	151,561	97,283
15	Rekaofela Kelp	10,300	19,550	0	23,646	0	0	0	160,500	36,380
16	Rekaofela Kelp	35,920	28,600	84,445	16,804	0	0	0	156,000	24,000
18	FAMDA	0	0	0	0	0	0	0	0	0
19	Premier Fishing	0	0	0	0	0	0	0	0	0

Estimates of both kelp bed area and biomass for different stretches of coastline vary considerably depending on the survey method used. The values from Rand (2006) presented in Table 5are used here to illustrate similarities in kelp bed area per kilometre of rocky coast (Kelp Concessions 15, 16 and 18). It must be kept in mind that the values in Table 5are based on kelp beds that reach the surface at low spring tide and do not take into account the extensive *Laminaria* beds that extend into deeper water. As *Laminaria* is the dominant species in Namaqualand, both kelp bed area and biomass are thus likely underestimates of the available standing stock.

Table 5 The estimated total area of kelp beds for each of the kelp concessions between the Orange River mouth and Cape Columbine (Rand 2006).

Kelp Concession/Area	Kelp bed area (ha)	Length of rocky coastline (km)
19	254.95	48.5
18	976.0	18.25
16	206.44	5.0
15	732.22	104.5
Groen-Spoeg	71.94	~15.0
14	206.64	63.75
13	10.8	4.25
Strandfontein	no data	~15
12	15.9	1.25
11	617.95	28.75

Linefishing

Commercial linefishing is conducted from a variety of vessels ranging from large deckboats to tiny rock lobster bakkies, most of which operate very close to the shore. In Namaqualand, the boats belong mostly to the rock lobster fishery, with most of the fishing undertaken during the rock lobster closed season. As with the rock lobster fishery, linefishing effort is centred around the harbours in the area. The main species targeted by the line-fishermen are Snoek, Yellowtail, Hottentot and Galjoen (Sauer & Erasmus 1997). The estimated annual linefish catch on the West Coast is 6,000 tons of which only 10% is contributed from inshore and offshore fishing in the northern regions. Sauer and Erasmus (1997) estimated that the inshore linefish catch along the Northern Cape coast amounts to <5tons/km/yr.

The landings and effort in the linefishery show distinct seasonality, influenced to a large extent by the availability of the target species. Of the species targeted by the linefishery, the Hottentot is available to the fishermen throughout the year. The occurrence of Snoek is more seasonal with the fish being more abundant during late summer and autumn. Yellowtail show a similar seasonality with catches peaking in March/April. Catches of Galjoen are limited to the winter months, there being a closed season from 15 October to the end of February.

Clark *et al.* (2002) identified approximately 330 fishers in the area between Port Nolloth and Doring Bay. The increase in the number of artisanal fishers in the region since the 2002 survey is unknown, but in the interim many of these fishers will have received official recognition and have been granted small scale commercial or "interim relief" rights.

From 2002 to 2004, the Northern Cape provincial government initiated a small scale experimental fishery out off Port Nolloth and Hondeklip Bay which targeted Hake, Kingklip, Snoek, and St Joseph Shark in the near-shore zone (www.northern-cape.co.za).

Recreational Fisheries

Recreational and subsistence fishing on the West Coast is small in scale when compared with the south and east coasts of South Africa. The population density in Namaqualand is low, and poor road infrastructure and ownership of much of the land by diamond mining companies in the northern parts of the West Coast has historically restricted coastal access to the towns and recreational areas of Port Nolloth, McDougall's Bay, Hondeklip Bay and the Groen River mouth.

Recreational line-fishing is confined largely to rock and surf angling in places such as Brand-se-Baai and the more accessible coastal stretches in the regions. Boat angling is not common along this section of the coast due to the lack of suitable launch sites and the exposed nature of the coastline. Fishing effort has been estimated at 0.12 angler/km north of Doring Bay. These fishers expended effort of approximately 200,000 angler days/year with a catch-per-unit-effort of 0.94 fish/angler/day (Brouwer *et al.* 1997; Sauer & Erasmus 1997). Target species consist mostly of Hottentot, White Stumpnose, Kob, Steenbras and Galjoen, with catches being used for domestic consumption, or sold.

Recreational rock lobster catches are made primarily by diving or shore-based fishing using baitbags. Hoop-netting for rock lobster from either outboard or rowing boats is not common along this section of the coast (Cockcroft & McKenzie 1997). The majority of the recreational take of rock lobster is made by locals resident in areas close to the resource. Due to the remoteness of the area and the lack of policing, poaching of rock lobsters both by locals as well as seasonal visitors is becoming an increasing problem. Large numbers of rock lobsters are harvested in sheltered bays along the Namaqualand coastline by recreational divers who disregard bag-limits, size-limits or closed seasons. This potentially has serious consequences for the sustainability of the stock in the area.

3.2.5 Cumulative Impacts

In 1994 the Department of Minerals and Energy established formal diamond-mining concessions covering the continental shelf off the west coast of South Africa between the Orange River mouth and Cape Columbine. The concessions are grouped into Land, Surf-zone and Marine Concession Areas (Figure 29). The marine concession areas are split into four or five zones (Surf zone and (a) to (c) or (d)-concessions), which together extend from the high water mark out to approximately 500 m depth (Figure 30).

Nearshore shallow-water mining is typically conducted by divers using small-scale suction hoses operating either directly from the shore or from converted fishing vessels in small bays and out to ~30 m depth. Diver-assisted mining is largely exploratory and highly opportunistic in nature, being dependent on suitable, calm sea conditions. The typically exposed and wave-dominated nature of the west coast effectively limits the periods in which mining can take place to a few days per month. Sea conditions also control where safe operations can be conducted, as these often have to be in areas with some shelter from waves. As sea conditions vary enormously over small spatial and temporal scales, it is impossible to sequentially mine a concession from one end to the other. While some (typically calmer) sites may be systematically worked out over a sustained period of time, others are repeatedly revisited when conditions permit.

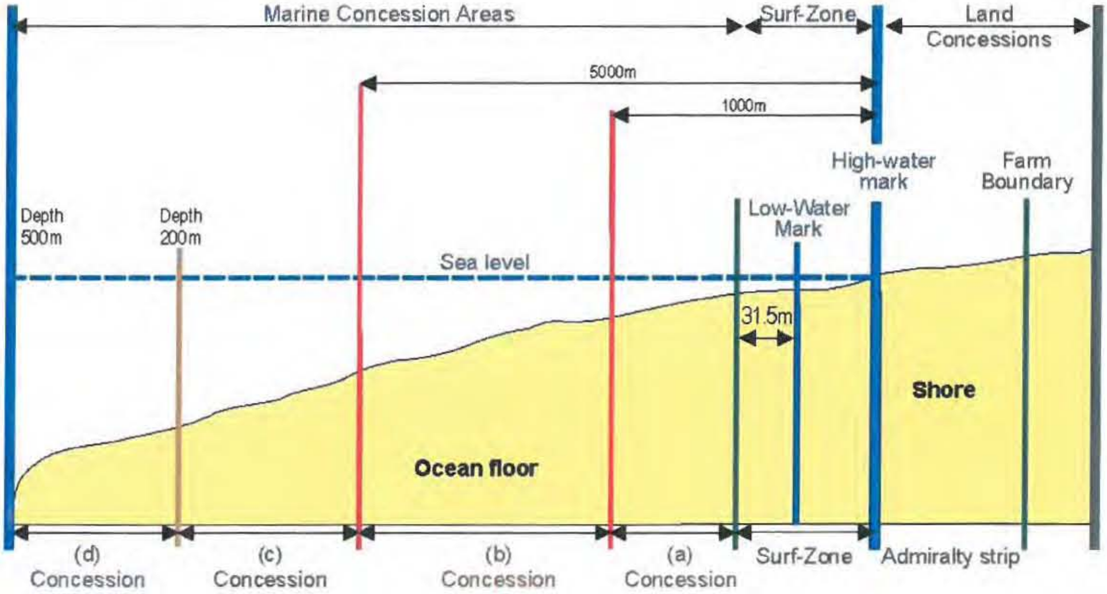

Figure 29: Diagram of the onshore and offshore boundaries of the South African (a) to (d) marine diamond mining concession areas.

As shore-based divers cannot excavate a gravel depth much more than 0.5 m, mining rates are low, being only about 35 m^2 worked by each contractor per year. Because of the tidal cycle and limitations imposed by sea conditions, such classifiers usually operate for less than 4 hours per day for an average of 5-6 days per month, although longer periods may be feasible in certain protected areas.

Vessel-based diver-mining contractors usually work in the depth range immediately seaward of that exploited by shore-based divers, targeting gullies and potholes in the sub-tidal area usually just behind the surf-zone. A typical boat-based operation consists of a 10 - 15 m vessel, with the duration of their activities limited to daylight hours for 3 - 10 diving days per month. Estimated mining rates for vessel-based operations range from 300 m^2-1,000 m^2/yr.

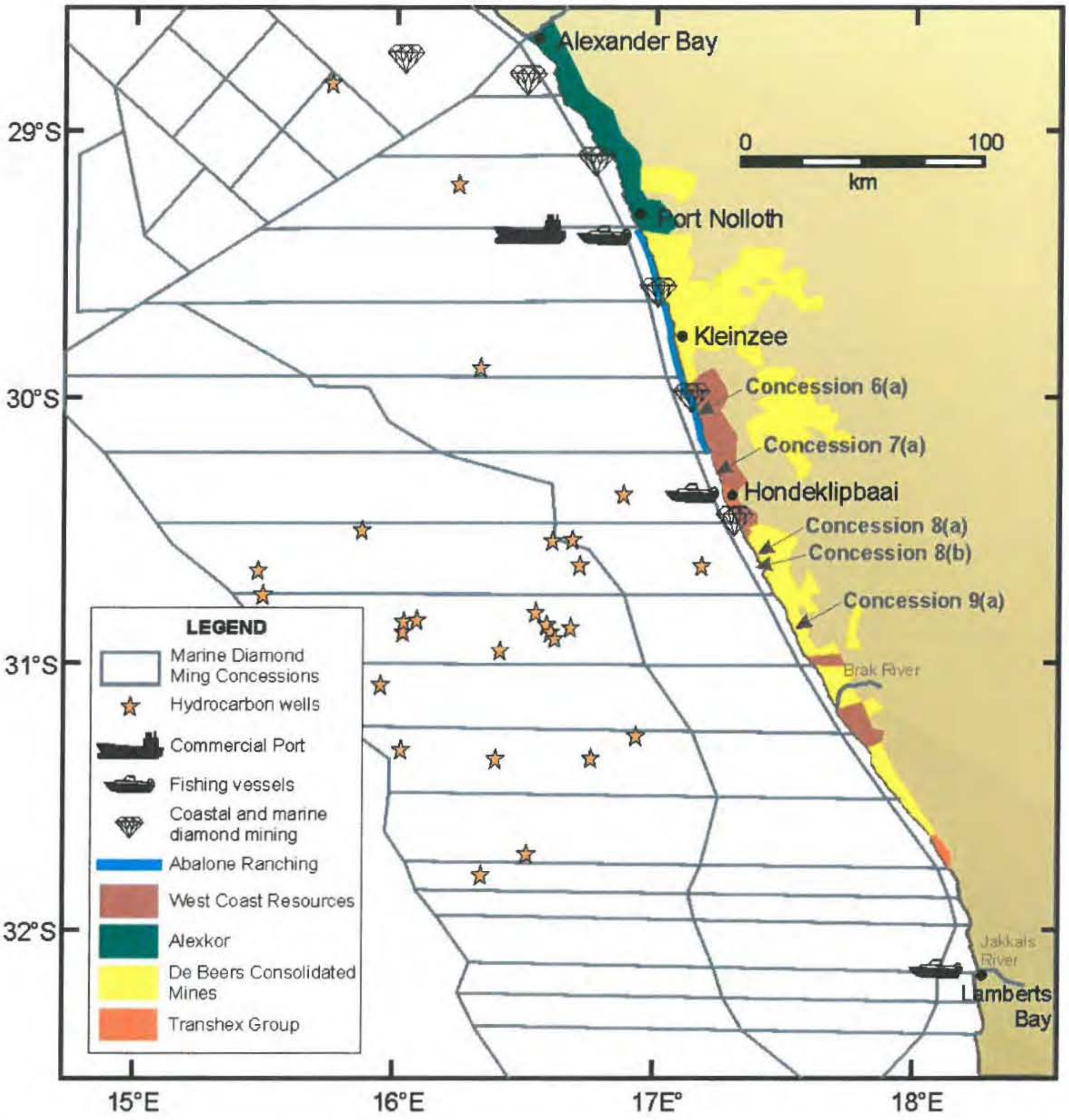

Figure 30: Project - environment interaction points on the West Coast, illustrating the marine diamond mining concessions, the terrestrial concessions held by various mining companies and the experimental abalone ranching area.

3.2.6 Development Potential of the Marine Environment in the Project Area

The economy of the Namaqualand region is dominated by mining. However, with the decline in the mining industry and the closure of many of the coastal mines, the economy of the region is declining and jobs are being lost with potential devastating socio-economic impacts on the region. The Northern Cape provincial government has recognized the need to investigate alternative economic activities to reduce the impact of minerals downscaling and has commissioned a series of baseline studies of the regional economy (Britz & Hecht 1997, Britz *et al.* 1999, 2000, Mather 1999). These assessments concluded that fishing and specifically mariculture offer a significant opportunity for long term (10+ years) sustainable economic development along the Namaqualand coast. The major opportunities cited in these studies include hake and lobster fishing (although the current trend in quota reduction is likely to limit development potentials), seaweed harvesting and aquaculture of abalone,seaweeds, oysters and finfish.

The Northern Cape provincial government is facilitating the development of the fishing and mariculture sectors by means of a holistic sector planning approach and has in partnership with a representative community and industry based Fishing and Mariculture Development Association (FAMDA), developed the Northern Cape Province Fishing and Mariculture Sector Plan. This plan forms part of the 'Northern Cape - Fishing and Mariculture Sector Development Strategy' (www.northern-cape.gov.za, accessed December 2013) whereby implementation of the plan will be coordinated and driven by FAMDA.

Abalone ranching (*i.e.* the release of abalone seeds into the wild for harvesting purposes after a growth period) has been identified as one of the key opportunities to develop in the short- to medium-term and consequently the creation of abalone ranching enterprises around Hondeklip Bay and Port Nolloth forms part of the sector plan's development targets (www.northern-cape.gov.za). In the past, experimental abalone ranching concessions have been granted to Port Nolloth Sea Farms in sea mining areas 5 and 6, effectively a 60-km strip of coastline, and to Ritztrade in the Port Nolloth area (www.northern-cape.co.za). These experimental operations have shown that although abalone survival is highly variable depending on the site characteristics and sea conditions, abalone ranching on the Namaqualand coast has the potential for a lucrative commercial business venture (Sweijd *et al.* 1998, de Waal 2004). As a result, the government publication 'Guidelines and potential areas for marine ranching and stock enhancement of abalone *Haliotis midae* in South Africa' (GG No. 33470, Schedule 2, April 2010) identified broad areas along the South African coastline that might be suitable for abalone ranching.Applications for abalone ranching projects have been submitted and permits for pilot projects for some of the zones have been granted.

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

3.2.7 Threat status and Vulnerable Marine Ecosystems

'No-take' Marine Protected Areas (MPAs) offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) are currently absent northwards from Cape Columbine (Emanuel et al. 1992; Lombard et al. 2004). Rocky shore and sandy beach habitats are generally not particularly sensitive to disturbance and natural recovery occurs within 2-5 years.

However, much of the Namaqualand coastline has been subjected to decades of disturbance by shore-based diamond mining operations (Penney et al. 2007). These cumulative impacts and the lack of biodiversity protection have resulted in many of the coastal habitat types in Namaqualand being assigned a threat status of 'critically endangered' (Lombard et al. 2004; Sink et al. 2012) (Table 6).

Using the SANBI benthic and coastal habitat type GIS database, the threat status of the benthic habitats within Concessions 6a, 7a (Figure 31a), 8a and 8b (Figure 31b) and those potentially affected by proposed beach mining, were identified (Table 6). Although 'vulnerable', 'endangered' and 'critically endangered' habitats occur in the two concessions, the only overlap of note with proposed mining targets is the Namaqua Mixed Shore, which is categorised as 'endangered'. Within Concessions 6a and 7a, this habitat type accounts for ~15.4 km and ~12.3 km of coastline, respectively, of which ~2 km will fall within identified mining targets in 7a. Within the portion of Concession 8a not being relinquished to the proposed MPA, the Namaqua Mixed Shore accounts for ~1.0 km of coastline of which 0.15 km fall within identified mining targets within Mitchell's Bay. Potential loss of this endangered habitat will therefore constitute 16.3% of available Namaqua Mixed Shores habitat in Concession 7a, or 7.3% of the total Mixed Shores habitat in both Concession 6a and 7a.

Table 6: Ecosystem threat status for marine and coastal habitat types in Concessions 6a, 7aand 8a (adapted from Sink *et al.* 2011).

Habitat Type	Threat Status	Occurs in Concessions	Occurs in Mining Targets
Namaqua Boulder Shore	CE		
Namaqua Exposed Rocky Coast	LT	X	X
Namaqua Hard Inner Shelf	LT		
Namaqua Inner Shelf Reef	CE		
Namaqua Inshore Hard ground	CE		
Namaqua Inshore Reef	CE		
Namaqua Island	CE		
Namaqua Mixed Shore	E	X	X
Namaqua Muddy Inner Shelf	LT		
Namaqua Muddy Inshore	V		
Namaqua Sandy Inner Shelf	LT		
Namaqua Sandy Inshore	CE	X	
Namaqua Sheltered Rocky Coast	CE	X	
Namaqua Very Exposed Rocky Coast	V	X	
Southern Benguela Intermediate Sandy Coast	LT	X	X
Southern Benguela Dissipative-Intermediate Sandy Coast	LT	X	X
Southern Benguela Dissipative Sandy Coast	LT	X	
Southern Benguela Reflective Sandy Coast	LT	X	X
Southern Benguela Estuarine Shore	LT	X	

CE = Critically Endangered E = Endangered V = Vulnerable LT = Least Threatened

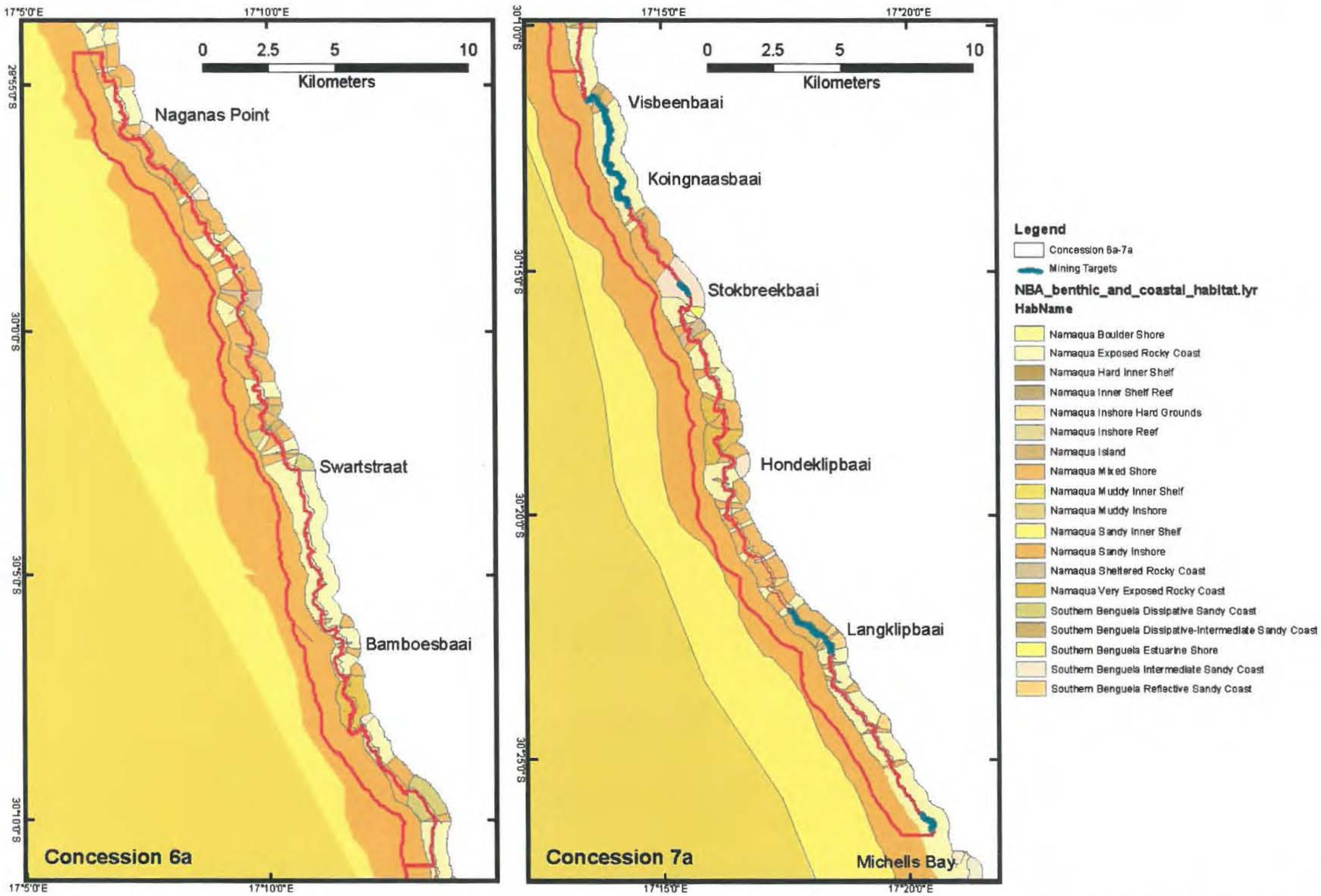

Figure 31a: Concession 6a (left) and 7a(right) in relation to the benthic and coastal habitat types identified by SANBI. The habitats within the concessions and affected by the proposed cofferdam mining operations are identified in Table 6.

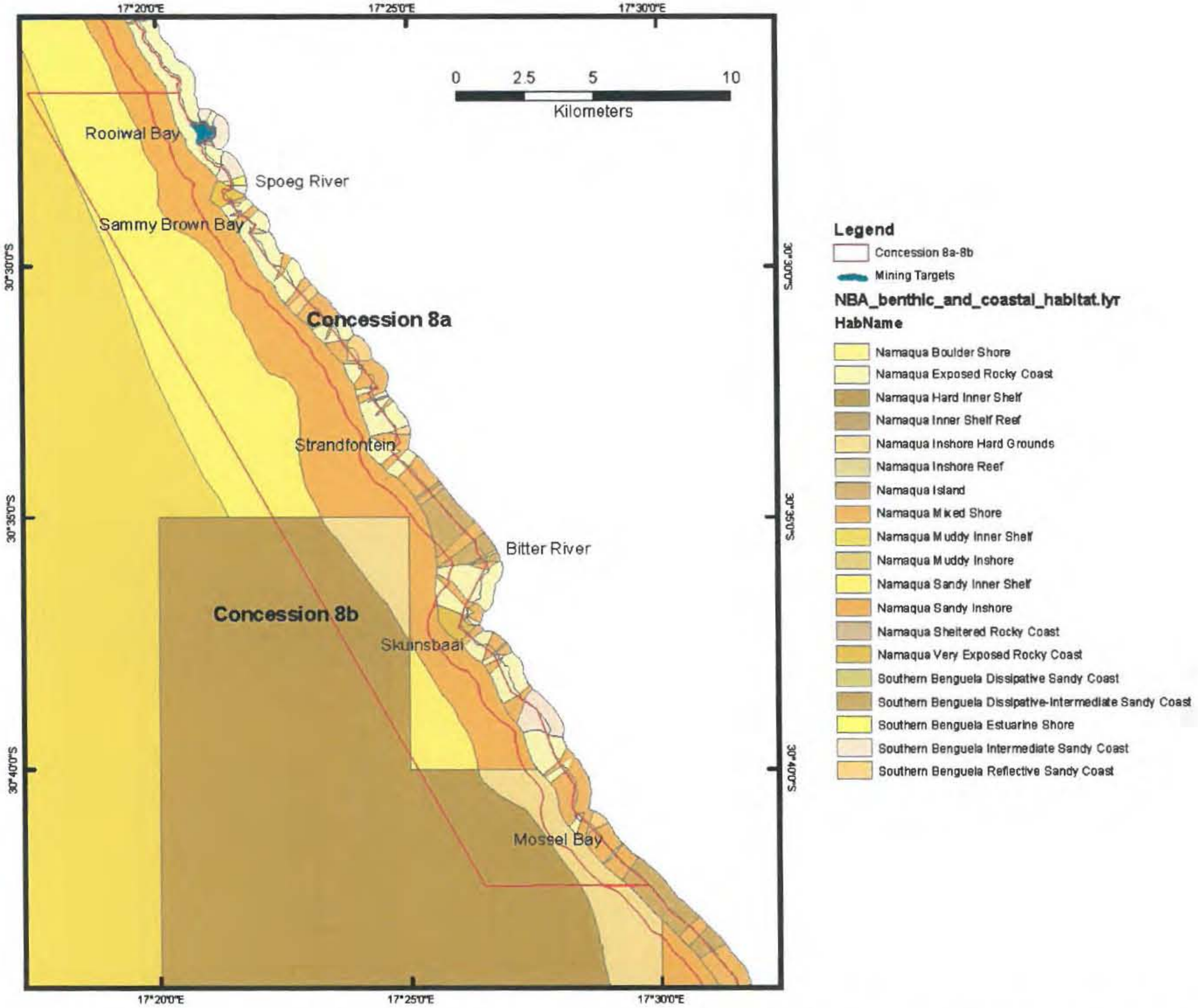

Figure 32b: Concession 8a and 8b in relation to the benthic and coastal habitat types identified by SANBI. The habitats within the concessions and affected by the proposed cofferdam mining operations are identified in Table 6.

3.2.8 Conservation Areas and Marine Protected Areas

Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan has been developed for the West Coast with the objective of identifying coastal and offshore priority focus areas for MPA expansion (Sink *et al.* 2011; Majiedt *et al.* 2013).The biodiversity data were used to identify nine focus areas for protection on the West Coast between Cape Agulhas and the South African - Namibian border. Those within the broad project area shown in Figure 33.

Of principal importance in the project area is the proposed Namaqua MPA, which stretches between the Groen and Spoeg Rivers and adjacent to the Namaqua National Park. This area meets habitat targets for 14 habitat types including 'Critically Endangered' habitat types such as Namaqua Inshore Reef, Namaqua Inshore Hard Grounds and Namaqua Sandy Inshore. Although the proposed Namaqua MPA inshore protected area overlaps with Concession 8a, 9a and 8b, all but a small area of interest in Concession 8a, which lies outside the proposed MPA, will be relinquished.

Figure 33: Project - environment interaction points on the West Coast, illustrating the location of seabird and seal colonies and priority areas for biodiversity protection in relation to the proposed project area.

4. IMPACT ASSESSMENT METHODOLOGY

Assessment of predicted significance of impacts for a proposed development is by its nature, inherently uncertain - environmental assessment is thus an imprecise science. To deal with such uncertainty in a comparable manner, standardised and internationally recognised methodology has been developed, and is applied in this study to assess the significance of the potential environmental impacts of the proposed exploration activities.

For each impact, the SEVERITY (size or degree scale), DURATION (time scale) and EXTENT (spatial scale) are described (Table 4-1). These criteria are used to determine the CONSEQUENCE of the impact (Table 4-2), which is a function of severity, spatial extent and duration.

Table 4-1: Ranking criteria for environmental impacts

SEVERITY/INTENSITY	H	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Irreplaceable loss of resources.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Noticeable loss of resources.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Limited loss of resources.
DURATION	L	Quickly reversible. Less than the project life. Short term (0-5 years)
	M	Reversible over time. Life of the project. Medium term (6-15 years)
	H	Permanent. Beyond closure. Long term (>15 years)
SPATIAL SCALE	L	Localised - Within the site boundary.
	M	Fairly widespread - Beyond the site boundary. Local
	H	Widespread - Far beyond site boundary. Regional/ national

Table 4-2: Determining the Consequence

			SPATIAL SCALE		
SEVERITY	DURATION		Site Specific (L)	Local (M)	Regional/ National (H)
Low	Long term	H	Medium	Medium	Medium
	Medium term	M	Low	Low	Medium
	Short term	L	Low	Low	Medium
Medium	Long term	H	Medium	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Low	Medium	Medium
High	Long term	H	High	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Medium	Medium	High

The SIGNIFICANCE of an impact is then determined by multiplying the consequence of the impact by the probability of the impact occurring (Table 4-3), with interpretation of the impact significance outlined in Table 4-4.

Table 4-3: Determining the Significance Rating

		CONSEQUENCE		
PROBABILITY (of exposure to impacts)		L	M	H
Definite/ Continuous	H	Medium	Medium	High
Possible/ frequent	M	Medium	Medium	High
Unlikely/ seldom	L	Low	Low	Medium

Table 4-4: The interpretation of the impact significance.

SIGNIFICANCE	CRITERIA
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

Table 4-5: The interpretation of the status of the impact.

IMPACT STATUS	CRITERIA
Positive	The impact benefits the environment
Negative	The impact results in a cost to the environment
Neutral	The impact has no effect on the environment

Once the significance of an impact has been determined, the CONFIDENCE in the assessment of the significance rating is ascertained using the rating systems outlined in the Table 4-6.

Table 4-6: Definition of Confidence Ratings

CONFIDENCE RATINGS*	CRITERIA
High	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact. Greater than 70% sure of impact prediction
Medium	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. Between 35% and 70% sure of impact prediction.
Low	Limited useful information on and understanding of the environmental factors potentially influencing this impact. Less than 35% sure of impact prediction.

* The level of confidence in the prediction is based on specialist knowledge of that particular field and the reliability of data used to make the prediction.

The degree to which the impact can be reversed is estimated using the rating system outlined in Table 4-7.

Table 4-7: Definition of Reversibility Ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	Where the impact is permanent.
Partially Reversible	Where the impact can be partially reversed.
Fully Reversible	Where the impact can be completely reversed.

The degree to which there will be a loss of resources (Table 4-8) refers to the degree to which a resource is permanently affected by the activity, i.e. the degree to which a resource is irreplaceable.

Table 4-8: Definition of Loss of Resources

LOSS OF RESOURCES	CRITERIA
Low	Where the activity results in a loss of a particular resource but where the natural, cultural and social functions and processes are not affected.
Medium	Where the loss of a resource occurs, but natural, cultural and social functions and processes continue, albeit in a modified way.
High	Where the activity results in an irreplaceable loss of a resource.

Lastly, the degree to which the impact can be mitigated or enhanced is given

DEGREE TO WHICH IMPACT CAN BE MITIGATED	CRITERIA
None	No change in impact after mitigation.
Very Low	Where the significance rating stays the same, but where mitigation will reduce the intensity of the impact.
Low	Where the significance rating drops by one level, after mitigation.
Medium	Where the significance rating drops by two to three levels, after mitigation.
High	Where the significance rating drops by more than three levels, after mitigation.

Environmental Assessment Policy requires that, "as far as is practicable", cumulative environmental impacts should be taken into account in all environmental assessment processes. EIAs have traditionally, however, failed to come to terms with such impacts, largely as a result of the following considerations:

- Cumulative effects may be local, regional or global in scale and dealing with such impacts requires coordinated institutional arrangements; and
- Environmental assessments are typically carried out on specific developments, whereas cumulative impacts result from broader biophysical, social and economic considerations, which typically cannot be addressed at the project level.

However, when assessing the significance of the project level impacts, cumulative effects have been considered as far as it is possible (as High, Medium or Low) in striving for best practice. The sustainability of the project is closely linked to assessment of cumulative impacts.

5. PUBLIC SCOPING AND IDENTIFICATION OF KEY ISSUES

5.1 Stakeholder Engagement

As part of the stakeholder engagement for this EMPr amendment, numerous meetings were held with commenting authorities. These are summarised below:

- 14 September 2015: Department of Agriculture, Forestry and Fisheries (Cape Town)
- 15 September 2015: Department of Environment and Nature Conservation (Springbok)
- 18 September 2015: Department of Environmental Affairs - Oceans and Coast (Cape Town)

The full minutes of these meetings and the Issues and Responses tables are provided as Appendix 5:Meetings, in the ScopingReports and overall EIA for this project. The issues specifically associated with the marine environment raised by key stakeholders are summarised below. For the sake of clarity, these have been grouped into specific environmental aspects:

Interaction with other users or future use scenarios

- Overlap of proposed mining activities with proposed MPAs and with Operation Phakisa;
- Potential conflict with abalone ranching rights holders regarding water quality and habitat loss, particularly those companies that have already started seeding juveniles;
- Increased turbidity near mining site(s)may compromised water quality at the seawater intakes to land-based abalone farms.

Water Quality

- The impacts of suspended sediment plumes and elevated turbidity as a result of mining operations need to be assessed;
- Increased turbidity near mining site(s) mayimpact filter feeders;
- Requirements for discharge permits regarding discharges to the sea (particularly from diver-assisted shore units) is unclear.

Disturbance of Habitats

- Blasting in the marine environment should be avoided and materials used for the construction of berms re-used as much as possible;
- Concern regarding the introduction of non-native material onto the beach during berm construction;
- Concern regarding the disturbance to marine habitats and associated biota through mining in subtidal areas; and
- The impacts associated with coffer dam construction vs. accretion need to be carefully considered.

Impacts on Seals

- As seal colonies are unique habitats within the project area these should be mapped, and information available at DAFF and DEA should be used.

Baseline Studies and Impact Monitoring

- Quantitative marine baseline studies focussing on the specific mining sites need to be undertaken;
- Provide DEA with information on the experimental design of baseline and monitoring studies prior to commencement of surveys;
- Give consideration toco-ordination of monitoring programmes with DEA and sharing of research information;
- Baseline and monitoring studies should focus both on rocky habitats (including an assessment on the impacts on reef structure) as well as sandy beach habitats;
- The recovery of these habitats following mining needs to be understood from the perspective of species recruitment and colonisation;
- Monitoring programmes should be co-ordinated to ensure an upfront understanding of sensitive habitats in the project area, with subsequent avoidance of these in the mine plans; and
- Give consideration to implementing a Strategic Environmental Assessment approach in partnership with other role players in the area so as to gain a broader understanding of the coastline rather than focusing on the project specific sites.

Rehabilitation, Closureand Biodiversity Offsets

- Decommisioning and closure is required of old mining sites no longer used;
- As active rehabilitation below the low water mark is not practicable, there is concerns that wave action may not be sufficient to ensure natural rehabilitation of berms; and
- The viability of creating artificial habitats to offset habitat disturbance should be considered (e.g. leaving the rock armour of the berms in place to form islands as roosting habitats for seabirds);

Environmental Management

- There is a need for the development of beach management plans for management of mining impacts;
- Strict house-keeping is required at beach mining sites (e.g. no refueling on the beach, and all equipment to be removed on cessation of operations); and
- An Environmental Control Officer should be appointed to ensure compliance with the Environmental Management Plan;

5.2 Identification of Key Issues

The following specific issues relating to potential impacts on the marine environment were identified by the marine specialist and during the public scoping process:

Shore-based diver-mining operations

- Damage to and destruction of intertidal and shallow subtidal communities as a result of shore-based diver-mining activities.
- Reduction in kelp bed habitats, potentially reducing suitable rock lobster recruitment habitats, and affecting the long-term sustainability of the resource.

- Blanketing of near-shore reefs and bedrock outcrops and their associated communities by discharged tailings.

Beach and offshore channel mining

- Burial of rocky shore and sandy beach benthos as a consequence of accretion and berm construction;
- Alteration of the physical characteristics of the beach through construction of coffer dams and aggressive shoreline accretion;
- Changes in macrofaunal community structure in response to physical changes of the beach;
- Generation of suspended sediment plumes;
- Disturbance and loss of intertidal and subtidal habitat and associated communities in the berm footprint and within the mining block; and
- Sedimentation of reef habitats adjacent to the mining site due to redistribution of sediments

6. ASSESSMENT OF ENVIRONMENTAL IMPACTS

6.1 Impacts of Shore-Based Divers

6.1.1 Crushing and Trampling

On rocky coasts targeted by shore-based diver units, intertidal and subtidal organisms are damaged or destroyed by movement of mining equipment, removal of boulders from subtidal gullies into the intertidal zone or into rock piles, discard of tailings and the general activities of the contractors around the mining unit (Parkins & Branch 1995, 1996, 1997; Pulfrich 1998; Pulfrich et al. 2003a). This mining-related disturbance is very localized being limited to a scale of 10s of metres around each individual operation(Barkai & Bergh 1992; Pulfrich et al. 2003a) and effects are often difficult to detect above the natural variability inherent in rocky intertidal communities.

During mining the characteristic decline in grazers results in a proliferation of fast-growing, opportunistic, intertidal foliose algae. As grazer abundance recovers following cessation of mining, algal cover begins to diminish and within two years the community structure recovers to a pre-mining level(Pulfrich et al. 2003a). Recovery following wave disturbance and experimental removal of mussels and limpets on the Namaqualand coast similarly occurred within 24 months (Eekhout et al. 1992; Steffani & Branch 2003b, 2005). Studies conducted in other parts of the world have shown that high intensity trampling can result in the removal of most of the rocky intertidal assemblages, although the effects are dependent on the community present, with foliose algae (particularly fucoid species) being more susceptible than algal turfs, and barnacles more susceptible than dense patches of mussels. Recovery was typically achieved two years after the trampling event, although the interaction of season, location, the indirect effects of reduction in certain algal species and facilitative processes in recruitment of other algae all contributed to varying speeds of recovery (Povey & Keough 1991; Brosnan & Crumrine 1994; Schiel & Taylor 1999).

While recovery of the intertidal and subtidal communities is rapid, physical alteration and degradation of the shoreline in ways that cannot be remediated by swell action can be more or less permanent. For example, the discard of oversize tailings above the high water mark precludes natural redistribution by waves and unless thesetailings dumps are actively removed, they remain a more or less permanent feature in the high shore.

The highly localised impact of crushing and trampling of rocky intertidal communities by shore-based divers and their equipment is consequently deemed to be of low intensity in the mining target areas and for the duration of operationsand is considered to be of**LOW** significance both without and with mitigation.

6.1.2 Kelp Cutting

In areas where shallow-water kelp beds are particularly dense, shore-based divers may cut kelp to facilitate movement of the suction hoses and airlines. Kelp cutting results in a localised impact, the severity and duration of which depends on the extent of kelp removed, the frequency and method of removal and the age of the kelp. Increased light availabilityfollowing harvesting of whole plants typically results in an increase in the diversity of understorey algae (Simons & Jarman 1981; Kennelly 1987a, 1987b;Christie et al. 1998; Levitt et al. 2002; Pisces Environmental Services

2007). No changes in the associated understorey faunal species diversity occurs, however (Levitt et al. 2002).

Although recovery following cutting is in most cases rapid (Parkins & Branch 1996; Christie et al. 1998; Levitt et al. 2002; Pisces 2007), long-term changes in kelp forest communities in response to various disturbances have been documented (Dayton et al. 1992), with disturbance potentially causing many lag-effects including the proliferation of understory algae (see also Foster 1975), changes in grazing patterns of herbivores and the availability of, and intraspecific competition for primary space.

Following harvesting of*Ecklonia maxima*,recovery of the kelp bed in terms of plant biomass and density, and understorey community structure can occur within two years (Anderson 2000; Levitt et al. 2002)), whereas for*Laminaria pallida* recovery of kelp biomass to pre-harvest levels can occur within 4 - 8 months (Pisces 2007). However, extensive and repeated kelp cutting by diamond divers can result in kelp bed habitats being locally eliminated and replaced by extensive stands of mussels (Engeldow & Bolton 1994), or colonies of the Cape reef worm *Gunnarea capensis* (G. Koeglenberg & Q. Snethlage, diamond divers, pers. comm.).Kelp beds providing shelter for a wide diversity of marine flora and fauna (Field et al. 1980), and in the central and southern Benguela region are known to serve as an essential nursery area for rock lobster and several fish species (Velimirov et al. 1977; Velimirov & Griffiths 1979; Carr 1989, 1994). Reduction or loss of kelp beds may thus have knock-on effects on the recruitment success of commercially important species through reduction of suitable habitat and food sources.

The highly localised impact of kelp cutting by shore-based divers is thus considered to be of low intensity in the mining target areas and for the duration of operationsand is considered to be of**LOW** significance both without and with mitigation.

6.1.3Degradation of Nearshore Reef Habitats

Diver-assisted mining specifically targets gravel areas, which are typically sparsely inhabited by infauna or commercially important species such as rock lobsters. By removing the overlying gravel, mining exposes expanses of previously embedded boulders, which are rapidly colonised by benthic organisms and mobile predators such as rock lobsters. Within a year, the species richness on the exposed surfaces issimilar to that of adjacent unmined reef areas (Barkai & Bergh 1992; Parkins & Branch 1995, 1996, 1997; Pulfrich 1998a, 1998b, 2004; Pulfrich & Penney 1998, 1999b, 2001; Pulfrich et al. 2003a, 2003b), although the structure of the developing community remains distinguishable from unmined areas for several years. Impacts are highly localised, however.

If oversize tailings are dumped below the high water mark, they are rapidly redistributed by wave action and their effects on the benthic communities remain highly localised and persist over the short-term only (Barkai & Bergh 1992; Parkins & Branch 1995, 1996, 1997; Pulfrich 1998b; Pulfrich & Penney 1998, 1999b, 2001). Although initial scouring of the benthic communities occurs,the affected communities recover within 1-2 years (Parkins & Branch 1996, 1997; Pulfrich 1998b; Pulfrich & Penney 2001; see also Hard et al. 1976). As a result of the change in seabed type, the structure of the communities in areas affected by discards persists for longer, particularly where excessive and repeated dumping in the same area precludesrapid dispersion.

The highly localised impact of tailings disposal around the pumping units is thus considered to be of low intensity in the mining target areas. As these tailings heaps can persist over the medium to long-term if located in areas where wave action precludes dispersion, the impact is considered to be of**MEDIUM** significance without mitigation, but reducing to **LOW** significance if correctly managed.

Mitigation

Recommendations for mitigation include:

- No disposal of tailings above the high water mark;
- Avoid re-mining of sites in the medium term;
- Prohibit blasting and large-scale removal of rocks from subtidal gullies into the intertidal;
- Designate and actively manage specific access, storage and operations areas;
- Remove all equipment on completion of activities; and
- Flatten all remaining tailings heaps on completion of operations.

Physical damage and trampling of intertidal biota		
	Without Mitigation	**Assuming Mitigation**
Severity	Low	Low
Duration	Short-term: recovery within 2 years	Short-term
Extent	Site specific: limited to mining area	Site specific
Consequence	Low	Low
Probability	Seldom	Seldom
Significance	Low	Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	The highly localised disturbance and loss of intertidal benthic communitiesthrough trampling and crushing is not expected to result in cumulative impacts
Degree to which impact can be reversed	The impact is fullyreversible as natural recovery of communities will occur on cessation of operations
Degree to which impact may cause irreplaceable loss of resources	Low
Degree to which impact can be mitigated	Medium

<table>
<tr><th colspan="3">Changes in community structure through kelp cutting</th></tr>
<tr><th></th><th>Without Mitigation</th><th>Assuming Mitigation</th></tr>
<tr><td>Severity</td><td>Low</td><td>Low</td></tr>
<tr><td>Duration</td><td>Short-term: recovery within 1 year</td><td>Short-term</td></tr>
<tr><td>Extent</td><td>Site specific: limited to mining area</td><td>Site specific</td></tr>
<tr><td>Consequence</td><td>Low</td><td>Low</td></tr>
<tr><td>Probability</td><td>Seldom</td><td>Seldom</td></tr>
<tr><td>Significance</td><td>Low</td><td>Low</td></tr>
<tr><td>Status</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Confidence</td><td>High</td><td>High</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Nature of Cumulative impact</td><td>The highly localised removal of kelp is not expected to result in cumulative impacts</td></tr>
<tr><td colspan="2">Degree to which impact can be reversed</td><td>The impact is fullyreversible as natural recovery of communities will occurduring and on cessation of operations</td></tr>
<tr><td colspan="2">Degree to which impact may cause irreplaceable loss of resources</td><td>Low</td></tr>
<tr><td colspan="2">Degree to which impact can be mitigated</td><td>Medium</td></tr>
</table>

<table>
<tr><th colspan="3">Degradation of reef habitat through disposal of tailings</th></tr>
<tr><th></th><th>Without Mitigation</th><th>Assuming Mitigation</th></tr>
<tr><td>Severity</td><td>Low</td><td>Low</td></tr>
<tr><td>Duration</td><td>Short-term</td><td>Short-term</td></tr>
<tr><td>Extent</td><td>Site specific: limited to mining area</td><td>Site specific</td></tr>
<tr><td>Consequence</td><td>Low</td><td>Low</td></tr>
<tr><td>Probability</td><td>Possible</td><td>Unlikely</td></tr>
<tr><td>Significance</td><td>Medium</td><td>Low</td></tr>
<tr><td>Status</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Confidence</td><td>High</td><td>High</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Nature of Cumulative impact</td><td>The highly localised disturbance and loss of intertidal benthic communitiesthrough tailings disposal is not expected to result in cumulative impacts</td></tr>
<tr><td colspan="2">Degree to which impact can be reversed</td><td>The impact is fullyreversible as natural recovery of communities will occur on cessation of operations and redistribution of tailings by wave action</td></tr>
<tr><td colspan="2">Degree to which impact may cause irreplaceable loss of resources</td><td>Low</td></tr>
<tr><td colspan="2">Degree to which impact can be mitigated</td><td>Medium</td></tr>
</table>

6.2 Impacts of Beach and Offshore Channel Mining

Both intertidal and subtidal rocky habitats and unconsolidated sediments will be affected by beach accretion, berm constructionand subsequent mining of the impounded area. Within the mining target footprint, these habitats will be severely disturbed and their associated communities completely eliminated. In the case of the reclamaion of Mitchell's Bay through accretion,rocky habitats within the bay will be smothered by sediments and a shift in communities from those characterising rocky shore to those typical of sandy beaches will occur. A change in the invertebrate macrofaunal communities present on the beach within the bay can also be expected in response to the accretion. The anticipated impacts are discussed in more detail below.

6.2.1Loss of Benthic Biota

The benthic communities occurring within the project area are largely ubiquitous to the central Benguela region, and no rare or endangered species have been recorded(Awad*et al.* 2002). Mitchell's Bayis, however, topographically unusual as it provides a localised relatively sheltered marine environment comprising exposed rocky shores, endangered Namaqualand mixed shores and two small intermediate sandy beaches along an otherwise comparatively exposed and predominantly rocky coastline. Although the impacts will be highly localised, the bay is of some importance from a biodiversity perspective. The loss of biota as a consequence ofaccretion of the Mitchell's Bay shoreline or berm constructionand subsequent mining of the impounded area along the adjacent coast is considered to be of medium to high intensity in the mining target areas. Impacts are likely to persist over the medium (open coast berms) to long term (Mitchell's Bay) and are thus considered to be of**MEDIUM**to **HIGH**significance both without and with mitigation.

6.2.2 Burial of Benthic Biota

The immediate impact of both beach accretion and berm construction would be the burial of the intertidal and subtidal benthos beneath a massive layer of non-native overburden sands and quarried sediments. This would commence in the upper shore and progress seawards as beach accretionand/or construction of the coffer dam advances thereby affecting benthic biota across the full width of the shore and/or target mining block and into the surf-zone. Depending on their size fraction, thesediments discharged in the intertidal zone would spread to a greater or lesser degree down the shore and into the surf-zone where they would be redistributed by wave action and surf-zone currents.

Factors known to determine the effect of burial on species are 1) the depth of burial; 2) the nature of depositing sediments; 3) burial time; 4) tolerance of species (life habitats, escape potential, tolerance to hypoxia etc.); 5) presence of contaminants in the depositing sediments, and 6) season (mortality rate by burial higher in summer than winter) (Kranz 1974; Maurer et al. 1981a, 1981b, 1982, 1986; Bijkerk 1988; Hall 1994; Baan et al. 1998; Harvey et al. 1998; Essink 1999; Schratzberger et al. 2000b; Baptist et al. 2009; Janssen et al. 2011).Many benthic invertebrates inhabiting unconsolidated sediments are able to burrow or move through the sediment matrix, and numerous studies have shown that some infaunal species are able to actively migrate vertically through overlying deposited sediment thereby significantly affecting the recolonisation and subsequent recovery of impacted areas (Maurer et al. 1979, 1981a, 1981b, 1982, 1986; Lynch 1994; Ellis 2000; Schratzberger et al. 2000a; but see Harvey et al. 1998; Blanchard & Feder 2003). Lynch

(1994) conducted vertical migration experiments with beach macrofauna to determine their tolerance to sand overburdens, and found that several species were capable of burrowing through sediments between 60 and 90 cm, and Maurer et al. (1979) reported that some animals are capable of migrating upwards through 30 cm of deposited sediment. In contrast, consistent faunal declines were noted during deposition of mine tailings from a copper mine in British Columbia when the thickness of tailings exceeded 15-20 cm (Burd 2002), and Schaffner (1993) recorded a major reduction in benthic macrofaunal densities, biomass, and species richness in shallow areas in lower Chesapeake Bay subjected to heavy disposal (>15 cm) of dredged sediments. Similarly, Roberts et al. (1998) and Smith & Rule (2001) found difference in species composition detectable only if the layer of instantaneous applied overburden exceeded 15 cm. In general, mortality tends to increase with increasing depth of deposited sediments, and with speed and frequency of burial.

The survival potential of benthic infauna, however, depends not only on their ability to migrate upwards through the deposited sediment, but also on the nature of the deposited non-native sediments (Turk & Risk 1981; Chandrasekara & Frid 1998; Schratzberger et al. 2000a; Speybroeck et al. 2004). Although there is considerable variability in species response to specific sediment characteristics (Smit et al. 2006), higher mortalities were typically recorded when the deposited sediments have a different grain size composition from that of the receiving environment (Maurer et al. 1981a, 1981b, 1982, 1986; Smit et al. 2006; Smit et al. 2008), migration ability and survival rates generally being lower in silty sediments than in coarser sediments (Hylleberg et al. 1985; Ellis & Heim 1985; Maurer et al. 1986; Romey & Leiseboer 1989, cited in Schratzberger et al. 2000a; Schratzberger et al. 2000a). Some studies indicate that changes to the geomorphology and sediment characteristics may in fact have a greater influence on the recovery rate of invertebrates than direct burial or mortality (USDOI/FWS 2000). The availability of food in the depositional sediment is, however, also influential.

The burial time, or duration of burial, will also determine the effect on benthos. Here a distinction must be made between incidental deposition, where species are buried by deposited material within a short period of time (e.g. during berm construction), and continuous deposition, where species are exposed to an elevated sedimentation rate over a long period of time (as would occur during accretion of Mitchell's Bay). Whereas the volumes deposited per unit time will likely be lower under conditions of continuous deposition, such deposition can nonetheless have negative effects when the sedimentation rate is higher than the velocity at which the organisms can move or grow upwards. The sensitivity to long-term continuous deposition is species dependent and also dependent on the sediment type, with continuous deposition of silt being more lethal than a deposition of sand.

The nature of the receiving community is also of importance. In areas where sedimentation is naturally high (e.g. wave-disturbed shallow waters) the ability of taxa to migrate through layers of deposited sediment is likely to be well developed (Roberts et al. 1998). The life-strategies of organisms is a further aspect influencing the susceptibility of the fauna to mortality. Kranz (1972, cited in Hall 1994) studied the burrowing habits of 30 species of bivalves and showed that mucous-tube feeders and labial palp deposit-feeders were most susceptible to sediment deposition, followed by epifaunal suspension feeders, boring species and deep-burrowing siphonate suspension-feeders, none of which could cope with more than 1 cm of sediment overburden. Infaunal non-siphonate suspension feeders were able to escape 5 cm of burial by their native sediment, but normally no more than 10 cm. The most resistant species were deep-burrowing siphonate suspension-feeders, which could escape from up to 50 cm of overburden. Menn (2002) reported that meiofaunal species appeared less susceptible to burial than macrofauna, and Carey (2005) was unable to detect any effects of beach replenishment on benthic microalgae.

The exact depth of sand through which beach biota can successfully migrate ('fatal depth') thus depends on the species involved (reviewed by Essink 1993). Although numerous studies have investigated the burrowing efficiency of local species under different swash conditions or grain size composition (e.g. Brown & Trueman 1991, 1995; Nel et al. 2001), information on successful upward migration and survival following heavy deposition of sediments is largely lacking (but see Trueman & Ansell 1969). However, benthic organisms living in nearshore wave influenced areas in the Benguela region are likely to be adapted to relatively high sedimentation rates. Nonetheless, it is safe to assume that most beach infauna and rocky habitat communities in the berm/accretion footprint would be smothered in the berm-building process, and in the immediate vicinity of the sediments deposited during active beach accretion.

Burial can also lead to a chain of other stressors on benthic species communities like oxygen depletion and high sulphide concentrations. These are discussed further in Section 6.2.5.

The localised impacts of smothering, burial and loss of intertidal and shallow subtidal benthic communities through beach accretion, berm constructionand subsequent mining of the impounded area is considered to be of medium to high intensity in and adjacent to the mining target areas. Impacts are likely to persist over the medium (open coast berms) to long term (Mitchell's Bay) and are thus considered to be of**MEDIUM**to **HIGH**significance both without and with mitigation.

6.2.3Changes in Biophysical Characteristics

On sandy beaches, the physical characteristics of the beach, namely the sand particle size, wave energy and beach slope, play an important role in determining the composition of the biological communities inhabiting the beach (McLachlan et al. 1993; McLachlan 1996). The nature of the sediments used for shoreline accretion will thus not only affect the immediate survival potential of impacted communities, but will determine the physical characteristics of the beach over the medium- to long-term. This in turn will influence the recovery rate of the impacted communities as well as the ultimate community structure (Pulfrich & Branch 2014a; Pulfrich et al. 2015).

When the sediments used for beach accretion have similar properties (grain size and organic matter) to the native sediments, replenishment results in the least impact on benthic infauna and the shortest recovery time of affected communities (Hayden & Dolan 1974; Culter & Mahadevan 1982; Gorzelany & Nelson 1987; Hurme & Pullen 1988; Nelson 1993; Löffler & Coosen 1995; Birklund et al. 1996; Le Roy et al. 1996; Rakocinski et al. 1996; Peterson et al. 2000; Van Dalfsen & Essink 2001;Menn 2002; Menn et al. 2003; Pulfrich et al. 2004; amongst other). Effects, however, differ depending on what part of the shore receive the fill material. When the application of sediments of similar size occurs high on the beach, recovery of infaunal communities occurs relatively quickly (reviewed in USACE 1989; Greene 2002), due to the gradual redistribution of sands across the beach (Dankers et al. 1983; Baptist et al. 2009). In contrast, communities in the deeper subtidal show higher sensitivity to disturbance due to a higher abundance of long-lived species than in the highly dynamic intertidal and surf-zones (Parr et al. 1978; Reise 1985; Brown & Mclachlan 1994; Rakocinski et al. 1996; Menn 2002). In the case of the accretion of the Mitchell's Bay shoreline, the entire shore from the high water mark to the deepest protions of the bay would be affected.

The effects of using sediments that poorly match the native beach sediments result in more substantial changes in macrofaunal community structure (Naqvi & Pullen 1982; Nelson 1989; Hackney et al. 1996; Peterson et al. 2000; Lindquist & Manning 2001; Peterson & Manning 2001; Bishop et al. 2006; Fanini et al. 2009). The addition of coarser sediments onto a beach results in changes in the beach morphodynamics, which in turn influences both the species diversity and abundance of the associated invertebrate fauna, thereby causing changes in community structure, as has been clearly demonstrated in numerous biological monitoring studies of beach mining operations in southern Namibia (Pulfrich 2004b; Clark et al. 2004, 2005, 2006; Pulfrich & Atkinson 2007; Pulfrich et al. 2007, 2008; Clark et al. 2009; Pulfrich et al. 20010, 2011; Pulfrich & Branch 2014; Pulfrich et al. 2015).

Due to the intrinsic tolerance of the assemblages inhabiting intertidal beaches, declines in infaunal abundance, biomass, and diversity following disturbances such as beach replenishment or small-scale mining are short term, with recolonisation following the cessation of disturbance occurring within weeks (Schoeman et al. 2000) and recovery of communities to a condition of functional similarity to the original state occurring after 2 to 7 months (Nelson 1985, 1993; Hackney et al. 1996). Recovery of macrofaunal diversity and abundance following replenishment of beaches typically occurs within 1 year (Dankers et al. 1983; Van Dolah et al. 1994; Essink 1997; Jutte et al. 1999a, 1999b; USACE 2001; Menn 2002; Menn et al. 2003), with full recovery of the benthic community and age structure considered to take between 2 and 5 years (USACE 1989; Kenny & Rees 1994, 1996; Rakocinski et al. 1996; Essink 1997; Van Dalfsen & Essink 1997; van Dalfsen et al. 2000; Newell et al. 2004; Boyd et al. 2005; Mulder et al. 2005; Baptist et al. 2009). Recovery after repeated replenishment or disturbance, however, takes longer, particularly if this results in medium- to long-term changes in sediment structure (Menn et al. 2003; Janssen & Mulder 2005).In a study investigating the impacts of beach diamond-mining north of the Olifants River on the South African West Coast, which employed cofferdams constructed of native beach sediments, it was demonstrated that despite a significant immediate negative impact on the biotic parameters studied (abundance, biomass, species richness, and community structure), recovery of macrofaunal communities following the cessation of mining was rapid, with recovery to pre-mining conditions occurring after 20-50 months (Nel et al. 2003; Pulfrich et al. 2004).

Recolonisation of disturbed beaches takes place by passive translocation of animals from adjacent areas during successive tidal cycles or storms, active immigration of mobile species, and immigration and settlement of pelagic larvae and juveniles (Hall 1994; Kenny & Rees 1994, 1996; Herrmann et al. 1999; Ellis 2000; Menn 2002). Usually, undisturbed sediments adjacent to the impacted site provide an important source of colonising species, enabling faster recovery (van Moorsel 1993, 1994; Cheshire & Miller 1999). Should accretion of the Mitchell's Bay shoreline occur, the recovery of communities to a condition of functional similarity to those inhabiting the original beach may take a little longer as recolonisation would depend on immigration of species from adjacent beaches, the nearest of which is at the mouth of the Spoeg River ~1.5 km to the south.

When the sediment used for replenishment contain a high proportion of fines, the recovery of macrobenthic communities is generally retarded (Saloman & Naughton 1984; Gorzelany & Nelson 1987; Rakocinski et al. 1996; Bilodeau & Bourgeois 2004). This effect is intensified when the fill sediments have high organic loads or are polluted (Colosio et al. 2007).Prolonged recovery following the addition of fine fill sediments has partly been attributed to an increase in turbidity in the surf-zone (see section 5.4.1) and to compaction of beach sediments(Ryder 1991; Greene 2002), which negatively affects the abundance of burrowing organisms (Maurer et al. 1978).The effects of compaction are also manifested through changes in the interstitial space, the water retention ability, sediment permeability and the exchange of gasses and nutrients. Compaction is usually temporary, as wave action and bioturbation turns over the sediments, and fine sediments will ultimately be winnowed out and redistributed in the surf-zone (USACE 1989).

In summary, large-scale disturbances of beach habitat, associated with activities such as beach mining and shoreline accretion, are evident on all the biotic parameters (abundance, biomass, species richness, and community structure), and at all taxonomic levels of the sandy beach infaunal communities (see also Defeo & Lecari 2003). However, if the surface sediment is similar to the native beach material when operations cease, and if the final long-term beach profile has similar contours to the original profile, the addition or removal of layers of sediment does not have enduring adverse effects on the sandy beach benthos and recovery following the initial disturbance can occur within a few years. In contrast, structural changes in grain size over the medium- to long-term due to repeated nourishmentor seawall construction results in either permanent changes in community structure or longer recovery times.

The construction of berms and the accretion of Mitchell's Bay is highly likely to result in localised changes in the physical characteristics of the impacted beaches, and changes in community structure of invertebrate macrofauna in response to these physical changes can be expected.Such changes are considered to be of medium intensity in mining target areas. Impacts are likely to persist over the short (open coast berms) to medium term (Mitchell's Bay) and are thus considered to be of **MEDIUM** significance both without and with mitigation.

Mitigation

Berm construction and/or shoreline accretion, overburden stripping and removal and processing of target gravels are all an integral part of the mining approach and other than the 'no-go' option, there is no feasible mitigation for these proposed operations. Disturbance of beach habitat adjacent to the mining blocks can, however, be minimised through stringent environmental management and good house-keeping practices. Active rehabilitation involving backfilling of mined out areas, active removal of as much of the berms above the low water mark as feasible and re-structuring of the mining area to resemble the natural beach morphology should be undertaken on completion of mining operations.

Further recommendations for mitigation include:

- Mine beach targets in blocks sequentially from the north to the south along the beach, rehabilitating mined-out blocks immediately on cessation of mining in that block;
- Avoid re-mining of sites in the medium to long term;
- Designate and actively manage specific access, storage and operations areas;
- Remove all equipment on completion of activities; and

- Flatten all remaining tailings heaps on completion of operations.

<table>
<tr><th colspan="3">Loss of biota in the construction and mining footprint</th></tr>
<tr><td></td><td>Without Mitigation</td><td>Assuming Mitigation</td></tr>
<tr><td>Severity</td><td>Medium - High</td><td>Medium</td></tr>
<tr><td>Duration</td><td>Medium (open coast berms) - Long term (Mitchell's Bay)</td><td>Medium - Long term</td></tr>
<tr><td>Extent</td><td>Site specific: limited to the mining footprint</td><td>Local</td></tr>
<tr><td>Consequence</td><td>Medium (open coast berms) - High (Mitchell's Bay)</td><td>Medium - High</td></tr>
<tr><td>Probability</td><td>Definite</td><td>Definite</td></tr>
<tr><td>Significance</td><td>Medium - High</td><td>Medium - High</td></tr>
<tr><td>Status</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Confidence</td><td>High</td><td>High</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Nature of Cumulative impact</td><td>The highly localised loss of intertidal and shallow subtidal benthic communitiesmay result in cumulative impacts in threatened or endangered habitats</td></tr>
<tr><td colspan="2">Degree to which impact can be reversed</td><td>The impact is only partially reversible as active rehabilitation below the low water mark is not possible and recovery of habitats and communities will depend on natural processes. Natural erosion of accreted sediments in Mitchell's Bay and recovery of biota are likely to only be reversible over the long term.</td></tr>
<tr><td colspan="2">Degree to which impact may cause irreplaceable loss of resources</td><td>Medium</td></tr>
<tr><td colspan="2">Degree to which impact can be mitigated</td><td>Very Low</td></tr>
</table>

<table>
<tr><th colspan="3">Disturbance and loss of intertidal and subtidal benthic biota through burial by sediments</th></tr>
<tr><td></td><td>Without Mitigation</td><td>Assuming Mitigation</td></tr>
<tr><td>Severity</td><td>Medium - High</td><td>Medium</td></tr>
<tr><td>Duration</td><td>Medium (open coast berms) - Long term (Mitchell's Bay)</td><td>Medium - Long term</td></tr>
<tr><td>Extent</td><td>Local: may extend beyond themining area due to distribution of sediments</td><td>Local</td></tr>
<tr><td>Consequence</td><td>Medium (open coast berms) - High (Mitchell's Bay)</td><td>Medium - High</td></tr>
<tr><td>Probability</td><td>Definite</td><td>Definite</td></tr>
<tr><td>Significance</td><td>Medium - High</td><td>Medium - High</td></tr>
<tr><td>Status</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Confidence</td><td>High</td><td>High</td></tr>
</table>

Nature of Cumulative impact	The localised disturbance and loss of intertidal and shallow subtidal benthic communitiesburial and removal is not expected to result in cumulative impacts
Degree to which impact can be reversed	The impact is only partially reversible as active rehabilitation below the low water mark is not possible and recovery of habitats and communities will depend on natural processes. Natural erosion of accreted sediments in Mitchell's Bay are likely to only be reversible over the long term.
Degree to which impact may cause irreplaceable loss of resources	Medium
Degree to which impact can be mitigated	Very Low

Changes in the biophysical characteristics of the beach		
	Without Mitigation	**Assuming Mitigation**
Severity	Medium	Medium
Duration	Short (open coast berms) - Medium term (Mitchell's Bay)	Short - Medium term
Extent	Local: may extend beyond themining area due to distribution of sediments	Local
Consequence	Medium	Medium
Probability	Definite	Definite
Significance	Medium	Medium
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	The changes in biophysical characteristicson open coast beaches may result in cumulative impacts as adjacent blocks are mined
Degree to which impact can be reversed	The impact is only partially reversible as active rehabilitation below the low water mark is not possible and recovery of habitats and communities will depend on natural processes. Sediments accreted in Mitchell's Bay would be naturally eroded over the long term
Degree to which impact may cause irreplaceable loss of resources	Medium
Degree to which impact can be mitigated	None

Other potential impacts on the marine environment associated with beach accretion and berm construction include increased turbidity in the surf-zone opposite and down-stream of the mining site, possible hypoxia in the sediments following organic loading, introduction of contaminants, and mobilisation and deposition of eroded sediments onto adjacent reef habitats.

6.2.4 Increased turbidity

The coarser fractions of the sediments and boulders used for berm construction and for beach accretion settle out rapidly, but any silts and clays in the material will remain in suspension for longer and disperse further. Depending on the proportion of fines in the stripped overburden used for accretion, or the quarried material used as the berm core, wave action will winnow these from the coarser componentsresulting in increased turbidity in the surf-zone and nearshore water column (Greene 2002; Speybroek et al. 2004). Sediment plumes can become trapped in the surf-zone and may subsequently be transported for considerable distances alongshore with relatively little further dilution, thereby reducing their effective dispersion. The suspended sediment concentrations, the extent and area over which plumes disperse, and their duration, depend largely on the proportions of silts, muds and clays (<63 μm) in the discharged sediments, as well as local sea conditions. The higher the proportion of fine material, the larger and more persistent the suspended sediment plume is likely to be (Newell et al. 1998; Johnson & Parchure 1999; Posford Duvivier Environment 2001; Greene 2002).

One of the more apparent effects of increased concentrations of suspended sediments and consequent increase in turbidity, is a reduction in light penetration through the water column with potential adverse effects on the photosynthetic capability of phytoplankton (and other aquatic plants) (Poopetch 1982; Kirk 1985; Parsons et al. 1986a, 1986b; Monteiro 1998; O'Toole 1997) and the foraging efficiency of visual predators (Clark et al. 1998; Simmons 2005; Braby 2009; Peterson et al. 2001).

Suspended sediments also load the water with inorganic particles, which may have biological effects such as a reduction of invertebrate egg and larval survival (thereby potentially affecting the recovery rate of the impacted shoreline), and diminish the filter-feeding efficiency of suspension feeders (reviewed by Clarke & Wilber 2000). Increased turbidity following addition of finer sediments during beach replenishment has been reported to result in increased mortality of adult surf clams, and reduced survival of juvenile surf clams and polychaetes, resulting in delayed recovery of impacted populations (Reilly & Bellis 1983; Rakocinski et al. 1996; Speybroek et al. 2005; but see also Spring 1981; Gorzelany & Nelson 1987). However, in most cases sub-lethal or lethal responses occur only at concentrations well in excess to those of sediment plumes from mining operations. Furthermore, as marine communities in the Benguela are frequently exposed to naturally elevated suspended-sediment levels, they can be expected to have behavioural and physiological mechanisms for coping with this feature of their habitat.

It is anticipated that the sediments proposed for berm construction will have a negligible clay and silt fraction, so the generation of suspended sediment plumes above natural background levels during construction are expected to be insignificant. Likewise, the proportion of fines (<63 μm) in the overburden dune sands used to facilitate accretion, is expected to be insignificant. Turbidity offshore of the mine site(s) is thus unlikely to exceed levels attained naturally during turn-over of nearshore sediments by wave action or seasonal inputs in river discharges.As turbid water is a natural occurrence along the southern African west coast, any turbidity-related effects in the near-shore environment as a direct result of mining operations are likely to be insignificant.

The construction of berms and the accretion of Mitchell's Bay will result in the generation of localised suspended sediment plumes, which may affect primary productivity and larval survival, reduce the availability and suitability of food for higher order consumers or trigger emigration of higher order consumers from the area in search of food, thereby potentially having cascade effects through the marine food web. If the mining area is in the immediate vicinity of the seawater intakes for land-based abalone farms, the water quality requirements for abalone mariculture may be compromised. Due to the transient nature of such plumes, the potential impacts are, however, considered to be of low intensity and are thus considered to be of **LOW** significance both without and with mitigation. Suspended sediment concentrations within plumes are unlikely to exceed maximum levelsoccurringnaturally along the wave-dominated coastline.

Mitigation
No mitigation measures are possible or deemed necessary.

Effects of suspended sediment plumes		
	Without Mitigation	**Assuming Mitigation**
Severity	Low	Low
Duration	Short-term: as plumes would be transient and their effects temporary	Short-term
Extent	Site specific: limited to mining area	Site specific
Consequence	Low	Low
Probability	Seldom	Seldom
Significance	Low	Low
Status	Neutral: unlikely to exceed natural suspended sediment concentrations	Neutral
Confidence	High	High

Nature of Cumulative impact	Biota in the Benguela ecosystem have behavioural and physiological mechanisms for coping with this feature of their habitat so cumulative impacts are unlikely
Degree to which impact can be reversed	The impact is fullyreversible
Degree to which impact may cause irreplaceable loss of resources	Low
Degree to which impact can be mitigated	None

6.2.5 Hypoxia

Besides the physical effect of burial, a further indirect impact potentially associated with beach replenishment is the chemical effects of the fill sediments on the receiving communities. Studies from elsewhere have identified that the addition of either anaerobic sediments, or sediments with a high organic content, can result in the development of hypoxic/anoxic conditions in the sediments. Fine sediments are more likely to have a higher organic content and thus more likely to trigger a reduction in oxygen. Under conditions of limited oxygen, rates of nitrate and phosphate remineralisation, and sulfate reduction in the sediments increase. The resulting production of nitrite, ammonia, and sulfide in combination with low oxygen can have sub-lethal and lethal effects on benthic organisms (Baptist et al. 2009). Decreased dissolved oxygen levels can thus amplify the effects of increased sedimentation.

The high wave exposure in combination with the comparatively coarse nature of the beach sediments (D_{50} = ~270 µm; WSP 2015) in the project area make it highly unlikely that hypoxic conditions will develop as a consequence of the shoreline accretion. Addition of coarse sediment will ensure penetrability and flushing rates will remain high. Furthermore, the dune sands to be used for shoreline accretion will likely have a low organic content.

Accretion may result in the formation of hypoxic conditions in the sediments with potentially deleterious effects on the invertebrate infauna.The potential impactsof hypoxia are considered to be of low intensity and although the effects may persist over the short- to medium term, they are considered to be of **LOW** significance both without and with mitigation.

Mitigation

No mitigation measures are possible or deemed necessary.

Development of hypoxic sediments

	Without Mitigation	**Assuming Mitigation**
Severity	Low	Low
Duration	Short to Medium term: although hypoxic conditions would be transient, their effects on infaunal communities would extend over the short- to medium-term	Short-term
Extent	Site specific: limited to area of accretion	Site specific
Consequence	Low	Low
Probability	Seldom	Seldom
Significance	Low	Low
Status	Neutral: unlikely to vary beyond natural oxygen concentrations	Neutral
Confidence	High	High

Nature of Cumulative impact	Biota in the Benguela ecosystem have behavioural and physiological mechanisms for coping with this feature of their habitat so cumulative impacts are unlikely
Degree to which impact can be reversed	The impact is fully reversible
Degree to which impact may cause irreplaceable loss of resources	Low
Degree to which impact can be mitigated	None

6.2.6 Sediment mobilisation and redistribution

The overburden sands placed on the shoreline to achieve accretion will to some extent be reworked into the nearshore zone by wave action until the long-term equilibrium profile of the new beach is reached. The addition of sediments will result in the steepening of the beach profile, which in turn will lead to increased erosion of sediments by wave action. Some sediments will be carried offshore by undertow and rip currents and deposited beyond the surf-zone, to be returned shoreward again in calm conditions. Modelling studies suggest that the eroded sediments would be rapidly redistributed alongshore by wave-driven currents, initially leaking southwards out of Mitchell's Bay and ultimately extending seawards on the seabed beyong the mouth of the bay (WSP 2015).

These indirect effects manifest themselves as the inundation of reefs by sand, and corresponding responses by the benthic faunal and floral communities. In South Carolina, the effects of increased siltation and smothering from sand movement following beach replenishment were considered to have a greater impact on hard substratum habitats than on the replenished sandy shoreline. Smothering of nearshore reef habitats resulted in the loss of productive fishing grounds and declines in the nearshore fish communities (Van Dolah et al. 1994). Monitoring at various mining sites in southern Namibiahas shown that such mobilised and re-deposited sediments can have severe impacts on intertidal and shallow subtidal rocky shore habitats bordering the mined beaches and at some distance away, with both temporary and permanent loss of rocky intertidal habitats being reported as a result of shoreline accretion (Clark et al. 2004, 2005, 2006; Pulfrich & Atkinson 2007; Pulfrich et al. 2007, 2008; Pulfrich et al. 2010, 2011; Pulfrich & Branch 2014a, 2014b; Pulfrich et al 2015).

There are three possible avenues for depositing sediments to influence rocky-shore communities: (1) smothering that depletes all or some groups thereby affecting community diversity (Littler et al. 1983; McQuaid & Dower 1990); (2) alteration of supply of particulate materials with potential enhancement of suspension-feeders (Menge 1992); (3) ripple effects by which depletion of taxa in higher trophic levels influences the abundance of those in lower trophic levels (Littler & Murray 1975; Hawkins & Hartnoll 1983, Littler et al. 1983; Hockey & Bosman 1986; Branch et al. 1990; Eekhout et al. 1992). These predicted effects have all, to a greater of lesser extent, been observed in rocky shore communities in the vicinity of coastal mining operations in southern Namibia, and would, to some extent, be expected in the Mitchell's Bay area. Once constructed, the erosion and mobilisation of sediments from the berms is not expected to significantly exceed natural long-shore littoral drift, andnatural cyclical sedimentation processes on adjacent rocky shores or nearshore reefs willin all likelihood mask any mining-related effects.However,during the accretion of Mitchell's Bay with overburden sands,smothering of reef habitats in and beyond the mining site are expected, with concomitant changes in benthic communities, or in the worst case, complete loss of the reef habitat. Although likely only affecting a few kilometres of coastline, some of the coastal habitats in Namaqualand have been identified as 'vulnerable', 'endangered' or 'critically endangered' and any deterioration or loss of such habitats should be actively avoided.

The impacts associated with the mobilisation and redistribution of sediments from berms or accretions of the Mitchell's Bay shoreline are considered to be of high intensity and as they may persist over the short- (open coast) to medium term (Mitchell's Bay), they are considered to be of **MEDIUM** significance both without and with mitigation.

Mitigation

No mitigation is feasible other than the 'no-go' option.

Sedimentation of intertidal and subtidal reefs		
	Without Mitigation	**Assuming Mitigation**
Severity	High	High
Duration	Short to Medium term: although sediments in the nearshore will be continuously resuspended by wave action, natural erosion following accretionof Mitchell's Bay is likely to only occur over many years. Erosion of accreted sediments on rocky shores on the open coast will occur over the short term	Short to Medium term
Extent	Local: extending beyond the boundary of the mining target	Local
Consequence	Medium	Medium
Probability	Continuous: for the duration of the mining operation	Continuous
Significance	Medium	Medium
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Cumulative impacts are highly likely during the life-of-mine
Degree to which impact can be reversed	The impact is only partially reversible over time
Degree to which impact may cause irreplaceable loss of resources	Medium
Degree to which impact can be mitigated	None

6.2.7 Impacts on higher-order consumers

Although recovery of invertebrate macrofaunal communities following disturbance of beach habitats generally occurs within 3 - 5 years after cessation of the disturbance, the species inhabiting beaches are all important components of the sandy-beach food chain. Most are scavengers, particulate- and filter-feeders that depend on inputs of detritus or beach-cast seaweeds (Brown & Odendaal 1994). As such, they assimilate food sources available from the detrital accumulations typical of this coast and, in turn, become prey for surf-zone fishes and shorebirds that feed on the beach slope and in the swash- and surf-zones. By providing energy input to higher trophic levels, they are important in nearshore nutrient cycling. The reduction or loss of these assemblages in the long-term may thus have cascade effects through the coastal ecosystem (Dugan et al. 2003). Similarly, recovery of rocky intertidal habitats occurs over the short-term, but these also serve as important feeding habitats for shore birds. The negative effects on higher order consumers (surf-zone fish and shorebirds) of changes in abundance of macrofaunal prey itemsas a consequence ofbeach nourishment operations in North Carolina have been demonstrated (Peterson et al. 2000; Lindquist & Manning 2001). However, considering the extremely localised nature of the proposed mining operations in comparison to the available coastal feeding-ground habitat for the fish and shorebirds, and the relatively quick recovery of benthic communities following disturbance, the effects of these higher order consumers can be considered negligible (see also Essink 1997; Baptist et al. 2009).

Due to recovery over the short-term of the invertebrate communities that serve as a food source for higher-order consumers, the potential impactsare considered to be of low intensity and are thus considered to be of **LOW** significance both without and with mitigation.

Indirect effects on higher-order consumers		
	Without Mitigation	**Assuming Mitigation**
Severity	Low	Low
Duration	Short-term: as recovery of invertebrate communities that serve as food sources occurs within 2-5 years	Short-term
Extent	Site specific: limited to mining area	Site specific
Consequence	Low	Low
Probability	Seldom	Seldom
Significance	Low	Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Cumulative impacts are unlikely as being highly mobile, affected species can move to adjacent available feeding grounds
Degree to which impact can be reversed	The impact is fully reversible
Degree to which impact may cause irreplaceable loss of resources	Low
Degree to which impact can be mitigated	None

6.2.8 No-development Alternative

The "no-development" alternative implies that the beach and offshore channel mining operations will not go ahead. From a marine perspective this is undeniably the preferred alternative, as all impacts associated with beach disturbance, shoreline accretion, loss of habitat and indirect sedimentation will not be realised. This must, however, be seen in context with existing mining and exploration rights andsustainability of the associated mines, and thus needs to be weighed up against the potential positive socio-economic impacts undoubtedly associated withaccessing the potentially rich diamond depositspresent in the surf zone.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Environmental Acceptabilityand Impact Statement

The main marine impacts associated with the proposed mining activities are related to disturbance and loss of sandy and rocky habitats and their associated benthic flora and fauna in the mining footprint. From the results of past studies, it is now well established that mining in the intertidal zone of sandy beaches using seawall/coffer dam technologyand active beach accretion severely influences the diversity and community structure of the invertebrate macrofauna of the beach itself, and potentially the benthic biota of adjacent rocky intertidal and shallow subtidal habitats as well. However, as shoreline accretion and berm construction are an unavoidable consequence of the proposed mining, there can be no direct mitigation for their impacts on marine biological communities. Other than the 'no go' option, the impacts to the intertidal and shallow subtidal marine biota are thus unavoidable should mining go ahead. As mining operations have been ongoing along this section of the coast for decades, however, the proposed mining targets cannot be considered particularly 'pristine'. Nonetheless, from a marine perspective the 'no go' option is undeniably the preferred alternative, as all impacts associated with the disturbance of beach and rocky habitats will no longer be an issue.

The proposed mining operations behind berms, or the accretion of Mitchell's Bay will without a doubt severely impact the affected habitats and their associated communities. However, the impacts will remain localised, and will therefore not be substantial on a regional scale. Provided construction and mining activities are not phased over an extended period, the beaches and rocky shores are not repeatedly disturbed through persistent activities, and suitable post-construction rehabilitation measures are adopted, the impacted communities are likely to recover in the short- to medium-term (i.e. over a period of 2-5 years). Recolonisation of the mined area will be rapid and natural ecological functions and processes will thus continue albeit in a modified way. The benthic populations of the beaches and rocky shores are highly variable, on both spatial and temporal scales, and subject to dramatic natural fluctuations, particularly as a result of episodic disturbances such as unusual storms, low oxygen events and periodic flooding of the ephemeral coastal rivers. As a consequence, the biotaare considered to be relatively resilient, being well-adapted to the dynamic environment, and capable of keeping pace with rapid changes (McLachlan & De Ruyck 1993).

The highly localised, yet significant impacts of coffer dam mining along the open coast will endure over the short- to medium term, and these impacts thus need to be weighed up against the long-term benefits of the mining project. Provided the impacts are meticulously managed and pro-active rehabilitation is undertaken as far as is feasible in the coastal environment, there is no reason why the proposed mining of the open-coast beaches using coffer dams should not go ahead.

However, it is not the faunal communities which are the most distinctive feature of these shorelines, but rather the geomorphology and landforms resultingfrom natural erosional processes, particularly the cliffs in Mitchell's Bay. Although the beach and rocky shore communities within this bayare unlikley to be uniquefrom amarine biodiversity perspective nor even particularly species rich, the bay itself with its landward fringing cliffs and dunes is scenically attractive and geomorphologically distinctive on the Namaqualand coast.Every effort should thus be made to protect such coastal landforms from visual degradation and disturbance, particularly when engineering designs implemented to realise productive mining within the bay will persist over the long term as active rehabilitation below the low water mark is notfeasible.

If all environmental guidelines, and appropriate mitigation measures advanced in this report, and the SEIA for the proposed project as a whole, are implemented, there is no reason why the marine mining operations proposed along the open coast should not proceed.However, every effort should be made to avoid disturbance, even on a localised scale, of benthic habitats identified as 'endangered' or 'critically endangered' by Sink et al. (2012). Mining of Mitchell's Bay, either by beach accretion or berm or groyne construction, is however, not recommended from a biodiversity and geomorphological perspective.

The impacts identified above, along with other areas of concern raised by stakeholders during the scoping process and highlighted in this document, are addressed in more detail in the EMPr. The process followed meets the requirements of the MPRDA and of NEMA to ensure that the regulatory authorities receive sufficient information to enable informed decision-making.

7.2 Mitigation Measures and Management Actions

Environmental management actions for implementation in WCR's Environmental Management System should focus on the following aspects to be considered prior to, during and on cessation of mining activities in an area:

- Develop the mine plan to ensure that mining proceeds systematically and efficiently from one end of the target area to the next, and that the target area is mined to completion in as short a time as possible.
- To allow impacted communities to recover to a condition where they are functionally equivalent to the original condition, the beaches should not be re-mined for at least five years, if at all. Efficient, high intensity mining methods are thus preferable to repeated operations.
- To prevent degradation of the sensitive high-shore beach areas, all activities must be managed according to a strictly enforced Environmental Management Plan. High safety standards and good house-keeping must form an integral part of any operations on the shore from start-up, including, but not limited to:
    - drip trays and bunding under all vehicles and equipment on the shore where losses are likely to occur;
    - no vehicle maintenance or refuelling on shore;
    - accidental diesel and hydrocarbon spills to be cleaned up accordingly; and
    - collect and dispose polluted soil at appropriate bio-remediation sites.
- To avoid unnecessary disturbance of communities and destruction of habitats, heavy vehicle traffic in the high- and mid-shore must be limited to the minimum required, and must be restricted to clearly demarcated access routes and operational areas only. The operational footprint of the mining site should be minimised as far as practicable.
- Initiate restoration and rehabilitation as soon as mining is complete in an area. This should involve removal (and re-use) of as much of the rock armour off the berms as possible, levelling of seawalls above the low water mark to facilitate more rapid natural erosion by the sea, back-filling excavations using seawall material, tailings and discards