and restoring the beach profile to that resembling the pre-mining situation. No accumulations of tailings should be left above the high water mark.

- Berms or groynes should be designed in such a way that they will erodenaturally as rapidly as possible as soon as active maintenance ceases. Once mining has been completed in an area, as much of the berms as possible should be actively removed, leaving onlythose portions below the low water mark to be eroded naturally.
- On cessation of operations, all mining equipment, artificial constructions or beach modifications created during mining must be removed from above and within the intertidal zone.
- To quantify the full impact of the mining using berms on the beaches in the mining and prospecting licence areas, it is recommended that a structured Before-After/Control-Impact (BACI) monitoring programme be implemented. The experimental design and details of this programme should be compiled in collaboration with the DEA: Oceans & Coasts. Monitoring should commence before mining starts, be undertaken for at least as long as mining remains in operation, and thereafter to determine the rate of recovery. Monitoring should continue until communities in the impacted areas show evidence of having recovered to within 80% of levels at suitable 'reference' sites (bioequivalence tests) over a minimum of at least three successive years. However, following each survey the status of the beach should be re-assessed and the sampling programme revised to reflect both changes in the impacted communities as well as changes to the mining plan(s). The requirements for a monitoring programme and the proposed methodology are presented in Appendix I.
- In the case of diver-assisted shore-based mining operations, the following mitigation measures should be implemented:
  - 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.

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APPENDIX I

REQUIREMENTS FOR A MONITORING PROGRAMME TO DETECT ENVIRONMENTAL IMPACTS OF COFFER DAM MINING AND ACCRETION ON THE MARINE ENVIRONMENT

In identifying and assessing environmental impacts it is important to acknowledge that change is not necessary unnatural nor is it due to human disturbance alone (Green 1979, 1993). An impact should not therefore be characterised as being the difference in some measure at a particular site before and after a disturbance only. An impact should be characterized as being the relative difference between changes at a disturbed site (*i.e.* the change from before to after a disturbance) compared with changes that have occurred in a similar undisturbed (or control or reference) site (Underwood 1992, 1993, 1994). In other words there must be some change from before to after a disturbance and such change must be different from what occurred in undisturbed control areas. To achieve this it is necessary to study communities in impacted and reference sites prior to (provided that this is of course possible) and after an impact has occurred. If such conditions are not met, the interpretation of the impact will be compromised (Underwood 1996).

Having established the basic protocol required for an impact assessment, several decisions have to be taken with regard to how one should proceed with the research or monitoring program. The most important of these include how much monitoring should be undertaken (intensity, frequency and duration), what in terms of community parameters should be monitored and, if monitoring is continued through to the recovery stage, when can a site be declared fully rehabilitated. Central to all of these is the question of how much change or disturbance matters. Two sorts of mistakes are inherent in monitoring programs because of the need for statistical analyses. Type I error occurs where results of a monitoring program suggest that there has been an environmental changes when there has not. Type II errors occur when there has been an environmental change but the monitoring program fails to detect it. The most common reason for the occurrence of Type II error is a sampling program that it poorly designed or one that is not comprehensive enough (i.e. insufficient samples) (Underwood 1996). Assuming that the whole point of a monitoring program is to illicit managerial response in the event that there is an impact, Type I error should become self-correcting (further investigation is likely to expose the error). (It may however result in a waste of money, time, resources, reputations and possible loss of economic activity). In contrast Type II error elicits no response. The cost is in terms of the environment - environmental degradation continues unnoticed.

In terms of environmental management, precautionary principals require that more attention be paid to Type II error, such that this is unlikely to occur (Mapstone 1995; Underwood 1996). The only realistic trade-off is to increase the probability of the Type I error until costs of errors (the cost of responding to a non-existent environmental threat) are likely to be unacceptably high. Then trade back the rate of the Type I error in return for more resources for sampling. The potential costs to society through crying wolf - mistakenly declaring there to be an environmental change because of a Type I error - can be reduced provided proper resources are made available to detect real changes (i.e. to have a small probability of Type II error).

To quantify the full impact of the proposed coffer dam mining or accretion of Mitchell's Bay on the marine environment, all affected habitats and/or communities should be monitored before, during and after mining. However, prior research has indicated that this is impractical, impossible or simply unnecessary. Monitoring should rather focus on what are likely to be the most sensitive, significantly affected and/or representative species, communities, habitats and resources. The proposed mining areas comprises intertidal sandy beach and rocky shore habitat, as well as subtidal sandy and rocky habitats. A suite of standard, and widely accepted techniques have been developed for the monitoring of benthic communities associated with thesehabitats, and it is proposed that these be adopted for this study. These techniques include both univariate and multivariate statistical analyses. Vertebrate communities, specifically birds and fish, associated with surf-zone habitats require a different approach. Previous studies have shown that these highly mobile animals are generally not significantly affected by beach mining operations. Monitoring of these populations is therefore considered unnecessary.

The final question that needs to be resolved, is how long should a habitat appear to be restored before it can be declared restored? It is now widely accepted that when assessing recovery following a disturbance event, the classic scientific approach of testing a null hypothesis is not really valid (Dixon & Garrett 1992; McDonald & Erickson 1994; Underwood 1996). The classic approach is an attempt to reject or disprove the "null" hypothesis, which assumes that two populations are identical. The alternative hypothesis, that the two populations are not identical, can only be accepted if the probability that any differences detected are due to chance alone is less than 5%. In deciding whether an impact has occurred, this approach is perfectly acceptable, as it largely eliminates the probability of declaring a false positive i.e. that an impact has occurred when this is not the case. However, when we are assessing recovery, this is not the case. We have accepted that an impact has occurred (otherwise we would not be monitoring recovery), and we now wish to establish an end point at which we can declare recovery complete. The approach proposed as an alternative to the classic significance testing is known as the test for bioequivalence. The approach is to define two areas to be bioequivalent if, for example, the mean density of a particular organism or organisms on the impacted site exceed a predefined percentage (R say 80%) of the mean density on the reference site for a defined time interval. Conversely, a site is said to be impacted or disturbed until the selected variable(s) exceed(s) the predefined level over a defined time interval. This procedure is commonly used in testing the equivalence of drugs (Kirkwood 1981; Westlake 1988) and is becoming more popular in other biological sciences (Dixon & Garret 1992; McDonald & Erickson 1994). It has recently been successfully applied in assessing recovery of deepwater invertebrate macrofauna following remote mining (Clark 2014), as well as beach macrofauna following seawall mining and shoreline accretion in southern Namibia (Pulfrich et al. 2015). Full details of the test are contained in McDonald & Erickson (1994).

One of the greatest merits of this approach is that it recognises (a) that systems are naturally variable and (b) that one does not always have "adequate" baseline data for the assessment of the significance of a particular impact. It also recognises that while physico-chemical factors are an important determinant of the structure of biotic communities, other biological factors (such as timing of recruitment and variations in recruitment success which, to some extent are linked to the abundance of adults in neighbouring areas, as well as competition and predation) also play an important role in structuring biotic communities, which can vary greatly in both space and time even when biophysical conditions remain constant (see for example Hall 1994; Kenny & Rees 1994, 1996; Herrmann et al. 1999; Ellis 2000; Schratzberger et al. 2004a).

The predefined percentage is necessarily site- or situation-specific, but the value of 80% seems to have attained fairly wide acceptance (McDonald & Erickson 1994; Underwood 1996). Similarly, the number of successive intervals over which this value should be achieved is site- and situation-specific but also depends on the sampling interval. It is proposed that sampling of sandy beach invertebrates, and rocky intertidal and subtidal benthic communities be conducted annually. Selected parameters include measures of the abundance and/or biomass of the communities or certain key species in each case, as well as a measure of the diversity of the community as a whole (e.g. Shannon-Weiner Diversity), and that the value of R must exceed 80% in each case for at least three to five years before a site can be considered to have recovered.For the purposes of this study, the term recovery would thus be defined as: "the re-establishment of ecological function through colonisation of previously mined areas by marine faunal communities that can be considered to be functionally equivalent to those that exist in comparable undisturbed sites, taking into account natural variability, as judged by the fact that they are at least 80% similar in terms of their species composition, abundance and biomass, measured over a period of at least 3-5 years". The bioequivalence tests should also be supplemented with standard multivariate graphical and statistical tests (e.g. hierarchical cluster analysis, multidimensional scaling, ANOSIM) for which no bioequivalent alternatives exist. Levels of significance for these tests should be set at 95%.

A graphic depicting how such a process may play out in the case of the assessment of mining impacts, as presented in Clark 2014) is shown in Figure 1 below. The blue and purple line represents the average number of individuals, biomass or species at a suite of stations at reference sites outside of the mining area, and a second group in close proximity to the area being mined (Discharge), but potentially affected by other mining-related activities, respectively (in the example the 'indirect' effect was the discharge onto the beach of a sediment slurry of fine tailings from an on-site processing plant to aid with accretion). The red line represents average abundance at a suite of stations in an area that is subject to mining during the course of the study. The dots on each line represent average values derived from discrete samples collected, in the example, at quarterly intervals (every 3 months) at these respective sites. The horizontal dotted lines indicate abundance/biomass/no. species for all the referencesites averaged across the full time period of the study, and the 80thpercentile for these sites. Sampling at all sites commenced 2 years before mining started and continued until it was established that the biota at the referencesitesin close proximity to the impact site (Discharge) and at the mined sites (Impact) had recovered to a level where the average abundance/biomass/no. species (dotted red line) had recovered within the 80thpercentile for the reference stations (blue shaded area). Note that in this diagram abundance at the reference station in close proximity to the impact site (Discharge) dropped during the construction phase but recovered again shortly thereafter.

In light of the above, an impacted site would be considered recovered or "functionally equivalent" if the data measured over a period of at least three years falls between the 20th and 80thpercentiles of the reference and baseline data. Should the pre-mining and reference site data show extremely high variability, the more conservative approach of using the 25th to 75thpercentile can be adopted.

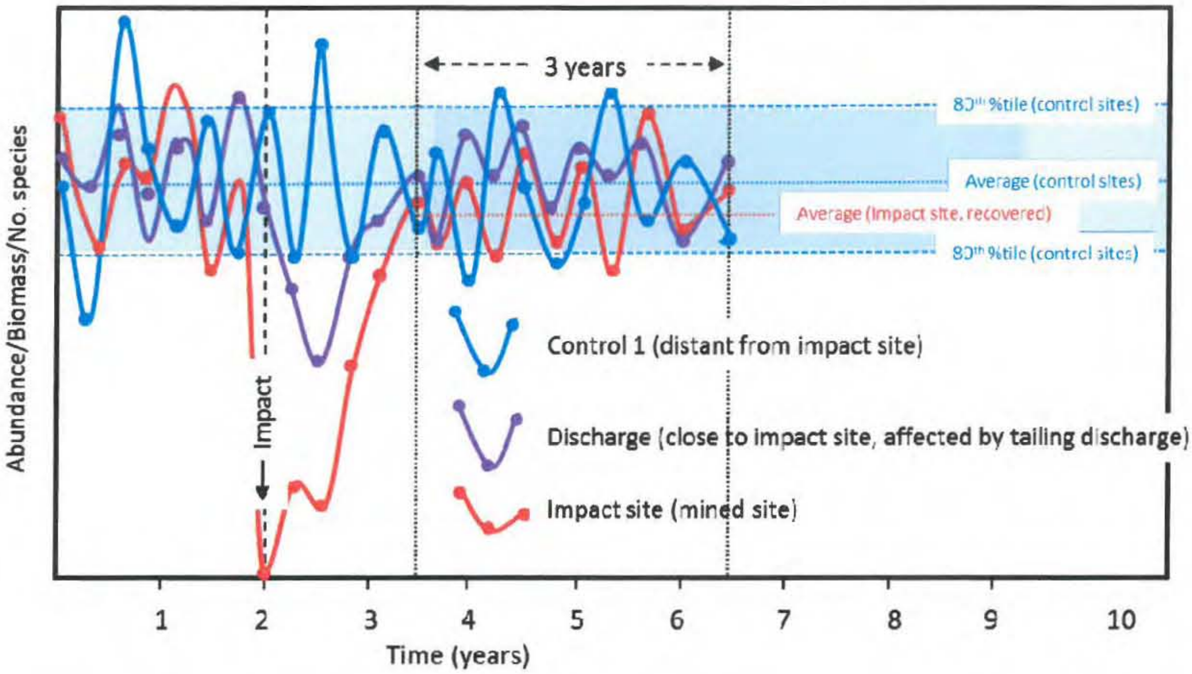

Figure 1: Graphic demonstration of procedures for monitoring environmental impacts and recovery. See text for details. Source: Clark (2014)

PROPOSED METHODOLOGY FOR MONITORING OF SANDY BEACHES, ROCKY SHORES AND SUBTIDAL REEFS

The monitoring study should consider both physical and biological parameters at reference sites some distance from the mining sites and at sites targeted for cofferdam mining or beach accretion.Monitoring sites would span three habitat types, namely 1) sandy beaches, 2) intertidal rocky shores, and 3) shallow subtidal reef habitats. It is recommended that the respective sites be selected following a site visit and in close collaboration with both the mine planners and DEA: Oceans & Coast. Monitoring should be conducted on an annual basis starting a minimum of two years prior to that in which mining commences, and continuing until all impacted communities have recovered to acceptable levels as defined in the monitoring program requirements outlined above. It is recommended that sampling be conducted at approximately the same time (March-June) each year to eliminate any seasonal variations.

The intertidal beach and rocky-shore surveys have to be undertaken over a spring tide period when the tides are low enough to permit access to the low shore. Because the amplitude of any given spring tidal movement can vary considerably during the course of a year, the timing of surveys is crucial if accurate and reliable data are to be collected. Consequently, surveys must be scheduled over spring tides when the height of the low tides above chart datum (= Lowest Astronomical Tide) is at a minimum. A 'rule of thumb' for intertidal surveys is that data is only collected when the height of the low tide is 0.25 m or less, above chart datum. As natural variables such as oceanic swell and wind-induced waves will affect the predicted tidal levels, it is all the more critical that surveys are conducted during the lowest possible tides.The lowest spring tides during the year usually occur between February - June and in some years between August - October. Commencement of the monitoring programme will be determined by the mine plan.

The recommended methodologies for the quantitative collection of community data in each of the habitat types is detailed below.

Sandy Beach Macrofauna

Beach faunal community sampling would be carried out using established sandy-beach sampling techniques. At each identified sampling site three transects, perpendicular to the shore and spaced 5 m apart, would be surveyed from above the drift line to the lowest point of the swash during spring low tide. Ten stations would be positioned along each transect line at equal horizontal intervals across the beach face. At each station, three 0.1-m^2 quadrat samples would be excavated to a depth of 30 cm, and the sediments rinsed in a 1-mm mesh sieve bag. All macrofauna retained in the sieves would be preserved in 96% alcohol, and identified to the lowest taxonomic level possible. Dry biomass of all fauna would be obtained by drying the specimens at 60°C for 24 hours. Macrofaunal densities would be expressed as the number of individuals per square metre, and the biomass as $g.m^{-2}$.

A variety of physical parameters will also be measured at each site. These will include wave height and period, surf-zone width, beach profile and water table depth. Sediment samples will be collected from Station 1 (the drift line), Station 5 (mid-shore) and Station 10 (spring low water mark). In the laboratory, the sediment samples will be passed through a series of graded sieves to determine the grain-size composition. Graphic methods will be used to obtain the mean particle diameter, sorting and skewness of the sediments. These physical data will be used to calculate the dimensionless fall velocity (or Dean's value, Ω) and to rate each site in terms of wave exposure. Using the dimensionless fall velocity an indication of the beach morphodynamic state will be provided.

Rocky Intertidal Macrobenthos

The macrobenthos of rocky intertidal areas would be sampled in six 0.5-m^2 quadrats along each of five replicate transects laid perpendicular to the shore between the mean low water spring and mean high water spring marks. The quadrats are divided into a regular 50x50 mm grid pattern giving 171 intersecting points in a 1 x 0.5 m frame. The individual species occurring in the algal canopy would be recorded under each intersecting point as primary and secondary cover, as would be rare species and mobile organisms within the quadrat. The point counts would be used to calculate the mean percentage cover of all species (both mobile and sessile), and the counts of individual mobile organisms to calculate densities within the quadrat area. Data on mean percent cover and abundance for the community as a whole, individual species and trophic groups would then be compared.

Shallow Subtidal Reefs

Experienced scientific divers, familiar with underwater census techniques and identification of benthic organisms, will be used to conduct the underwater benthic assessmentswithin Mitchell's Bay and at an equivalent reference site. Dive sites will be selected in three depth zones namely, 1-5 m, 5-10and 10-15 metres below mean sea level. At each dive site, two divers will each conduct 5 point counts at 5-m intervals along transects across the seabed. Within a 2-m diameter circle at each point, the seabed type (percentage composition of rock, boulders, gravel or sand), reef profile (height in metres) and structure (degree of ledging and under-cutting - see Table I) will be recorded. To minimise individual dive time at the depths surveyed, and maximise the number and coverage of dives over the survey area, quantitative benthic quadrats will not be attempted. Instead, the percentage cover of principal benthic community components within the surveyed 2 m will be estimated and ranked using the Braun-Blanquet scale of coverage categories (Kent & Coker 1992, see Table 1). This scale uses smaller categories at lower coverage, ensuring that scarcer species are not outweighed by abundant species in subsequent analyses.

Various benthic studies have indicated that there is considerable redundancy in the species which characterise the composition of benthic communities (Clarke & Warwick 1994; Warwick 1993). This redundancy often allows analysis at higher taxonomic levels, rather than at species level, without weakening the results (Warwick 1988a, 1988b, 1993; Ferraro & Cole 1990; Vanderklift et al. 1996; Bowman & Bailey 1997). As many of the taxa encountered in the southern African west coast hard-bottom epifauna are undescribed and detailed identification by divers is slow underwater, organisms recorded during dives will be aggregated into larger, predefined taxonomic groups (Classes or Families) during actual data collection.

The successful completion of the shallow subtidal surveys will be dependent on sea conditions. Typically a wave height of <1.5 m is required for confident and accurate underwater data collection.

Table 1. Ranking scales used for estimating the percentage cover of benthic organisms and the degree of crevicing or overhang of reef structure.

Benthic Communities Rank	Braun-Blanquet scale % Coverage	Reef structure Rank	Extent of crevicing/overhang
0	<1%	0	Flat
1	1-5%	1	0.5 m
2	6-25%	2	1.0 m
3	26-50%	3	1.5 m
4	51-75%		
5	76-100%		

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7.1.2. Marine monitoring recommendations

ENVIRONMENTAL IMPACT ASSESSMENT IN SUPPORT OF THE AMENDMENT TO THE MINING RIGHT HELD BY WEST COAST RESOURCES (PTY) LTD OVER THE NAMAQUALAND MINES, NORTHERN CAPE PROVINCE

Marine Monitoring Proposal

Prepared for:

MYEZO ENVIRONMENTAL MANAGEMENT SERVICES
Environmental Stewardship

On behalf of:

West Coast Resources

July 2016

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Pisces Environmental Services (Pty) Ltd

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INTRODucTioN

1.1 BACKGROUND

West Coast Resources (Pty) Ltd (WCR) intends to re-visit and mine a number of mines on the Namaqualand coast, particularly those in the existing mining licences for Koingnaas 475 and Samson's Bak 330. The acquisition of the existing mining rights in the South African Sea Concessions 8a and 9a, formerly held by Namagroen Prospecting and Investments, are also underway. As the mining approach would involve the construction of cofferdams in the intertidal area to optimise the extraction of coastal diamond resources, an amendment of the current environmental authorisations over these mining rights areas is being compiled, and an Environmental Impact Assessment (EIA) process is underway to obtain environmental authorisation for the proposed new activities.

The marine ecology specialist assessment compiled as part of the EIA, put forward various environmental management actions for implementation in WCR's Environmental Management System. That of most relevance here is summarised below:

- To quantify the full impact of the mining using cofferdams and beach berms, it is recommended that a structured Before-After/Control-Impact (BACI) monitoring programme be implemented. Monitoring should commence before mining starts, be undertaken for at least as long as mining remains in operation, and thereafter to determine the rate of recovery. Monitoring should continue until communities in the impacted areas show evidence of having recovered to within 80% of levels at suitable 'reference' sites over a minimum of at least three successive years.

The requirements for such a monitoring programme and the proposed methodology were subsequently presented in an Appendix, which for the sake of completeness is included below. Following discussions with the Oceans & Coasts section of the Department of Environmental Affairs (DEA: O&C), the proposed methodology has been expanded and amended to form the basis of WCR's proposed marine monitoring programme.