Proposed Deepening, Lengthening and Widening of Berth 203 to 205, Pier 2, Container Terminal, in the Port of Durban

Ecological Risk Assessment pertaining to the creation of Estuarine Habitat in Durban Bay by extension of the Central Sandbank
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January 2014

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For bibliographic purposes this report should be cited as:
CSIR and Anchor Environmental (2014). Ecological Risk Assessment pertaining to the creation of Estuarine Habitat in Durban Bay by extension of the Central Sandbank. CSIR/NRE/ECOS/ER/2014/0002/C.
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1 Introduction

Transnet National Ports Authority (TNPA) has proposed infrastructural upgrades in the Port of Durban in order to cater for safe operating requirements of fully laden new generation Super Post-Panamax container vessels and to meet the demands of projected growth in container trade. Specifically deepening, lengthening and widening of Berths 203-205 of Pier 2 has been proposed. Potential environmental impacts of this proposed development have been investigated as part of an Environmental Impact Assessment (EIA) process.

The final EIA report (dated 01 August 2013) was rejected by the Department of Environmental Affairs (correspondence DEA Reference: 14/12/16/33/3275 signed on 21 October 2013) pending, in part, clarity on the certainty and risks associated with the creation of sandbank habitat which was proposed in mitigation for unavoidable losses of sandbank which would be incurred should the proposed development go ahead.

This document deals with this request and addresses ecological issues associated with the proposed creation of sandbank habitat in the Port. Engineering (physical) risks associated with the proposed creation of sandbank habitat and those associated with climate change (sea level rise) have been addressed in separate reports prepared by ZAA Engineering Projects and Naval Architects (Pty) Ltd (ZAA 2014a and 2014b, respectively). Specific issues requiring clarity and questions posed by the Department of Environmental Affairs in their letter in respect of ecological issues were as follows:

- What are the baseline thresholds of acceptable change against which monitoring will take place?
- What actions are proposed if the monitoring results detect change?
- What are the socio-economic and ecological implications should the proposed mitigation measures prove not to be successful?
- All potential risks and mitigation measures associated with the creation of a portion of the Central Sandbank as a mitigation measure must be fully assessed and addressed in the amended EIA report.
- Consideration needs to be given as to how realistic and practical the mitigation measure is and what costly commitment and assurances have been provided by the applicant to implement this measure.

This report provides a brief summary of the findings of the original ecological impact assessment as captured in specialist study reports that were incorporated into the original EIA (Anchor Environmental 2012a, b, c, CSIR 2012a, b), a summary of the engineering feasibility and risk assessment for sandbank creation (ZAA 2014) (which addresses in part Questions 4 and 5 above), and an ecological risk assessment which seeks to provide answers to aspects of Questions 1-5 above, not addressed in the Engineering risk assessment.
2 Summary of the EIA ecological assessment

An ecological assessment of potential impacts of the proposed Pier 2 Container Terminal development on sandbank habitats, water and sediment quality in Durban Bay and of offshore disposal of dredge spoil was conducted and submitted as a series of specialist study reports that were incorporated into the original EIA (Anchor Environmental 2012a, b, c, CSIR 2012a, b). These reports assessed potential short and long term ecological impacts of the proposed development on sandbank habitats in the Port of Durban, and the potential impacts of changes in hydrodynamic circulation (caused by changes in sandbank morphology) on water and sediment quality in the port. The assessments relied on hydrodynamic modelling to investigate changes in currents over the sandbanks which might result in changed erosive forces and have implications for the Central Sandbank’s long term stability and its ecological function and of potential impacts on water quality in the Port of Durban caused by dredging operations (CSIR 2012a, ZAA 2012a, b, c). The ecological assessments addressed all the major fauna and flora groups that could potentially be affected by the developments including microalgae (phytoplankton), invertebrates (benthic invertebrates and zooplankton), fish and birds. Risks to macrophytes (notably mangroves) were identified as being negligible and were not assessed in detail in these reports. The work conducted focussed on several different design options and bathymetric layouts to include mitigation measures. It included quantitative assessments of habitat loses and gains associated with these options (based on linking predictive hydrodynamic modelling outputs and spatial analysis using a Geographic Information System) and qualitative ecological desktop study.

The only tidal banks found to be impacted by the proposed development were the Bay’s Central Sandbank and Little lagoon. Most affected would be an area of sandbank at the western end of the Central Sandbank near the Little Lagoon. This involved loss of intertidal sandflat as well as sloping subtidal sandbank. Some sloping subtidal sandbank at the eastern extremity of the Central Sandbank would also be lost owing to the need for scour protection to prevent larger scale long term losses associated with the creation of a ship turning basin. Mitigated design layouts involved a downsized turning circle resulted in reduced encroachment into the eastern tip of the Central Sandbank. Mitigation also made provision for the creation of a significant area of tidal sandbank by infilling an area of current deep water habitat. The final development option assessed (Option 3H) resulted in the lowest impact in terms of habitat losses when all tidal elevation zones were considered and was clearly the preferable alternative to other development options assessed. The layout actually results in a slight increase in sandbank habitat in Durban Bay (i.e. no net loss of sandbank habitat). This was achieved through significant gains in low intertidal and shallow subtidal habitat by extension of the Bay’s Central Sandbank. As such it was deemed the preferred option in terms of estuarine habitat considerations.

Design Option 3H was found to result in a net gain of 0.03% of sandbank habitat in Durban Bay representing an increase of 13520 m$^2$ of estuarine habitat. Habitat losses were shown to be incurred in high intertidal and deep subtidal areas, but these were offset by gains in low intertidal and shallow subtidal sandbank habitat. Low intertidal and shallow subtidal sandbank habitats especially have higher value as nursery habitat for estuarine fishes and crustaceans than high intertidal and deep subtidal areas.
Changes in hydrodynamics associated with a changed bathymetry were found to result in changed bed shear stresses on the Central Sandbank. However, in terms of structural changes in benthic habitats these changes are largely insignificant, except for the region between the Berth 205 extension and Little Lagoon where the sediments are expected to become coarser in nature. Results indicated that changes in water fluxes associated with the development across most of the port would be minimal. Significant long term changes to water and sediment quality in the Bay were therefore deemed unlikely.

The assessment concluded that while Development Option 3H would undoubtedly result in a modified ecosystem functioning compared to the present layout of the port and the Bay’s sandbanks, its residual impact would be neutral if the sandbank creation mitigation proposed was successfully implemented. Indeed, successful utilisation by estuarine biota of the increased low intertidal and shallow subtidal habitats could result in a residual positive impact.

Potential impacts associated with elevated suspended sediment concentrations in the water column and toxicity of heavy metals, hydrocarbons and polychlorinated biphenyls in the suspended dredge material were also assessed in the EIA process (Anchor Environmental 2012a). The concentrations of metals and organic chemicals in sediment within and near the dredging footprint were found to be low (CSIR 2012b), and thus it was concluded that there was a very low probability that chemicals released from the sediment during the dredging and spoil disposal processes will be present in the water column at toxic concentrations. Hydrodynamic model simulation studies undertaken to assess impacts of the proposed dredging programme on suspended sediment concentrations in the water column (ZAA 2012b) indicated that suspended sediment concentrations in the water column would approach 80 mg.L\(^{-1}\) in the immediate vicinity of the dredge head and the hopper (which places it firmly in the high risk category for microalgae, invertebrates and fish in accordance with the rating system developed by Steffani et al. (2003) for South African coastal waters, but that levels were not predicted to exceed 50 mg.L\(^{-1}\) at the Central Sandbank (i.e. in the medium risk category of Steffani et al. (2003). Suspended sediment levels in east coast estuaries tend to be naturally higher than those typical found in coastal waters in other parts of the country (Cyrus 1988, Cyrus and Blaber 1988), and the local fauna tend to be quite tolerant of such conditions. As such, it was concluded that provided levels of suspended did not exceed 50 mg.L\(^{-1}\), impacts on water quality would remain in the ‘low significance’ range but that this should be carefully monitored during dredging and that that dredging operations should be halted immediately if turbidity levels exceed this level at designated monitoring stations to be established adjacent to the Central Sandbank (Anchor Environmental 2012a).
3 Engineering feasibility and risk assessment for sandbank creation

Uncertainty regarding the feasibility of creating sandbank habitat using dredged materials to extend a section of the existing Central Sandbank in Durban Bay stems arise from engineering and ecological concerns. In terms of engineering the overriding issue is whether or not sandbank habitat can be created to emulate the existing Central Sandbank structurally, in terms of shape and sediment characteristics (granulometry, organic content and compaction) and whether or not this structure will be stable in the long term. An implicit assumption of the ecological assessment made in CSIR (2012a) and in further assessment in this document is that these requirements can be met. This was an issue that was discussed in meetings of the EIA project team and is formally addressed in an engineering risk assessment of the proposed extension of the sandbank (ZAA 2014).

From the ZAA assessment it is apparent that the shape of the existing sandbank can indeed be emulated. Design slopes of 1:4 will be stable and match and closely present slopes on the existing sandbank. Sediment characteristics will also be matched by selection of newly dredged material from within the port and an offshore borrow site. Moreover, these studies indicate that the proposed sandbank extension will be stable in the long term and that it will not endanger the stability of the existing sandbank during construction, or during operation of the container terminal (ZAA 2014).

4 Ecological risk assessment

4.1 What are the baseline thresholds of acceptable change against which monitoring will take place?

Baseline thresholds of acceptable change need to be established for at least three purposes on this project:

1. The first is to confirm that that defined maximum/minimum water quality thresholds (e.g. maximum turbidity and minimum dissolved oxygen levels in the water column) are not exceeded during the construction phase of the project. This will ensure that the maximum extent of the impact on the port environment is kept to a minimum.
2. The second is to confirm that biotic communities (microalgae, invertebrates, fish and birds) on the existing sandbank, some of which may be impacted by the project related activities, successfully recover to pre-impact levels.
3. The third is to confirm that the newly established sandbanks are successfully colonised by a similar suite of organisms and that they reach similar levels of abundance to those on the existing sandbanks. This will serve to confirm that any loss of sandbank habitat in the Port of Durban has been successfully offset by the newly established sandbank areas.

The baseline thresholds of acceptable change for each of these aspects will be derived from ecological baseline data that will be collected over a period of 12-24 months prior to the start of the project, along with ongoing monitoring at control stations outside of the zone of impact during and
after the end of the construction period (sediment and biota only). The baseline assessment will focus on the following components:

**Physico-chemical (habitat) variables**
- Total Suspended Solids (TSS)
- Salinity
- Temperature
- Dissolved Oxygen
- Sediment grain size distribution
- Organic carbon content
- Trace metal content in sediment (Cd, Hg, As, Cr, Cu, Pb, Ni, Zn).

**Faunal and floral assemblages**
- Benthic microalgae (microphytobenthos)
- Benthic macrofauna
- Fish
- Birds

Baseline water quality characteristics will be established by taking water quality measurements at a suite of 20 stations distributed in the navigation channel adjacent to Berth 203-205 and in the main channel of the port adjacent to the Central Sandbank. This will include a number of control stations that will serve as reference stations in the future that will be located outside of the influence of the proposed project activities (piling, dredging, and sandbank construction). Daily water quality measurements (salinity, temperature, dissolved oxygen and turbidity) will be taken at high tide with a hand-held water quality meter (Hach HQ40d) at the surface and bottom over a five day period each season (autumn, winter, spring, summer) (total of 800 measurements over 12 months).

Baseline sediment characteristics will be established through collection of sediment samples from 50 stations (10 supratidal, 20 intertidal and 20 subtidal) distributed on top and sides of the existing Central Sandbank in the Port of Durban on four occasions (autumn, winter, spring, summer) over the course of one year. Intertidal samples will be collected with a hand corer (10 cm diameter) and subtidal samples collected with a Van Veen grab. Samples will be placed in sampling jars on ice immediately after collection and submitted to an SANAS accredited analytical laboratory for determination of grain size distribution, organic and trace metal (Cd, Hg, As, Cr, Cu, Pb, Ni, Zn) content.

The baseline assessment for benthic microalgal biomass will be undertaken through collection and analysis of sediment samples from the same stations as for the sediment monitoring activities in accordance with methods prescribed by Pinckney and Zingmark (1993). Sediment cores will be taken by slowly inserting a plastic pipe of known diameter (≈20 mm), either directly into the sediment (in the case of the intertidal samples) or into the contents of the grab (in the case of the subtidal samples) down to a depth of 40 mm. The top of the pipe will then be plugged with a bung and a spatula inserted under the bottom of the tube, before it is slowly withdrawn from the
sediment. Samples will then be placed in sampling jars on ice, protected from light, and submitted to an analytical laboratory where microalgae biomass will be estimated as total chlorophyll (Chl a) according to the methods of Whitney and Darley (1979), Dandonneau and Neveux (2002) and Seuront and Leterme (2006).

The baseline assessment for benthic macrofauna characterisation will be undertaken through collection and analysis of macrofauna samples from the same stations as for the sediment monitoring activities. Samples will be collected at four occasions over the year (autumn, winter, spring, summer). Intertidal samples will be collected at spring low tide by inserting a large (18 cm diameter) corer into the sediment to a depth of 30 cm, plugging the open end, extracting the core and transferring the contents to a 0.5 mm mesh bag. The mesh bag will be agitated until all the fine sediment has been removed and the remaining contents placed in a sample jar together with 5% formalin. Subtidal samples will be collected at corresponding times (autumn, winter, spring, summer) using a Van Veen grab deployed from a small inflatable boat. In all cases, macrofauna from the samples will be extracted from the residual sediment in the lab, identified to species level, counted and weighed (wet weight).

The baseline assessment of fish populations along the margins of the Central Sandbank will be undertaken using a 30 m beach seine net with 12 mm stretched mesh. At least five hauls will be made on either side of the Central Sandbank on four occasions during the year (autumn, winter, spring, summer). All fish and invertebrates collected in the net will be enumerated, weighed and measured, and if possible, returned to the sea alive.

The baseline assessment of birds utilising the Central Sandbank will entail counting all birds present on the bank once a month for 12 months over spring-low tide periods. Numbers of birds of each species will be recorded within a series of belt transects spanning the Central Sandbank. These belt transects will be oriented parallel to the shoreline of the bank along its southern and northern edges to form a series of blocks which will extend from the waters’ edge up to the middle of Central Sandbank. Counts will be conducted with the aid of binoculars and telescope within a six hour period.

Standard univariate and multivariate techniques will be used to describe baseline characteristics for the benthic macrofauna, fish and bird communities both in terms of abundance and biomass (fish and macrofauna only) and to compare these with conditions during the construction phase (i.e. whilst dredging operations are underway) and thereafter (post construction). Univariate measurements will include total species, species diversity, evenness and richness for intertidal and subtidal areas and for each season and for the entire baseline period under assessment. Multivariate analyses will employ techniques used in Plymouth Routines in Multivariate Ecological Research (PRIMER) (Clarke and Warwick 2001), specifically non-metric multidimensional scaling and cluster analyses, k-dominance curves and an analysis of the characteristic and distinguishing species (SIMPER) of macrofauna and fish at Central Sandbank.

It is anticipated that during construction (dredging) phase of the project, the primary impact vector will be levels of suspended sediment and/or organic material in the water column. High levels of suspended sediment and organic material can affect living organisms by reducing levels of dissolved
oxygen in the water column (mediated through the decomposition of organic matter or release of hydrogen sulphide), by blocking the transmission of light through the water column (thereby affecting phytoplankton and macroagal production), by blocking the gills or feeding apparatus of filter feeding organisms (invertebrates, fish and sharks), or by smothering benthic organisms. (Note that surveys of the dredge sediment conducted as part of the EIA study (CSIR 2012a) have indicated that levels of trace metals and other contaminants in the dredge sediments are low and pose minimal risk to marine organisms). Thus, the focus during the construction (dredging) phase of the project will be on ensuring that suspended sediment levels in the water column adjacent to the sandbanks do not exceed a defined threshold risk level of 50 mg/L and that oxygen levels in the water column do not drop below 5 mg/L (99% of the time) and below 6 mg/L (95% of the time). These threshold risk level has been derived from the work of Steffani et al. (2003) and from the South African Water Quality Guidelines (DWAF 1995). Steffani et al. (2003) provided guidelines for concentrations of suspended solids in relation to the risk they pose to benthic marine invertebrates, which are considered to be amongst the most sensitive organisms to elevated suspended sediment levels given that they are mostly sedentary and are unable to move away from the source of impact, as follows:

- Low risk: < 20 mg.L\(^{-1}\)
- Medium risk: 20-80 mg.L\(^{-1}\)
- High risk, requiring mitigation: > 80 mg.L\(^{-1}\)

The defined threshold risk level of 50 mg/L lies at the centre of the medium risk range as posed by Steffani et al. (2003).

The dissolved oxygen of water is a non-conservative property; solubility of oxygen in water being dependent on the salinity and temperature of the water (DWAF 1995). The South African Water Quality Guidelines provide the following data on solubility of oxygen in seawater under constant pressure (one atmosphere) for a range of salinities and temperatures (Table 1). Cells spanning the typical range in temperature and salinity in the Port of Durban and corresponding oxygen saturation values are highlighted in grey on this table. From this it is clear that under ideal conditions (i.e. 100% saturation), levels of dissolved oxygen would vary between 6.3 and 8.2 mg/L under the influence of changing temperature and salinity alone. For this reason the SA Water Quality Guidelines recommend that the target levels for dissolved oxygen in the coastal zone off the south and east coasts should not fall below 5 mg/L (99% of the time) and below 6 mg/L (95%) of the time. These are also the defined threshold risk levels that have been adopted for this study as well.
Table 1. Solubility of oxygen in seawater (mg/L) under constant pressure (one atmosphere) for a range of salinities and temperatures (Source: DWAFR 1995).

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With this in mind the following protocol is proposed during the dredging operations:

1. Continuous monitoring should be undertaken of turbidity\(^1\) and dissolved oxygen levels at a point immediately adjacent to the Central Sand Bank, between the bank and the dredger and/or dredge hopper, and at a point immediately adjacent to Little Lagoon at a point between the Lagoon and the dredger and/or dredge hopper (hereinafter referred to as “the designated monitoring stations”), during the dredge operations.

2. Data from such monitoring work should be available in real time to the person coordinating dredging activities.

3. Dredging operations should be halted immediately if (a) turbidity levels exceed a threshold level of 50 mg/L and/or (b) if levels of dissolved oxygen are observed to drop below 5 mg/L for more than 1 minutes in every 60 minutes (1.7% of the time) or below 6 mg/L for more than 3 minutes in every 60 minutes (5% of the time), and should not recommence until levels have declined below this point.

4. If turbidity frequently exceeds or levels of dissolved oxygen frequently drops below threshold levels at the designated monitoring stations, ‘Silt Curtains’ should be deployed at the burrow pit as a mitigation measure. The lower end of the ‘skirt’ of the silt curtains must be allowed to rest upon the seafloor, and the top of the ‘skirt’ must be above the water surface.

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\(^1\) Note that it is not possible to measure suspended sediment load in real time and this will have to be inferred from measurements of turbidity (water clarity) which can be measured in real time. Such empirical relationships have been derived for other studies but will need to be validated for use in this study through simultaneous collection of turbidity and suspended sediment data.
5. Turbidity should also be minimised by choking the dredge hopper overflow with a fully automated system. In this scenario, a computerized process controller ensures dynamic adjustment of the valve in the overflow funnel which choking the flow in such a way that a constant fluid level in the hopper is maintained and, as a result, no air is taken down with the suspension leaving the hopper.

The approach to be adopted for assessing the rate of recovery of the newly created portion of the Central Sandbank and for determining when this area can be considered to be fully recovered is known as the test for bioequivalence and was developed by researchers in New Zealand - McDonald and Erickson (1994). The approach is to define two areas to be bioequivalent if the mean density of a particular organism or organisms at suite of impacted sites (the newly created sandbank) exceeds a predefined percentage of the mean density at a reference or control sites (on the existing sandbank area) 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 was developed for testing the equivalence of drugs (Kirkwood 1981, Westlake 1988) but has since been adopted for other biological sciences as well (Dixon and Garret 1992, McDonald and Erickson 1994, McDonald et al. 1995). Full details of the test are contained in McDonald and Erickson (1994).

The predefined percentage and defined time interval referred to above are necessarily site- or situation-specific, but the value of 80% and a time period of two years are now both fairly widely accepted for ecological applications (McDonald and Erickson 1994, McDonald et al. 1995, Underwood 1996). This implies that the number of species, abundance, and/or biomass of the organism or organisms in question at the rehabilitation site must reach a level of at least 80% of the measured pre-impact baseline levels (and/or those at comparable control stations) and must remain at this level for at least two years before a site can be considered to have recovered. Note that this takes account of the natural variations in abundance/biomass of individual species and communities that are inherent in any natural system. Note also that the equivalence level proposed here (80%) is by nature lower than the level of similarity that is required for drug testing (i.e. when comparing generic and branded drugs where an equivalence level of 90-95% is often required) owing to higher levels of variability typically found within natural systems (see for example Birkett 2003 and Niazi 2007).

A graphic depicting how such a process may play out in the case of this project is shown in Figure 1. The blue and purple line represents the average number of individuals or species at a suite of stations on the existing sandbank distant from the impact (dredge) area (Control 1) and a second group in close proximity to the area where the new sandbank habitat will be created (Control 2), respectively. The red line represents average abundance at a suite of stations on the newly created sandbank. The dots on each line represent average values derived from discrete samples collected at quarterly intervals (every 3 months) at these respective sites. The horizontal dotted lines on the diagram represent abundance for all the Control 1 stations (which are located far from the impact site Control 1) average across the full time period of the study, and the 80% level for these sites. Sampling at the control stations will commence at 12-24 months before the commencement date of the project and will continue until it can be established that the biota at the control stations in close proximity to the impact site (Control 2) and that on the newly established
sandbank area have recovered to a level that corresponds to at least 80% of the average level measured at Control 1 (the lower dotted line). Sampling at the stations on the newly established sandbank will commence immediately after construction is complete (denoted by the vertical dotted line on the left side of the diagram) and will continue until the abundance at these sites exceeds the 80% level at Control 1 for at least five years (denoted by the vertical dotted line in the centre of the diagram). Note that in this diagram abundance at the control station in close proximity to the impact site (Control 2) dropped during the construction phase but recovered again shortly thereafter. Note also that in this example, monitoring continued for a further 12 months following the date on which the newly created habitat had been declared fully recovered.

![Diagram demonstrating environmental monitoring and recovery](image)

**Figure 1.** Graphic demonstration of procedures for monitoring environmental impacts and recovery. See text for an explanation.

**4.2 What actions are proposed if the monitoring results detect change?**

Monitoring of potential impacts during the construction phase of the project will be achieved primarily through the monitoring of turbidity (total suspended solids) and dissolved oxygen. This is because suspended solids, and indirectly through its effect on levels of dissolved oxygen, are expected to be the primary vector of water quality and ecological impacts on areas surrounding the immediate dredge area. A three pronged approach will be adopted to control suspended solids from dredging activities. The first involves adopting dredge methods to reduce the suspended solids at the source. Specifically:

- The dredge hopper overflow will be choked with a fully-automated computerized process controller that can ensure dynamic adjustment of the valve in the overflow funnel which chokes the flow in such a way that a constant fluid level in the hopper is maintained and, as
a result, no air is taken down with the suspension fluid leaving the hopper. This has been shown to significantly decrease turbidity in the surrounding waters.

- The period over which the dredging operation is to take place will be minimised to avoid the daily re-suspension of sediments.

The second involves containing suspended sediments and preventing their dispersion into the wider Bay area. This will be achieved by:

- The installation of ‘Silt Curtains’ at the dredge burrow pit during dredging to contain turbidity levels in the surrounding waters. The lower end of the ‘skirt’ of the silt curtains will rest upon the seafloor, and the top of the ‘skirt’ will be kept be above the water surface (see ZAA 2014).

Monitoring will be the last measure. A clearly defined management action has been identified if, in spite of control measures noted above, TSS levels during the dredge operations exceed a threshold level of 50 mg.L\(^{-1}\) or dissolved oxygen levels drop below 5 mg/L (>1% of the time) or below 6 mg/L (>5%) at any of the monitoring stations:

- Dredging operations will be halted immediately and will not recommence until levels have declined below threshold levels.

4.3 **What are the socio-economic and ecological implications should the proposed mitigation measure prove not to be successful?**

In the event that the proposed mitigation measures (construction of additional sandbank area on the Central Sandbank) prove unsuccessful and fail totally, losses of sandbank area in Durban Bay can be estimated as being equivalent to those associated with the unmitigated design Option 3C assessed in the original EIA (see CSIR 2012). In this case the proposed development will result in the net loss of approximately 6.4% of existing intertidal and subtidal area of the Central Sandbank area. High intertidal area near the Little Lagoon will be lost (14.2%) but offset by an increase in low intertidal area (1.3%) resulting in a zero net loss of tidal sandbank at the Little Lagoon (CSIR 2012a). Overall on these banks there will be a 5.6% loss (106,177 m\(^2\)) of tidal sandbank area. Intertidal sand flat habitat in the Port of Durban has already been reduced to only 14% of its original extent (Allan *et al.* 1999) and the remaining intertidal sand flat area is recognised as being extremely important to the ecological functioning of the Port of Durban (Newman *et al.* 2008; Weerts 2010). These banks are considered to be very important for birds, juvenile fishes, and invertebrate populations in the Bay and indeed the region as a whole (Day and Morgan 1956; Cyrus and Forbes 1996; Forbes *et al.* 1996, McInnes *et al.* 2005, Weerts 2010). Losses of sandbank, should the proposed mitigation measures not be successful, will therefore result further losses of ecological goods and services provided by these banks. Further loss of this habitat type should therefore be avoided or effectively mitigated.

It is not possible to quantify precisely the ecological implications of the loss of this habitat area should the mitigation measures prove unsuccessful. Assuming total failure of the habitat creation project, ecological losses would at best be directly proportional to habitat losses (i.e. a 5.6% loss of sandbank will result in a 5.6% loss of associated ecological function). It might, however, be argued
that any loss in habitat area could result in a disproportionately large impact on populations of affected species owing to the fact that this type of intertidal and shallow subtidal sandbank has been so severely reduced within the Durban Bay already, and that the affected species may already be close to a threshold or tipping point which could result in a much larger reduction in their population size. For example, McInnes et al. (2005) argue that “potentially half the waterbird population of Durban Harbour could be negatively impacted as a result of any modification of [the Central Sandbank].” This, they argue, is because the intertidal sand banks play a critical role in providing food in the form of invertebrates (macrofauna) to many bird species.

Socio-economic implications are even harder to predict because the socio-economic benefits cannot be explicitly quantified. The primary value of sandbank habitats in Durban Bay is their ecological function as estuarine nursery area. Arguably the primary socio-economic benefit derived from them is from the fishes they support and which are targeted by recreational and subsistence fishers both in the Bay and elsewhere along the coast. The habitat creation planned will result in an increase in fish habitat and therefore increase the ecological value and socio-economic benefits derived from the Bay.

Through a process of risk assessment and based on published scientific evidence from similar habitat creation projects conducted elsewhere (see below), the likelihood of habitat successfully replaced through this development successfully fulfilling an ecological role similar to that of existing sandbanks is extremely high. The marine specialists on the project team, whom all have direct experience and working knowledge of Durban Bay and the species involved place high confidence in this assessment.

4.4 Ecological risks associated with the creation of a portion of the Central Sandbank and mitigation of these risks

This section addresses issues 4 and 5 raised by DEA (see Section 0 above) viz.:

- All potential risks and mitigation measures associated with the creation of a portion of the Central Sandbank as a mitigation measure must be fully assessed and addressed in the amended EIA report.
- Consideration needs to be given as to how realistic and practical the mitigation measure is and what costly commitment and assurances have been provided by the applicant to implement this measure.

Ecological certainty cannot be established using quantitative predictive tools in the way that engineering risk assessment is performed. Rather it must rely on sound ecological rationale based on knowledge of habitats and species involved, review of available scientific literature and consideration of appropriate case studies.

The ultimate measure of ecological success of habitat creation is whether or not the habitat is used beneficially by appropriate biota and fulfils its intended ecological function. In Durban Bay sandbank habitats the invertebrate benthic fauna are fundamental in this regard. Estuarine and marine fishes have more obvious value to humans, but their use of Durban Bay sandbanks as nursery and feeding area is dependent on a few relatively clear criteria; water quality, structural habitat and prey...
availability. The first two are dealt with in CSIR (2012a), ZAA (2012b) and Anchor Environmental (2012a), and in ZAA (2014), respectively. Zooplankton as prey items occur with relatively little dependence on sandbanks whereas benthic prey species rely heavily on these habitats. Much of the discussion below therefore deals specifically with this biotic component.

Having established the engineering feasibility of creating a stable sandbank with similar morphological and sediment characteristics as that that exists presently, habitat quality needs to be addressed. Of relevance here is the use of potentially contaminated sediments to create new habitat. With no sources of contamination, offshore sediments will be clean. Sediments in Durban Bay are, however, potentially exposed to an array of contamination sources from inflowing urban waters and port activities. Sediments in dredge footprint in the port have, however, been shown to be uncontaminated, with few exceptions that are highly unlikely to render them unsuitable for colonisation by invertebrate fauna (CSIR 2012b).

Remaining issues pertinent to the feasibility of the newly created habitat are ecological. Specifically the ecological process of colonisation by species and community succession are relevant. Colonisation is the process by which species recruit to new areas and establish populations. Succession is a related process of change over time in the relative and absolute abundances of different species in a biological community.

Several questions arise immediately in the context of the likely colonisation success and ecological succession on sandbank to be created as mitigation for habitat losses brought about by the proposed development. These are:

- Will colonisation by appropriate species occur naturally?
- How long will colonisation take?
- In what abundances will species establish populations?
- Will succession to a functional ecological community proceed naturally?

Colonisation is a function of availability of recruits and their access to suitable habitats. In marine and estuarine systems in general and the context of this study specifically, the majority of biota typical of sandbank habitats have pelagic larval forms that are widely dispersed in the water column by currents (with a notable exception discussed below). Most of these species generate an excess of eggs and larvae, to account for natural losses due to mortality, predation and dispersal away from suitable habitat. In Durban Bay a ready source of larvae will therefore be available to settle on suitable newly created habitat from existing nearby adult populations. This will be enhanced by the semi-enclosed nature of the Bay and water retention within it.

An important component of Durban Bay’s invertebrate fauna on the existing Central Sandbank is the sandprawn Callichirus (previously Callianassa) kraussi. Callichirus kraussi does not have a planktonic larval stage but instead relies on a reproduction strategy in which young are hatched and develop in parent burrows and then tunnel off from these parent burrows. A post-larval dispersive stage also occurs however (Forbes 1973). This method of dispersal is an efficient strategy for the species to spread and establish wider populations within individual systems (Forbes 1977). Quick generation times and strong recruitment are also regarded as indicative that C. kraussi populations could
probably recover rapidly from exploitation (Forbes 1976). *Callichirus kraussi* can therefore be predicted with high confidence to recruit onto and colonise newly created sand habitat in Durban Bay.

Patterns of colonisation and succession of newly created habitat can be expected to follow closely those of disturbed habitat. Typically in ecological systems initial colonisation of disturbed habitat is dominated by opportunistic species. These species are usually small, short-lived forms that proliferate and dominate the community until they are outcompeted by longer-lived, larger forms. Perhaps the simplest example of the likelihood of colonisation in Durban Bay can be found on floating structures, such as navigation markers and pontoons. These structures are rapidly colonised by a range of so-called fouling fauna with dispersing larvae, to the extent that they periodically need to be removed and cleaned. There is no reason to doubt that newly created sandbank habitat will not be similarly colonised, albeit with organisms typical of sediments rather than hard substrata.

In terrestrial systems disturbed habitats are often colonised invasively by undesirable alien species. This is especially evident in vegetation. It also occurs in marine and estuarine systems. Indeed, alien species have established in pest proportions in marine and estuarine systems in many parts of the world with negative ecological, economic and human health consequences (Bax *et al.* 2003, Williams *et al.* 2008). Ports, as man-made features of the coastal landscape port with artificially sheltered waters are likely ‘hot-spots’ for marine invasive alien species (e.g. Bax *et al.* 2002). The potential for colonisation of newly created sandbanks in Durban Bay by invasive alien species might therefore be a concern. Confirmed alien marine species have established populations in South African and many of these occur in ports and sheltered bays. However, only one (the ascidian *Ciona intestinalis*) extends into the subtropical biogeographical zone of KwaZulu-Natal (Robinson *et al.* 2005). This species colonises hard substrates and does not occur on sandbanks so will not be an issue in the context of habitat creation proposed here. An alien gastropod, *Tarebiagranifera*, has however invaded several of KwaZulu-Natal’s estuaries (Appleton *et al.* 2009) and proliferates in sandy habitats. It does not persist in salinities ≥ 30 ppt however (Miranda *et al.* 2010). The proposed sandbanks are in an area of Durban Bay that is permanently exposed to marine waters of 35 ppt, so populations of this species will not also establish on the proposed new sandbank. Cryptogenic marine fauna (species may be either native or introduced) do occur in Durban Bay (and indeed in most of KwaZulu-Natal’s estuaries) but these are now regarded as part of the natural cosmopolitan of circumtropical biota. Thus there is very low probability for colonisation of newly created sandbanks in Durban Bay by invasive alien species.

These findings strongly support the conclusion that recruitment and colonisation of the proposed new sandbank habitat in Durban Bay with species typical of existing sandbanks will occur naturally and will be successful. Additional considerations are the location of the proposed new sandbank area and the fact that it will be created using locally sourced sediments. Both of these factors will augment colonisation by larval and post-larval recruitment as discussed above, and provide further surety of the ecological success of habitat creation proposed. The new sandbank as an extension of the existing Central Sandbank will ensure not only a supply of colonising larval and post-larval recruits but also allow recruitment by migrating juveniles and adults. This has been found to be an important in the cases of completely defaunated sediments (Bolam and Rees 2003 and references therein) and habitat creation projects (Bolam and Whomersley 2003). Sediments sourced locally will
also be ‘pre-seeded’ with biological recruits. This is especially true of sediments sourced from the dredge works to be performed in Durban Bay. Deep water sediments in the Bay support a fundamentally different fauna from those that occur in the shallower subtidal and intertidal areas, but some species occur in common between these two habitats. Ideally sediments that are to be unavoidably removed from the Central Sandbank should be used as a final capping over the proposed new sandbank habitat. This will contain invertebrates and fast-track colonisation by appropriate species which already occur on Durban Bay sandbanks. Clearly mortalities will occur because of the dredging and placement processes but in some cases benthic species do survive the dredging and disposal process and contribute to recovery of the disposal area (e.g. Jones 1986 cited in Wilber and Clarke 2007).

Colonisation and succession of soft substrate benthic fauna has been well studied in marine and estuarine systems, mostly in projects involving dredging and dredge spoil disposal, but also in the context of in beach nourishment and tidal flat habitat creation. As indicated above initial colonisation will be dominated by opportunistic species. Based on the work of Pearson and Rosenberg (1978) and Rhoads et al. (1978), Newell et al. (1998) proposed a model of benthic recovery from disturbance (dredging) that involves sharp increases in both number of species and abundance of organisms to above that of baseline or control communities. This initial colonisation comprises opportunistic species which generally reach a peak in population numbers within six months. Models such as this are widely accepted in the scientific literature, and are based on sound ecological theory as well as empirical observations. Opportunistic species as initial colonisers are, by virtue of the life histories and biology, either quick to take advantage of new resources and/or exploiting resources in the absence of competitors (Thistle 1981). Numerous experimental studies involving field manipulation of sediments have shown very quick initial colonisation of defaunated sediments. Botter-Carvalho et al. (2011) found colonisation to occur very quickly with some species recruiting within one day, but others obviously taking longer. Abundances at treatment sites were generally not statistically different from those at control sites within six months. In reviewing other studies of colonisation of defaunated sediments in the subtropics they found abundance of macrofauna to recovery within periods ranging from 2 weeks to 14 months, while species richness recovered within 4 months to >19 months.

This concurs well with results from field studies of benthic colonisation and succession after disturbance. Recovery rates of benthic communities in these cases have been found to vary widely (Newell et al. 1998, Desprez 2000, Kotta et al. 2009, and references therein). Moreover, different aspects of the community may recover at different rates. Desprez (2000) cited several recolonisation studies where numbers of species and abundance recovered quickly after dredging (within 12 months) but biomass recovered at a slower rate. Similar findings were reported by Newell et al. (2004). These studies were in temperate systems and in the subtropical Durban Bay markedly slower biomass recovery is unlikely. Other works have reported more rapid and complete recolonisation within much shorter periods. Guerra-García et al. (2003) reported recovery within about six months of dredging fine sediments in a small harbour while Van Dolah et al. (1984) noted even quicker recovery (within three months) after dredging soft estuarine muds.

While colonisation of defaunated sediments and recovery of total faunal abundances and species richness can, and usually does occur rapidly, recovery to a similar community as that at reference or
undisturbed sandbanks often takes longer. Published ranges of recovery periods following dredge disposal in marine and estuarine systems vary but are typically between nine months and four years (Bolam and Rees 2003). Some studies have found shorter recovery of the benthic community (e.g. six months, Guerra-García et al. 2003) while others have found much longer recovery rates, although this is frequently related to long term changes in habitat, such as changed sediment granulometry (e.g. Boyd et al. 2005) or tidal elevation (e.g. Bolam and Whomersley 2003).

Summary information on a number of other case studies from estuaries or shallow water marine systems is presented below:

- Evens et al. (1998) investigated the recolonisation of an existing intertidal mudflat by macroinvertebrates and birds in the Tees Estuary, England, following restoration of tidal inundation. He reported that a stable macroinvertebrate population had developed after a period of 3 years. The actual success of restoring the mudflats, however, could not be evaluated as no baseline data were available prior to tidal inundation ceasing for comparative purposes.
- Ray (2000) reported on creation and colonisation of an artificial mudflat made of dredge spoil on the coast of Maine, USA. In this instance an artificial mudflat was created and its macroinvertebrate community assessed and compared to an adjacent reference site over a period of five years. The study found that diverse and complex infaunal assemblages were able to establish themselves on the mudflats constructed of dredged materials, and that within three years the communities on constructed flats resembled those on the natural flats.
- Brooks (1983) reported on colonisation of dredged sediments on a dredge spoil disposal site located at 20 m depth in Long Island Sound. He found that three months after final capping of the disposal site the numbers of benthic macrofauna individuals and species present and were “roughly comparable” to those at the reference stations and that after 15 months the number of macrofauna individuals and species were significantly higher than reference sites and in the predisposal reference collections.
- Bolam and Whomersley (2005) reported on changes in physical parameters and recovery of benthic macrofauna in dredge spoil at three beneficial use schemes in estuaries in south-east England. They found that environmental parameters (sediment redox potential, and water, organic carbon and silt/clay contents) and univariate community attributes (total individuals and species, diversity, evenness and biomass) had attained reference levels at two schemes but that assemblages differed significantly in terms of species composition at all three schemes. (Note however, the role of potentially confounding variables as articulated above).
- Bolam et al. (2004) found that recolonisation of 1 m$^2$ of defaunated sediments resulted in recovery of univariate indices after only three months and community structure after 6-12 months on a mudflat in south-east England.
- Beukema et al. (1999) reported that number of species and individuals took 6 and 12 months to recover, respectively, following the defaunation of larger areas (120 m$^2$) of mudflat in the Dutch Wadden Sea.
- Vogt (2010) studied experimental restoration of the Big Egg Marsh in Jamaica Bay, New York City harbour. He reported on recovery of salt marsh vegetation and macrofauna on artificial
islands constructed from dredge spoil. He found that the project was a success in that the
dredge spoil had been successfully transforming into a silty and organic saltmarsh soil, that a
dense cover of smooth cordgrass had developed on the islands, and that an “appropriate”
animal community had become established.
- Bolam and Whomersley (2004) found that the diversity, abundance and species richness of
two mudflat communities created from dredged material near Jonesport, Maine, had re-
established the levels found at reference mudflats after two years.

Literature on the impacts and colonisation of offshore (deep water) dredge spoil disposal areas
provides a similar perspective. Studies in the OSPAR maritime area (North-East Atlantic) for example,
indicate recovery rates for species richness, abundance and diversity amongst macrofaunal
communities to range from 3 months to 2 years (Stronkhorst et al. 2003; Bolam and Rees, 2003;
CEFAS, 2005; Bolam et al. 2006a; b; Bolam and Whomersley 2005; Van Dalfsen and Lewis 2006).

Thus there are many factors which govern the rate of benthic invertebrate colonisation, recovery
and succession. These include the magnitude and scale of the initial disturbance, the nature of the
system and its biological community (Oliver et al. 1977). Most notably, in dynamic or disturbed
areas, where fauna are characterised by stress tolerant, small, fast-growing species with fast
population regeneration times, recovery after disturbance is likely to be rapid compared to areas of
greater hydrological and granulometric stability with species that are typically large and slow-
growing (Newell et al 1998). Recovery rates in highly disturbed sediments in estuaries that are
dominated by opportunistic species are most often rapid, but they increase in stable gravel and sand
habitats dominated by long-lived components (Kotta et al. 2009). Recovery is also generally faster in
low latitude temperate and subtropical regions compared with high latitude cold regions (Wiber and
Clark 2007).

An important distinction should be drawn between habitat creation schemes in vegetated terrestrial
compared with unvegetated marine and estuarine environments. Already discussed above is the
much lower risk of colonisation by undesirable (invasive alien) species. An additional consideration is
the frequent necessity, in cases involving of vegetated terrestrial habitats, to actively manage newly
created habitats by seeding initial colonisation and manipulating succession. In sandbank creation
projects active management (beyond using locally sourced sediments and targeted placement,
which are both being done in this case) is seldom likely to be more effective than allowing natural
processes to prevail and therefore, more importantly, it is seldom (if ever) needed.

These factors are relevant in assessing the ecological feasibility of sandbank creation in Durban Bay.
Most benthic species typical of subtropical shallow marine waters and estuaries in South Africa are
pre-adapted to periodic large scale turnover of sediments. Storms such as those experienced on the
KwaZulu-Natal coast in March 2007 result in massive sediment movements in coastal waters less
than 30 m in depth. Floods also scour estuaries and particularly severe events, such as those on the
KwaZulu-Natal south coast in June 2008 can result in the complete removal of estuary beds and their
replacement with defaunated sediments. These events are natural disturbances which, in effect,
reset sandy habitats which then rely on colonisation and succession for benthic fauna to re-establish
viable populations and ecologically functional communities. It is unarguable that disturbances on
this scale would have significant detrimental ecological effects if they re-occurred frequently in quick
succession, but similarly there can be little doubt that colonisation and succession of benthic invertebrates occurs naturally in KwaZulu-Natal marine and estuarine systems, and will be successful on the scales of the habitat creation exercise proposed in Durban Bay.

There are unfortunately few published South African case studies which are relevant for assessing the ecological feasibility of sandbank habitat creation in Durban Bay. Some work has been done of recovery from dredge spoil disposal but this has limited applicability. Recovery from dredge spoil disposal offshore of Richards Bay and Durban has been monitored and found to occur quickly but this has been at open-water sites very different to the sheltered shallow waters pertinent to the Durban Bay case that is the topic of this assessment. Cyrus and Blaber (1988) commented on potential effects of dredging activities at the mouth of the St. Lucia Estuary, but this was with reference to turbidity and suspended sediments from ongoing dredging activity. Intrusion of fine dredge spoil into the Mhlathuze Estuary was found to result in die-back of the seagrass Zostera capensis, with recovery occurring in two years (Cyrus et al. 2008). Benthic assemblages were also impacted. While benthic abundance recovered quickly likely recovery to a faunal community the same as that prior to disturbance was estimated to be longer (three to five years) (Cyrus et al. 2000). A changed sediment granulometry, however, potentially confounded this assessment.

Perhaps more valuable are several good local examples of functional and valuable aquatic coastal habitats, and estuarine habitats in specific, that have been created from engineering projects (most incidentally rather than intentionally). Richards Bay, an industrial node some 200 km north of Durban that has been the focus of development since the 1970's is a case study that clearly demonstrates that artificially created shallow water estuarine habitats are successfully colonised and used by indigenous fauna and flora. The Thulazileka Pan is a shallow permanent artificial water body that was created as a result of earth moving involved in the development of the Port of Richards Bay. It developed into a productive water body that was one of KwaZulu-Natal's premier spots for waterbirds. Pollution of groundwater and surface runoff, together with water level manipulation has since seen the system degrade, but this speaks to poor environmental management of a valuable, albeit manmade, natural resource.

The Port of Richards Bay and the adjacent Mhlathuze Estuary are both engineered systems, created in the mid 1970s during port development by the construction of a berm dividing a large estuarine lagoon into two parts (Weerts and Cyrus 2002). Tidal changes brought about by these developments have seen proliferation of mangroves in the Mhlathuze Estuary to the point that over half of South Africa’s mangrove area now exists in this system. Although unintended, and a significant modification of the original estuarine lake, this estuary ranks amongst South Africa’s most important systems in terms of its conservation status (Turpie et al. 2002). Its sand- and mudflat habitats, completely different from their original form and structure, and exposed to waters with strongly altered physico-chemical properties, function as viable and valuable estuarine habitats (MacKay and Cyrus 1998/9) which act as nurseries for a high diversity estuarine associated fish species (Weerts and Cyrus 1998/9, 2002).

Habitats in the Port of Richards Bay (mangroves, sand- and mudflats, canals) have also developed to support functional estuarine communities (Forbes et al. 1996, Weerts 2002, Weerts and Cyrus 2002, Weerts et al. 2003). This is also of course also true of habitats in Durban Bay itself (Forbes et al.
1996, Newman et al. 2008) even though these habitats (especially the sandbanks) are also completely modified from their natural state and are in effect all the result of port development. The Little Lagoon in the Port of Durban is a pertinent example. It is widely recognised as being a ‘biodiversity hotspot’ in the Port of Durban supporting some of the most diverse assemblages of invertebrates, fish and birds in the entire Bay (Cyrus and Forbes 1996; Forbes and Demetriades 2003, Pillay 2002, Mckinnes et al. 2005). It was in fact artificially created, in the 1970s, by the expansion of port facilities which truncated a shallow channel through the sandbanks to leave an open basin with markedly changed hydrodynamic characteristics. Habitats in the case of these two ports, especially Durban, have admittedly had many years over which they might have developed ecologically. Succession following their development and recovery following disturbance was never studied. In the Mhlathuze Estuary however, the development of a viable estuarine function was shown to occur very quickly after massive alteration to the system (Hemens and Connell 1975, Hemens et al. 1976a, 1976b).

5 Risk Assessment Conclusion

In other parts of the world tidal sand- and mudflat creation and restoration initiatives have been undertaken with the expressed purpose of increasing this valuable habitat type; e.g. USA (Levin et al. 1996, Ray, 2000), UK (Evans et al. 1998), Japan (Lee et al. 1998; Ishii et al. 2008) and Australia (French et al. 2004). In many cases this has involved the use of dredged materials. The beneficial use of dredge spoil for use to create habitat is well established and has been proved to successfully used invertebrates, fishes and bird fauna. Indeed, the beneficial use of dredge spoil rather than disposal at sea is widely regarded as best management practise for dredge spoil disposal. This has long been realised and reported upon in the scientific literature (Rhoads et al. 1978, Bolam and Whomersley 2003, 2005, Bolam and Rees 2003, Yozzo et al. 2004). Relevant South African case studies do not exist unfortunately, but it is clear from the above that benthic invertebrates in Durban Bay are well adapted to recruit onto newly created soft sediment habitats quickly and in abundance and that natural succession will occur to an ecologically functional community.

This process is well studied and understood, but is complex and influenced by many interrelated factors (Zajac and Whittlatch 1982a,b, French et al. 2004, Parker et al. 2004). Assessment of the viability of habitat creation as a mitigation measure in the current project in Durban Bay has been considered in the context of:

- Physical processes: Hydrodynamic characteristics of proposed sandbank (CSIR 2012a).
- Substrate characteristics such as sediment particle size and organic content (ZAA 2014), sediment erosional and depositional characteristics (CSIR 2012a, ZAA 2014).
- Chemical processes: Long term implications for water quality (CSIR 2012a), suitability of dredged material for beneficial use (CSIR 2012b).
- Ecological processes: Larval availability, recruitment and colonisation via mobility of adults, the presence of existing biota in sediments to be used, the likelihood of establishment by alien invasive species (this document).
In many cases ‘success’ in the development of benthic infaunal assemblages is regarded as the establishment of a faunal community the closely resembles a reference habitat. Most studies indicate that benthic invertebrate communities can rapidly colonise constructed habitats (Kenworthy et al. 1980, Ray 2000, Craft and Sacco 2003) but others suggest that it may take several years, even decades, for the establishment of benthic fauna similar to long established natural habitats (Ray 2000, Craft and Sacco 2003, French et al. 2004). Cases which have involved lengthy recoveries have often involved slow growing biota, biota with a dependency on vegetation (e.g. seagrass, saltmarsh, mangroves) to establish first, or physical conditions at new habitat and reference habitats not matching.

In the case of extending the Central Sandbank in Durban Bay the hydrodynamic regime, water quality and sediment characteristics are all the same as those on the existing bank. A pool of larval and adult recruits exists in very close proximity. Colonisation will therefore occur very rapidly and populations of invertebrates will establish in a matter of months. Given the life histories of the local species it is highly likely that succession to a community similar to that at similar tidal elevations on the existing Central Sandbank will occur. Mitigation measures to ensure this have implicitly been adopted:

- Created habitat will emulate existing sandbanks in terms of structure, granulometry and hydrodynamic characteristics.
- Habitat will be created in an area where natural recruitment and colonisation of local species will occur.
- Created habitat will extend existing habitat.
- Local sediments will be used as far as practicable.

An additional mitigation measure to fast-track colonisation by appropriate species which already occur on Durban Bay sandbanks is:

- Use sediments that are to be unavoidably removed from the Central Sandbank as a final capping over the proposed new sandbank habitat.

Thus, given the long term engineering stability of the proposed new sandbank habitat, initial colonisation, succession and the establishment of an ecologically functioning benthic community is certain. Given the proximity of this sandbank to the existing Central Sandbank and its similarity in terms of structure, granulometry and hydrodynamic characteristics, it is highly likely that a similar biological community will develop. Minor differences should be expected and will probably beneficially increase benthic diversity in the Bay. Successful establishment of benthic biota will result in profitable utilisation of the created habitat by higher trophic level organisms (fish and birds). Fish especially will benefit from the creation of additional shallow intertidal and subtidal habitat. These habitats are the primary feeding areas for juvenile estuarine dependent species utilising Durban Bay as a nursery. Shallow subtidal area is especially important. The present configuration and bathymetry of Durban Bay, with a strong predominance of deep water habitat or intertidal habitat, and limited shallow subtidal habitat, reduces its value as a fish nursery. Shallow water offers juvenile fishes protection from predation by piscivorous fishes (Blaber 1987, Ruiz et al. 1993). Such habitat is limited in Durban Bay at low tide, leaving juvenile fishes susceptible to predation. The proposed
sandbank extension results in significant increases in these shallow water habitats and will fulfil an ecological role that is congruent with the Bay’s ecological value as an estuarine embayment. Indeed in the long term it will improve the systems ecological value.
6 References


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