Chapter 6:

Marine Ecology, Sediment Toxicology and Dredging

Marine Ecology, Sediment Toxicology and Dredging

Figures

Tables

6. MARINE ECOLOGY, SEDIMENT TOXICOLOGY AND DREDGING

This chapter is based on the specialist study prepared by Dr Robin Carter of Lwandle Technologies (Pty) Ltd, Cape Town (Carter, 2006). Dr Carter's specialist study incorporates the findings from the Sediment Sampling and Analysis Data Report prepared by Mr Andrew Pascall of CSIR, Stellenbosch (CSIR, 2006).

6.1 Introduction

A specialist study was commissioned by CSIR to investigate the expected impacts of the proposed additional development activities at the Port of Ngqura (i.e. the extension of the current container berth with berths D102 and D103; and development of an administration craft basin) on the marine environment in and adjacent to the Port. These two additional activities are referred to as "*Phase 2*" of the port development, with the existing overall port development referred to as "*Phase 1*".

6.1.1 Rationale and approach to the study

The overall objective for this assessment of the probable impacts of the proposed developments, at the Port of Ngqura, is to ensure that the ecological functioning of the marine environment of the possibly affected areas within Algoa Bay is maintained. More specifically the purpose of the study is to:

- Identify the type and location of habitats and important species/taxa that may be sensitive to, or disturbed by, the proposed activities.
- Identify the specific stress agents associated with the proposed developments and the marine ecological receptors of the disturbance(s).
- Assess the impacts of the proposed development on the marine biota of Algoa Bay through, e.g. turbidity, re-suspension of contaminants in dredge spoil and inundation.
- Evaluate all impacts for the proposed activities, including construction and operation. (*Note: The planned developments are seen as permanent structures and, as no decommissioning of the development is at present considered, decommissioning will not be addressed).*
- Quantify the magnitude of potential impacts and outline the rationale used.
- Propose mitigatory actions for significant impacts and possible monitoring actions required to assess the success of the mitigatory measures.

The study employed a 'desktop' approach utilizing the relative wealth of existing data and information collected by studies associated with the Ngqura Port development. This was augmented by measurements of sediment properties in the target dredge and the spoil disposal area utilised in the Phase 1 dredging. The assessment follows the approach typical of a project specific EIA and is structured on:

- A short description of the project background and design.
- A description of the affected environment; including physiography, oceanography, and ecology of the biological communities that inhabit or occur in Algoa Bay.
- Identification of the environmental disturbances directly and/or indirectly associated with dredging and dredge spoil disposal.
- Determination of the potential impacts of these environmental disturbances, assessment of their extent, duration, and intensity, and identification of requirements, if any, for mitigation.
- Identification of monitoring requirements.

As discussed in Chapter 2, potential options for the disposal of the dredge spoil were investigated by the project proponent, Transnet. These included land-based disposal and/or use of an offshore site in deeper water than the currently proposed site. These options were taken through a screening process at the start of the EIA process (refer to Section 2.2 for a full explanation of the screening process). The land-disposal option was found to be impractical as no suitable sites for disposal or potential users for the dredge material have been identified; and the deeper water site was identified to be considerably less desirable from an environmental perspective. Therefore, with regards to the potential impacts on the marine environment, no reasonable and feasible design or construction alternatives have been carried forward into this chapter.

6.1.2 Limitations to the study

The study is limited to a 'desktop' approach and primarily relies on existing information augmented by directed measurements of sediment properties in the dredge and dredge spoil disposal areas. These measurements were made due to the presumption that sediment properties in both of these areas may have been altered by the earlier Phase 1 capital dredging. Further, sediment properties were also determined for the current reclaimed area extending south-eastwards from the present container berth quay from sub-samples taken from boreholes.

Potential changes in the marine environment such as sea level rise and/or increases in the severity and frequency of storms related to climate change are not included in the Terms of Reference and therefore are not dealt with in this report.

6.2 Sources of risks to the marine environment

The sources of risks to the marine environment posed by the proposed container berth extension and administrative craft basin development and operation are largely similar to those identified by CES (2001(b)) in the EIA for the previous phase of port development. These are listed below for the harbour area (i.e. construction site) and the wider receiving environment and are partitioned into construction and operational phases, and cumulative effects.

6.2.1 Construction: Harbour area

The disturbances and risks involved with the dredging operation in the harbour area are:

- Removal of the sediment and associated biological communities
- Turbid plumes generated by sediment resuspended during dredging and released through hopper overwash affecting biological communities and/or disrupting ecological processes
- Settlement of material suspended during dredging and alteration of sediment characteristics and associated biological communities
- Remobilization of contaminants in dredged sediments disrupting ecological processes and/or compromising biological organisms
- Reductions in dissolved oxygen concentrations due to introduction of organic matter previously held in the sediments to the water column affecting biogeochemical processes
- Release of nutrients to the water column promoting eutrophication
- Introduction of alien species
- Noise from the dredging activities disturbing marine biota.

6.2.2 Construction: receiving environment

6.2.2.1 Dredge spoil disposal site

The risks that will be generated by disposal of dredge spoil to the selected dredge spoil disposal site are:

- Deposition of suspended sediment and alteration of seafloor sediment characteristics affecting biological communities and/or processes
- Elevated water column turbidity affecting ecological processes and/or disrupting biological communities
- Wave and current suspension of fine sediments generating elevated turbidity near the sea floor affecting demersal organisms
- Release of contaminants, altered dissolved oxygen distributions and increases in nutrients affecting ecological and/or biogeochemical processes
- Introduction of alien species.

6.2.2.2 Islands (Jahleel, St Croix)

- Elevated water column turbidity affecting inter- and shallow sub-tidal biological communities
- Inundation of island shores by sediment deposition altering substrates and modifying intertidal communities
- Introduction of alien species
- Effects on endangered coastal seabirds.

6.2.2.3 Abalone farm

- Increased abalone mortality due to entrainment of fine particles

- Introduction of alien organisms that may be pathogenic to abalone.

6.2.3 Operational phase

Risks in this phase are mainly those linked to ship operations and servicing and potential imports of alien species. These risks these are only considered for the harbour area as those for the adjacent marine environment have been assessed in CES (2001b).

6.2.3.1 Harbour area

- Fuel spills from the administrative craft basin and associated effects.

6.2.4 Cumulative effects

Cumulative impacts considered here are those that exacerbate and/or or prolong effects generated by the Phase 1 port construction and dredging activities. These are partitioned into those associated with the Phase 2 construction activities and those that may be generated during port operations.

6.2.5 Policy, law and guidelines that may guide the proposed development

Policies, laws and guidelines with a bearing on the protection of the marine ecology of Algoa Bay and that should guide the proposed infrastructure development and subsequent operations include:

Instruments focusing on **Overarching Duties of the developers of the Port of Ngqura**

- The Constitution of the Republic of South Africa (108/1996) – which enshrines people's rights to a healthy and safe environment, and means that Transnet's activities must demonstrably support this end.
- National Environmental Management Act (107/1998) – which sets out the environmental management principles that are <u>to be applied by all organs of state</u> when taking decisions that significantly affect the environment.
- The Draft National Ports Authority Bill (2002) – which, *inter alia,* requires the NPA to protect the environment in its area of jurisdiction (at #49(2) the Authority has the power to take any action, it considers necessary for the performance of any functions relating to the protection of the environment, which may be conferred or imposed upon it under this Act or any other law).
- Port Regulations in force in terms of section 21 of the Legal Succession to the South African Transport Services Act (9/1989) – these address safety and environmental protection in the port.
- National Ports Authority of South Africa: Environmental Policy (11/10/2001) – Sets out the environmental policy, and guidelines for implementation. These commit the NPA to comply with relevant environmental legislation and, in particular, to: prevent pollution; strive to

improve environmental performance; influence the implementation of acceptable environmental practices by its clients; and to develop environmental management systems to the ISO 14001 international standard by the end of 2003 in order to give effect to its policy.

Those focusing on Biodiversity Protection:

- Marine Living Resources Act (18/1998) – governs the conservation of marine ecosystems, the delimitation of marine protected areas, limits to vessel proximity to whales, etc.
- Seabird and Seals Protection Act (46/1973).
- Convention on Biological Diversity (1992), & the RSA White Paper & Bill on the Conservation & Sustainable Use of South Africa's Biological Diversity (1997) – to protect and to minimize adverse impacts on biological diversity.
- National Environmental Management: Biodiversity Act (2004) – Protection of threatened or protected species and control of alien and invasive species.
- National Parks Act.
- National Environmental Management Act (107 of 1998) – Chapter 5 provides a framework for the integration of environmental issues into the planning, design, decision-making and implementation of plans and development proposals.

Those focusing on Pollution Prevention:

- London (Dumping) Convention (and 96 Protocol) – see South African guidelines for the management of dredge spoil in coastal waters controlling dredge spoil quality.
- London (Dumping) Convention (and 96 Protocol) – Specifying dredge spoil dump area monitoring.
- MARPOL 73/78 – International convention controlling the discharge of wastes from shipping. The Algoa Bay region forms part of a MARPOL Annex 1 zero oil discharge Special Area accepted by the IMO Marine Environmental Protection Committee for ratification by IMO in 2006. One of the express purposes of the special area is to protect endangered and/or threatened seabirds, e.g. the African penguin and Cape gannet, from oiling.
- Dumping at Sea Control Act (73/1980) – sets limits on dumping substances that may pollute or, for reasons of their bulk may interfere with fishing or navigation.
- Marine Pollution (Prevention of Pollution from Ships Act) (2 of 1986) – limits the operational (oil, garbage, plastics) discharges from the dredge and vessels operating in the port area.
- National Water Act (36 of 1998) – sets limits to the quality of effluent & water run-off into the harbour area.
- UN Convention on Law of the Sea (1982) – includes provisions on prevention of pollution, amongst others.

6.2.6 Scenarios considered in the impact assessment

The scenarios considered in this assessment relate to normal dredger and construction activities in the construction phase and routine ship movements and cargo (container) handling activities in the operational phase. Upset conditions in terms of large oil spills associated with catastrophic shipping accidents are addressed from a cumulative impact perspective as these were individually considered in the initial environmental impact assessments for the Port of Ngqura (CES 2001(a)).

6.3 Outline description of the environment

Marine environments in general are ecologically complex and multifaceted and Algoa Bay, because of the range of environments it encompasses and the amenity uses it provides, is amongst the more complex. This has been exacerbated to an extent by Phase 1 of the Port of Ngqura development. In this an enclosed water body has been created on a previously open shoreline and hard structures have been placed on what was previously a linear sandy shore. Further, large volumes of sediment have been removed from the nearshore and dumped in the vicinity of the 30 m isobath (i.e. 30m water depth). It is important that the current environmental context of the proposed Phase 2 development is taken into account in the assessment of the associated environmental impacts. The environmental descriptions given below provide the detail for this.

The marine and coastal environment encompassing the Port of Ngqura has been extensively, and repetitively, described in the various EIAs, and specialist studies conducted as part of the overall project development (e.g. CEN 1999, CES 2001(b), PRDW 2001, CSIR 2002, Wood 2002, etc). These have been augmented by environmental monitoring programme reports that have added valuable measurement data to the existing information (e.g. Klages and Bornman 2003, 2005a, 2005b, Klages *et al* 2006). This description is largely based on these reports. The description is partitioned into a 'general' component, giving a regional view of Algoa Bay; and a component that specifically concentrates on environmental attributes that have been shown to be directly affected by dredging activities as well as those that may be indirectly impacted. These include water column turbidity, sediment distributions and properties, subtidal and intertidal biological communities, amenity uses and predator populations.

6.3.1 Regional overview

6.3.1.1 Physiography

Algoa Bay is a large log-spiral bay (Rust 1991), anchored by rocky headlands at Cape Recife in the south east, and Woody Cape and the Bird Island group in the north east (refer to Figure 2.1 in Chapter 2). The bay contains the relatively large Zwartkops and Sundays Rivers and the much smaller Papenkuils and Coega rivers that discharge into it. The coastline consists mainly of quartzitic sands backed by sand dunes which are largely unvegetated and mobile north east of the Sundays River mouth.

Algoa Bay contains two groups of islands: the St Croix/Brenton/Jahleel group in the south and the Bird Island group towards the north east. The bay is relatively shallow being generally <50 m in depth. The seabed is mostly sandy but has portions of partly exposed bedrock, which in places may be covered by a thin layer of coarse sediment. Coarse sediments appear to be associated with the island groups. The volume of sediment transported northward and eastward by longshore drift around Algoa Bay past the Coega River mouth is estimated at 150 000 – 200 000m^3/yr (Illenberger 1997). Sand supply is probably augmented from the rivers. Some of the sediment in the bay is deposited by wave action on the sandy shores, particularly in the northern sections of the bay north of Sunday River. However, the overall residence time for surficial sediments is unknown.

6.3.1.2 Climate

Algoa Bay is situated near the junction of temperate (winter rainfall) and subtropical (summer rainfall) climate regimes and experiences a warm temperate climate; but wide variations in temperature, rainfall and wind patterns are experienced in this region (Stone 1988).

Exceptionally high air temperatures (~30°C) may be experienced during berg wind conditions that occur frequently during the winter. Average maximum temperatures range from a minimum of 19.5°C in July to 25.5°C in February. Average minimum temperatures follow a similar pattern with a minimum of 7.3°C in July and a maximum of 16.9°C in February (Stone 1988).

The Port Elizabeth area has a bimodal rainfall pattern, with peaks in spring and autumn. Rainfall ranges from 400 – 800 mm per year. The rainfall in the Coega area falls at the low end of the range this range, averaging 400 mm per year (Coetzee *et al* 1996). Three directions dominate the wind pattern in Algoa Bay: WSW-SSW, E-ESE and NW-NNW. Westerly winds blow throughout the year (41% combined frequency), easterly winds attaining their highest frequencies in summer and NW-NNW winds are most strongly developed in autumn and winter. Calmest periods are experienced in May and June with strongest winds in October and November. The approximate peak wind velocities for each of the dominant direction sectors are WSW-SSW 20 m/s, E-ESE 15 m/s and NW-NNW 10 m/s. Durations of particular wind events, e.g. westerly or easterly winds, are rarely longer than a few days.

6.3.1.3 Oceanography

6.3.1.3.1 Waves

Wave directions are dominated by the direction sector SSE – ESE. This is due to the refraction effects on southerly and south-westerly ocean waves around Cape Recife resulting in waves approaching the region of interest from the SSE. Waves may also approach from an easterly direction; these are weakly refracted and consequently retain high wave energy and may cause damage to coastal structures and ships (CSIR 2002).

6.3.1.3.2 Tides

Tides around South Africa are classified as semidiurnal microtidal, with a dominant M_2 tide (i.e. there are two high tides and two low tides per day). The tidal period is 12 hours and 25 minutes, with a slight diurnal inequality (Schumann *et al*., 1996). Spring- neap tide variation is significant.

Tide ranges vary from as little as 0.5 m tides during neap tides to over 2 m at spring tides (South African Navy Tide Tables).

Longer-period water level variations also occur as a result of meteorological influences, particularly wind. Coastal trapped waves along the south coast have amplitudes that on occasion are in excess of 0.5 m (Schumann and Brink, 1990). Consequently net water level variations in Algoa Bay are a combination of wind and wave set-up as well as tidal variations. Offshore current variability associated with the Agulhas Current may result in slow (periods of 20 days or more) and relatively small water level variations.

6.3.1.3.3 Coastal currents

Both modelling (CSIR, 2002) and measurement programs (Goschen and Schumann, 1988, 1990, Schumann *et al* 2005) have provided a reasonably good understanding of the circulation in Algoa Bay.

The Agulhas Current exerts large scale forcing functions in the wider Algoa Bay even though its core is generally located around the 200 m depth contour. However, in the immediate vicinity of the Port of Ngqura this influence may be limited to the modification of water masses and water column stratification. In common with the rest of the RSA continental shelf tidal currents are likely to be small in Algoa Bay as a result of its open geometry and the small tidal phase lag along the East Coast (SA Naval Hydrographic Office data show high tide at Mossel Bay, Port Elizabeth and East London occurring within 3 minutes of each other). However, Schumann *et al* (2005) detected significant energy at the M_2 period in the vicinity of Port Elizabeth harbour implying that here; at least, there may be tidal influences on the currents.

Currents measured in the immediate vicinity of the Port of Ngqura (S4 instrument deployed near the head of the breakwater in 17.5 m water depth) appear to be predominantly wind-driven, as they respond rapidly to wind conditions. Conversely, Schumann *et al* (2005) show that elsewhere in Algoa Bay surface and bottom currents can run counter to the wind for appreciable periods of time (~45 days). These authors indicate that entrainment of bottom waters by the Agulhas Current is the most plausible explanation for their observations. Wave-driven currents predominate in the nearshore zone adjacent to the Port Of Ngqura. Depending on the wave conditions these flows may be either SW or NE. Under high wave conditions these nearshore currents are of a significant magnitude. The Port of Ngqura obstructs the alongshore flow somewhat and results in a zone to the NE of the eastern breakwater that is at times quiescent or a zone of persistent re-circulation. A similar quiescent or recirculation zone exists to the SW of the Port of Ngqura.

A rough characterization of surface current speeds from modelling studies (CSIR 2002) indicates that the maximum simulated surface current speeds 500 m offshore are approximately 0.5 m/s, while maximum current speeds in the nearshore zone may exceed 0.6 m/s on occasion. These compare with an average velocity of 0.04 and an apparent maximum flow of ~0.2 m/s at the 10 m depth contour adjacent to the Papenkuils river mouth measured by Schumann *et al* (2005). In the deeper (~17 m) areas of the southern section of Algoa Bay these authors measured maximum current velocities of >0.4 m/s at mid-depth and >0.35 m/s close to the sea floor. In general the current speeds 500 m offshore are greatest in spring and summer, less in autumn and lowest in winter when the water column is well mixed. In the nearshore zone the currents are strongest in winter and spring.

6.3.1.3.4 Coastal seawater temperatures

In an analysis of seawater temperature measured in a water depth of approximately 17 m at a location some 1km SSW of Jahleel Island, Schumann (2003) reports the following:

- The development of a significant thermocline in November that reaches a maximum intensity from January to April with the abrupt onset of more isothermal conditions in late April.
- Significant temperature variability in the summer months but low temperature variability in winter.
- Surface seawater temperatures below approximately 14ºC are rare throughout the year whilst summer sea surface temperatures are mostly above 16ºC.
- There is an abrupt drop off in the frequency of occurrence of surface seawater temperatures above approximately 24ºC in summer, 20 to 21ºC in late summer and 18ºC in the winter months.
- In winter the surface and bottom seawater temperature distributions are similar while in summer bottom waters may be a couple of degrees cooler, particular in late summer.

6.3.1.4 Ecology

Marine ecosystems comprise a range of habitats each supporting a characteristic biological community. The important habitats in Algoa Bay are sandy beaches and surf zones, rocky shores on the adjacent Jahleel Island and in the vicinity of the Marine Growers abalone farm, the subtidal zone in the bay itself, the islands, the water body in Algoa Bay, and artificial surfaces and the water body in the port.

The description of the beach, nearshore ecology and areas of special interest (marine protected areas, abalone farm) are based on a number of existing reports (e.g. CES, 2001, Wood, 2002). [1]

6.3.1.4.1 Sandy beaches and surf zones

Sandy beaches in the region extending eastwards from the Zwartkops River mouth are classified as being intermediate in the dissipative/reflective continuum with transverse bars and rip currents. Surf zones fluctuate with wave height but may be 250-300 m wide. Beach swash zones are usually shallow with low waves. Net sand transport on both the shore and the wave dominated shallow subtidal is north and north eastwards. This type of beach is characteristic of eastern Algoa Bay and has a wide distribution in the region.

[1] Note that taxonomic nomenclature used in this report follows that used in the previous assessments for the region and that in Branch *et al* (2004). It is acknowledged that some of the names used are no longer applicable (e.g. *Nodilittorina*, Ridgeway *et al* 1998) but uniformity within the series of assessments and monitoring reports on the Port of Ngqura may have been compromised by changing to the currently valid taxonomic names.

A major ecological feature of these beaches/surfzones is the development of dense patches of the diatom *Anaulus australis* which may comprise more than 95% of the total algal production. Consequently this species is a critical component in the nearshore food web driving interstitial, microbial and macroscopic food chains. The partition of the energy is 20%, 40% and 20% respectively with the balance exported to the adjacent nearshore water column and benthic environments. Molluscs dominate the macrofaunal biomass with the dominant forms in the surfzone area being scavenging plough snails (*Bullia* spp.) and the filter feeding sand mussels *Donax serra* and *D. sordidus*. Sand mussels are apparently largely dependent on *Anaulus* and consequently reach their highest biomasses where *Anaulus* blooms are most frequent, north east of the Sundays River mouth. Swarming mysids (*Gastrosaccus* and *Mesodopsis* sp) are also important in the surfzone food web, and Sand mussel and mysids specifically are important prey species for various fish including sand sharks, rays, mullet, blacktail, white steenbras, white stumpnose etc and the three spot swimming crab *Ovalipes*.

High concentrations of food organisms, *Anaulus* blooms and swarms of mysids, lead to north eastern Algoa Bay surfzones being important nursery areas for a wide range of fish species. 30 species have been recorded of which approximately half also occupy surfzones as adults contributing to the more than 70 species of teleost and cartilaginous fish recorded from the surfzones and nearshore of Algoa Bay. The biological structure of Algoa Bay beaches and surfzones is unique in South Africa and is considered to merit a high conservation status. This is reflected in the proposed establishment of a marine protected area east of the eastern breakwater of the Ngqura port as part of the Greater Addo Elephant National Park.

6.3.1.4.2 Rocky shores on the adjacent Jahleel Island and in the vicinity of the Marine Growers abalone farm

Eastern Algoa Bay does not have extensive rocky shores these being limited to isolated stretches immediately east of the Coega river mouth and the island shores of which those of Jahleel Island are closest to the Ngqura port. The Island shores have been quantitatively surveyed as part of the suite of environmental monitoring associated with the port development (e.g. Klages and Bornman 2003, 2005a, 2005b, Klages *et al* 2006), but there is apparently no information available on isolated rocky shores that mainly comprise wave cut terraces north east of the port, e.g. Hougham Park.

The island shores exhibit characteristic zonation patterns extending down the intertidal zone; namely Littorina, Upper Balanoid, Lower Balanoid Mussel and Cochlear zones. Both the macroalgae and fauna appear to be typical of the Algoa Bay region. The macroalgae fall into the south coast biogeographic region (Bolton and Stegenga, 2002), with dominant taxa being *Porphyra, Ulva, Gelidium, Enteromorpha, Hypnea, Laurencia* spp and *Cheilosporum*. Emanuel *et al* (1992) classify the macrofauna of the Port Elizabeth area as falling within the 'Warm temperate south coast community'. Dominant macrofauna include the winkle (Molluscan gastropod) *Nodilotorina africana*, the limpets *Patella cochlear, P. granularis, Siphonaria* sp and keyhole limpets (probably *Fissurella* sp.), the brown mussel *Perna perna*, amphipod and isopod crustaceans, barnacles, primarily *Tetraclita serrata* and *Octomeris angulosa* and echinoderms.

Rare and/or endangered species have not (yet) been recorded from Jahleel island shores but this may be a function of survey intensity rather than the absence of such species.

6.3.1.4.3 Subtidal zone

The subtidal sea floor adjacent to the Port of Ngqura is dominated by low relief emergent rock reefs interspersed by various grades of sands. Mud, silt and clay sediments generally do not occur in this area, probably due to high shear stresses at the seafloor associated with waves. Although not well known, the available research/observation literature indicates that the major primary producers are phytoplankton and a fine macroalgal turf growing on the shallower emergent reef surfaces. The Coega River is apparently an important contributor of nutrients to the shallow subtidal as elevated phytoplankton biomasses have been recorded adjacent to the river mouth. The sand areas support a benthic macrofauna distribution expected for a nearshore depth gradient, i.e. suspension feeders dominate the shallow areas, predators and scavengers are most common at intermediate depths and deposit feeders dominate in the deeper areas. Biomass covaries with lowest levels in the nearshore and highest levels at the deeper locations.

The benthic macrofauna include all of the major groups expected to be found in RSA inner continental shelf unconsolidated sediments. Crustaceans and polychaetes comprise the numerical dominants followed by molluscs and echinoderms. Subsidiary taxa such as sipunculids have also been recorded in the area. The pelagic fauna is perhaps different from other east and southeast coast beaches in that, aside from the ubiquitous fish species, the mysid *Mesopodopsis wooldridgei* forms dense swarms out to approximately 10 – 20 m depths and moves inshore to just behind the breaker line at night to feed. Here it consumes phytoplankton, including *Anaulus*, and is preyed on in turn by various fish. This mysid is probably instrumental in transporting primary production from the surfzone into the shallow and deeper subtidal regions.

6.3.1.4.4 Ecological communities in the Port of Ngqura

Sediment macrofauna in the harbour was relatively impoverished in 2006 at 9 specimens/0.25 m^2 (Klages *et al* 2006). These were apparently not taxonomically distinct from the biological community in sediments adjacent to the harbour. Photographic transect surveys across the full intertidal zone of the harbour structures in March 2006 indicated that they supported brown mussel *Perna perna* and rock oyster *Striostrea margaritacea* as well as attached epiphytic and filamentous algae, barnacles (*Tetraclita, Chthamalus*) etc (Klages *et al* 2006). These species can be considered as being typical of the region. In cursory observations made in July 2006 the mussels ranged up to 50 mm – 60 mm indicating ages of 12 – 18 months (Dye and Dyantyi 2002). It is unknown whether the current community developed recently (i.e. within past two years) or had begun colonising the artificial surfaces soon after their construction. Whatever the case, it appears that, as a minimum, the development of biofouling communities can be rapid in this particular location.

6.3.1.4.5 Biodiversity and conservation

The available biological records for Algoa Bay, encompassing the Ngqura port, indicate that none of the marine algae, fish and invertebrate species/taxa has either restricted distributions or small population sizes. In fact some of the organisms have extremely wide distributions in South

African coastal waters with apparently robust populations. Consequently none of the recorded species are classifiable as either rare or endangered in terms of their conservation status. Note that the initial tentative classification of a phyllocarid crustacean (*Nebalia*) in the subtidal benthos (Newman *et al* 2001) appears to have been erroneous.

The colonial breeding coastal seabirds that utilize the Algoa Bay Islands, including Jahleel, as nesting sites and specifically the Humpback dolphin *Sousa chinensis* are exceptions to this.

- The St Croix Island group, incorporating Jahleel Island, held a significant proportion of the global African penguin *Spheniscus demersus* population (~ 40%, Barnes (1998)) in the 1990s. These birds move between the islands and, although not as important as St Croix Island itself due to its size and terrain, Jahleel Island has hosted important numbers of penguins. African penguins are classified as globally threatened according to Birdlife International (2004). Accordingly islands in the St Croix Island group are denoted as Important Bird Areas (Barnes, 1998) and are currently provincial nature reserves. The reserve boundaries extend 500 m offshore of the islands as Marine Protected Areas. It has been proposed that the Algoa Bay Islands be incorporated into a National conservation area; the Greater Addo Elephant National Park.
- The southern African population of Humpback dolphin has been estimated at <1000 individuals and 200 – 400 of these are resident in Algoa Bay. Due to its low population size this species potentially classifies as vulnerable under the IUCN criteria but due to lack of information is currently held in the data deficient category (IUCN, 2000). The individuals in Algoa Bay are mainly distributed around rocky reefs in the nearshore south west of the Sundays River mouth. According to Wooldridge *et al* (1997) the surf zone off the Coega River mouth and around the St Croix Islands was an important foraging and socializing area for this species. Some of this habitat has already been altered by the construction of the Ngqura Port breakwaters which has unpredictable consequence for the local (Algoa Bay) sub-population.

6.3.1.5 Areas of special interest

Areas of special interest are the ***abalone farm*** and the ***marine protected*** areas both existing (associated with the Algoa Bay Island nature reserve) and proposed (the Greater Addo Elephant National Park).

The abalone farm is located on the coast ~1.8km north east of the eastern breakwater of the Port of Ngqura. The farm predates the establishment of the port and was one of the pioneering developers of the abalone farming industry in RSA. The farm abstracts seawater from shallow sumps cut into the rock platform below the farm; these are episodically covered in sand transported through the area by waves and currents. The sand acts as a large sand filter and can be beneficial in terms of the quality of the water pumped into the farm.

Abalone growth rates on the farm are rapid compared to farms that operate further to the west in the Danger Point/Hermanus area which is partly attributable to higher sea water temperatures.

These do bring risks, however, as summer temperatures may approach critical limits for the abalone. At these times the farm increases water turnover rates (i.e. more pumping) and increases aeration to counter the effects of increased temperatures. The abalone farm has suffered abalone mortalities and reduced growth rates directly attributable to increased suspended sediment concentrations in its intake water (C. Muller, Marine Growers, *pers. comm.*). Coupled with this have been increased pump maintenance requirements (W. de Wet, Marine Growers, *pers. comm.*). The farm can therefore be considered to be sensitive to increased suspended sediment loads in the region.

The Bird Island Marine Reserve (proclaimed in 2004) is designated as a 'no take' area with all forms of fishing and associated activities being banned in the area. Further, each of the St Croix Island group, consisting of St Croix, Brenton and Jahleel islands are designated nature reserves with their reserve areas extending out to 500 m offshore, and all of the Algoa Bay islands are declared Important Bird Areas (IBA), as they are inhabited by threatened and endangered species (Wood, 2002).

6.3.1.6 Resources, and Commercial and Recreational Fisheries

In excess of 70 fish species inhabit Algoa Bay comprising species endemic to South African coastal waters and fish with wider distributions. None of these species have distributions limited to the Algoa Bay area, i.e. they cannot be considered as rare and/or endangered or having narrow habitat preferences. Commonly occurring species include southern mullet, blacktail, sand and white steenbras, olive rock grunter, white stumpnose, and strepie. Elf and kob are present seasonally. Sharks, e.g. bronze whaler, lesser sandshark and rays, e.g. blue stingray, eagle ray are encountered in the region along with many other species (see distribution ranges for individual fish species given by Heemstra and Heemstra 2004). Pilchard, anchovy, red eye also occur in Algoa Bay and are important food resources for their common predators, e.g. piscivorous seabirds, dolphins etc.

Some of these species support commercial linefishing and are the basis for a significant recreational fishery in Algoa Bay. No trawling is allowed within the confines of Algoa Bay inshore of a line extending from Cape Recife to Woody Cape. No fishing at all is permitted in the Bird Island Marine Protected area (above).

Algoa Bay is important for commercial (and recreational) caches of squid (*Loligo vulgaris reynaudii*), a valuable fishery within the South African context. Squid spawn in Algoa Bay throughout the year but with apparent peaks in the spring/summer period. The squid attach their egg pods to the sea floor for egg maturation and hatching. Direct observations indicate that preferred substrate types for pod attachment are coarse sands and shell, flat and high profile reef and sand interspersed with reef (Roberts 1998). Egg pods have not been observed in fine sands and silt which is possibly due to insecure attachment. There are a minimum of 26 individual spawning sites in Algoa Bay. During spawning, at least, squid are mainly benthic predators consuming the larger polychaetes and crustacea (Sauer and Lipinski, 1991).

6.3.2 Site specific detail on the port area and environmental components that may be affected by the phase 2 activities

An over-arching description of the proposed project is provided in Chapter 2. This section provides additional project information specific to the marine impact assessment.

The capital dredging works required to create the Port of Ngqura involved the removal of ~15 000 000 m^3 of dredge spoil and disposal thereof to a designated dredge spoil dump located approximately 8km offshore on the 30 m depth contour (Newman *et al* 2001, Figure 6.1). The anticipated effects of this included removal/destruction of benthic organisms in the dredge area, inundation/burial of these organisms at the dredge spoil disposal site, modifications to biological processes and/or communities by elevated turbidity and possible remobilization of trace metals (CES 2001(b)). As a result of this, and predicted contaminant flows into the marine environment as the port and its associated industries develops, the Ngqura Development Corporation commissioned a series of environmental surveys and studies to provide a quantitative baseline against which any future changes could be compared (Newman *et al* 2001). Following this regular environmental monitoring has been conducted to demonstrate whether changes are occurring, or have occurred associated with the port development (Klages and Bornman 2003, 2005a, 2005b, Klages *et al* 2006). Information from these surveys together with fishery and coastal seabird monitoring data sourced from DEAT/MCM and CSIR sediment survey data (CSIR 2006) are used below to provide more specific detail on the Port of Ngqura area and environmental components that may be affected by the proposed port development activities.

Figure 6.1 shows the sampling sites for the variables monitored; additional data were sourced from DEAT/MCM (coastal seabirds and fisheries) and (CSIR 2006).

The following variables have monitoring/survey data and are discussed here:

- Sediment properties
- Turbidity
- Benthos
- Island intertidal communities
- Fisheries
- Coastal seabirds (penguins, gannets).

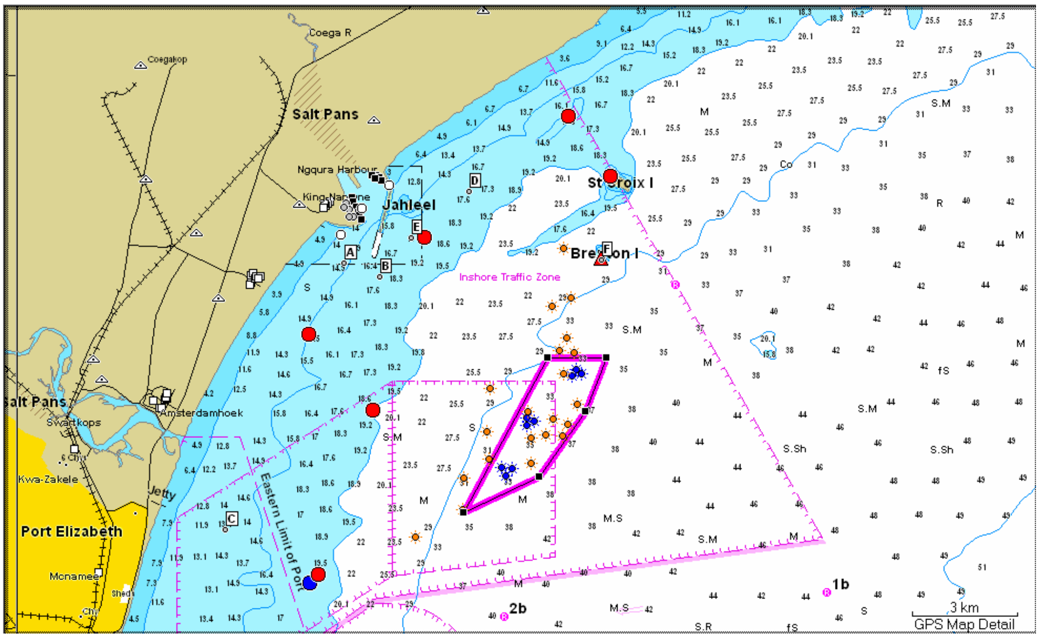

Figure 6.1: Chartlet of Algoa Bay showing sampling sites for various monitoring surveys associated with the Port of Ngqura development. The area enclosed by the purple lines denotes the dredge spoil dump site. Blue nav stars, black squares and grey circles show CSIR (2006) sediment sampling sites; orange nav stars show CES (2001) sites around the spoil dump area, red and blue circles show Klages and Bornman's (2003, 2005a,b) and Klages *et al*'s (2006) 'routine' sample sites and sites A-F show turbidity monitoring sites.

6.3.2.1 Sediment properties

Sediment properties (granulometry, texture and trace metals) have been determined for the pre-dredge (CES 2001(b), Newman *et al* 2001) and post-dredge conditions (Klages and Bornman 2003, 2005a, Klages *et al* 2006). The sediments in the dredge area and areas adjacent to the port were predominantly medium sands with minor amounts of silts, clays, gravel and cobbles. Prior to any dredged sediment discharge at the specified disposal site (Figure 6.3) sea floor sediments were classified as fine and medium sands (median particle size 1.86phi; = ~0.28 mm ESD) with a tendency to coarsen towards the north eastern extremity. Mud content ranged from 3% to 59% with a median value of 14.92%.

Contaminant (trace metal, chlorinated hydrocarbon and PCB) concentrations in the sediments targeted for dredging were all low with the exception of arsenic (CSIR 1999 in CES 2001(b)) and well within sediment quality guideline values (DEAT 1999, BCLME 2004). Klages and Bornman (2005a) attribute the elevated arsenic concentrations to the tanning industry but note that these were only slightly above the ERL (effects range low) concentration threshold of Long *et al* (1995) implying low toxicity risk. The observed contaminant concentrations are to be expected for a non-industrial site with low proportions of muddy sediments such as the Coega river mouth area (e.g. GIPME 1999). Data presented by Newman *et al* (2001) indicate that the organic content of sediments in the Ngqura port area were low; again this is to be expected from the sediment granulometry and texture distributions.

Post dredging monitoring surveys conducted by Klages and Bornman (2005a) and Klages *et al* (2006) indicate that the sediments in the vicinity of the port remained as being predominantly medium sands with admixtures of gravel. The data presented by the various authors do not permit a statistical evaluation but whatever changes there may have been would appear to be minor. Further, Klages and Bornman (2003, 2005a), Klages *et al* (2006) show that, after the completion of the dredging programme, contaminant concentrations in the sediments adjacent to the port have remained low. Arsenic, as stated above, is an exception to this. Given the quality of the source sediments (above) this is not an unexpected result.

CSIR (2006) measured sediment properties in harbour sediments, vibro-core samples retrieved from the proposed construction site for the planned container berths (Figure 6.1) and at the dredge spoil dump site. Tables 6.1a and 6.1b show that most of the individual sediment trace metal concentrations measured by CSIR (2006) in the harbour area were low, falling within the limits of special care set for RSA dredging and dredge spoil dumping activities (DEAT 1998, BCLME 2004). Arsenic and chromium were exceptions to this; the former exceeding the special care threshold and the PEL in one deep vibro-core sample and chromium marginally exceeding the special care threshold in the surficial layer at sample site CB4. Further, four of the samples in the harbour and 23 of the vibro-core samples exceeded the special care limits for combined London Convention Annex 2 trace metal concentrations.

Trace metal concentrations in the surficial and vibro-core samples (Tables 6.1a and 6.1b) were statistically indistinguishable at the 95% confidence level (One way ANOVA, p values 0.060-0.434). Regressions between the individual trace metal and aluminium concentrations for the combined data set show that large proportions of the variances in chromium, copper, nickel, lead, zinc and total trace metals were explained by aluminium concentration alone (r^2 values, Table 6.2). The relationships are graphically illustrated in Figure 6.2. The variance in arsenic appeared to be weakly linked to aluminium. Aluminium in marine sediments is a strong proxy for terrigenous clay minerals (Libes 1992) and therefore it is probable that all the trace metals except arsenic and to a lesser extent chromium have a lithogenic, as opposed to anthropogenic origin. Arsenic and a low proportion of the chromium may have an anthropogenic source or sources in the region, as pointed out above this may be from tanning industries as both trace metals have applications there.

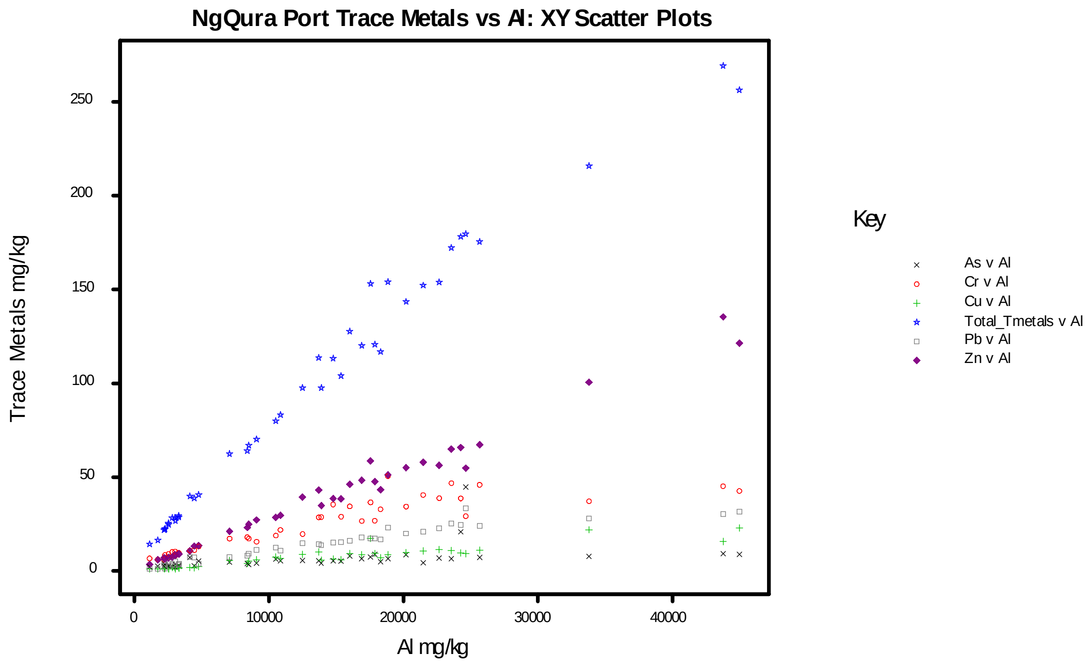

Figure 6.2: X/Y Scatter plots showing the relationships between London Convention (LC) Annex 2 trace metals and aluminium in surficial and vibro-core sampled sediments in the proposed dredge areas in the Port of Ngqura. The data are listed in Tables 6.1a and 6.1b and the regression statistics in Table 6.2.

Table 6.1a: London Convention (LC) Annex 2 trace metal concentrations in surficial sediments in the Port of Ngqura sampled in July 2006. Included are LC special care and prohibition thresholds (DEAT 1998) and sediment quality guideline concentrations (TEL and PEL) taken from BCLME (2004). The data are from CSIR (2006)

Sample	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Total Tmetals
CB1	*2210.8*	*2.4*	*<0.5*	*5.9*	*1.1*	*<0.5*	*1.4*	*4.0*	*6.9*	*21.8*
CB2	*3314.1*	*2.5*	*<0.5*	*9.5*	*1.4*	*<0.5*	*2.5*	*3.8*	*9.0*	*28.6*
CB3	*13892.5*	*4.2*	*<0.5*	*28.7*	*5.7*	*<0.5*	*10.5*	*13.7*	*34.7*	***97.5***
CB4	*18844.1*	*6.4*	*<0.5*	***50.5***	*8.7*	*<0.5*	*14.4*	*23.0*	*51.2*	***154.1***
CB5	*2560.7*	*2.8*	*<0.5*	*7.3*	*1.1*	*<0.5*	*1.7*	*4.8*	*7.1*	*24.8*
CB6	*18297.5*	*4.9*	*<0.5*	*32.8*	*7.0*	*<0.5*	*12.1*	*16.8*	*43.3*	***116.8***
ACB1	*15364.5*	*5.1*	*<0.5*	*28.8*	*6.0*	*<0.5*	*10.2*	*15.4*	*38.4*	***104.0***
ACB2	*4455.9*	*2.7*	*<0.5*	*11.0*	*1.6*	*<0.5*	*3.1*	*7.1*	*13.2*	*38.8*
ACB3	*3057.6*	*3.6*	*<0.5*	*8.1*	*<1.0*	*<0.5*	*1.8*	*5.0*	*8.2*	*26.7*
Mean	*9110.9*	*3.8*	*<0.5*	*20.3*	*4.1*	*<0.5*	*6.4*	*10.4*	*23.6*	*68.1*
Std Dev	*6860.0*	*1.3*	*-*	*14.7*	*2.9*	*-*	*5.0*	*6.6*	*17.0*	*47.2*
LC Special Care	***N/A***	***30-150***	***1.5-10.0***	***50-500***	***50-500***	***0.5-5.0***	***50-500***	***100-500***	***150-750***	***50-500***
LC Prohibition	***N/A***	***>150***	***>10.0***	***>500***	***>500***	***>5.0***	***>500***	***>500***	***>750***	***>500***
TEL	***N/A***	***7.2***	***0.7***	***52.3***	***18.7***	***0.1***	***15.9***	***30.2***	***124.0***	**-**
PEL	***N/A***	***41.6***	***4.2***	***160.0***	***108.0***	***0.7***	***42.8***	***112.0***	***274.0***	**-**

Table 6.1b: London Convention (LC) Annex 2 trace metal concentrations in sediments taken by vibro-core from the reclaim adjacent to the planned container berth expansion area in the Port of Ngqura in July 2006. Included are LC special care and prohibition thresholds (DEAT 1998) and sediment quality guideline concentrations (TEL and PEL) taken from BCLME (2004). The data are from CSIR (2006)

Sample Depth (m)	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Total Tmetals
21.5-23.0	*24628*	***44.6***	*<0.5*	*29.1*	*9.2*	*<0.5*	*8.5*	*33.4*	*54.7*	***179.6***
7.0-21.5	*33789*	*7.7*	*<0.5*	*37.1*	*21.9*	*<0.5*	*20.8*	*28.0*	*100.5*	***215.9***
19-20	*44960*	*8.8*	*<0.5*	*42.6*	*22.9*	*<0.5*	*29.1*	*31.6*	*121.4*	***256.4***
18.5-19	*43754*	*9.1*	*<0.5*	*45.1*	*15.6*	*<0.5*	*33.8*	*30.3*	*135.4*	***269.3***
16.45-17	*10516*	*6.3*	*<0.5*	*18.8*	*7.3*	*<0.5*	*6.7*	*12.3*	*28.5*	***79.9***
16-16.45	*4137*	*7.2*	*<0.5*	*10.9*	*1.7*	*<0.5*	*2.0*	*7.4*	*10.6*	*39.8*
15.45-16	*17869*	*8.9*	*<0.5*	*26.7*	*9.3*	*<0.5*	*11.0*	*17.3*	*47.5*	***120.7***
15-15.45	*4790*	*5.2*	*<0.5*	*13.0*	*2.2*	*<0.5*	*3.0*	*3.7*	*13.4*	*40.6*
14.45-15	*9084*	*4.1*	*<0.5*	*15.5*	*5.9*	*<0.5*	*6.4*	*11.1*	*27.1*	***70.2***
14-14.45	*23563*	*6.5*	*<0.5*	*46.7*	*10.7*	*<0.5*	*18.1*	*25.2*	*65.0*	***172.3***
13.45-14	*12504*	*5.6*	*<0.5*	*19.6*	*8.8*	*<0.5*	*9.7*	*14.7*	*39.3*	***97.6***
13-13.45	*14774*	*5.4*	*<0.5*	*35.4*	*6.4*	*<0.5*	*12.5*	*15.1*	*38.6*	***113.3***
12.45-13	*16905*	*6.4*	*<0.5*	*26.6*	*8.7*	*<0.5*	*12.3*	*17.9*	*48.3*	***120.2***
12-12.45	*2533*	*2.2*	*<0.5*	*9.0*	*1.2*	*<0.5*	*3.8*	*2.5*	*6.7*	*25.4*
10.45-11	*8512*	*3.3*	*<0.5*	*17.2*	*5.3*	*<0.5*	*7.0*	*9.2*	*24.9*	***66.9***
10-10.45	*3026*	*1.9*	*<0.5*	*10.3*	*1.7*	*<0.5*	*2.9*	*2.9*	*8.7*	*28.4*
9.45-10	*2281*	*3.0*	*<0.5*	*7.0*	*1.6*	*<0.5*	*1.8*	*2.7*	*6.5*	*22.6*
9-9.45	*2275*	*3.6*	*<0.5*	*8.4*	*1.1*	*<0.5*	*1.5*	*1.2*	*6.2*	*22.2*
8.45-9.0	*3294*	*3.0*	*<0.5*	*9.6*	*1.8*	*<0.5*	*2.7*	*3.2*	*9.1*	*29.3*
8-8.45	*1752*	*2.5*	*<0.5*	*6.0*	*<1.0*	*<0.5*	*2.0*	*<1.0*	*5.9*	*16.4*
7.45-8.0	*7080*	*4.6*	*<0.5*	*17.2*	*5.5*	*<0.5*	*6.7*	*7.3*	*21.0*	***62.4***
7.0-7.45	*2810*	*2.3*	*<0.5*	*10.0*	*1.7*	*<0.5*	*3.2*	*3.6*	*7.4*	*28.3*
6.45-7.0	*10862*	*5.3*	*<0.5*	*21.8*	*6.6*	*<0.5*	*9.0*	*10.8*	*29.6*	***83.2***
6.0-6.45	*1136*	*2.1*	*<0.5*	*6.6*	*<1.0*	*<0.5*	*2.1*	*<1.0*	*3.4*	*14.3*
5.45-6.0	*20197*	*8.6*	*<0.5*	*34.3*	*9.7*	*<0.5*	*16.0*	*19.9*	*55.0*	***143.5***

Sample Depth (m)	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Total Tmetals
5.0-5.45	*8398*	*4.0*	*<0.5*	*18.0*	*3.8*	*<0.5*	*7.0*	*8.2*	*23.1*	***64.1***
4.45-5.0	*16008*	*7.9*	*<0.5*	*34.4*	*9.2*	*<0.5*	*14.1*	*16.0*	*46.2*	***127.7***
4.0-4.45	*22656*	*6.8*	*<0.5*	*38.7*	*11.3*	*<0.5*	*18.2*	*22.6*	*56.2*	***153.9***
3.45-4.0	*17557*	*7.3*	*<0.5*	*36.5*	*17.2*	*<0.5*	*16.2*	*17.3*	*58.6*	***153.2***
3.0-3.45	*24259*	*20.8*	*<0.5*	*38.6*	*9.5*	*<0.5*	*19.0*	*24.4*	*65.7*	***178.1***
2.0-2.45	*25659*	*7.2*	*<0.5*	*45.8*	*10.9*	*<0.5*	*20.4*	*23.9*	*67.3*	***175.6***
1.0-1.45	*21466*	*4.2*	*<0.5*	*40.4*	*10.6*	*<0.5*	*18.2*	*20.9*	*57.9*	***152.2***
0.0-1.0	*13704*	*5.3*	*<0.5*	*28.5*	*10.0*	*<0.5*	*12.5*	*14.2*	*43.1*	***113.6***
Mean	*14447*	*7.0*	*<0.5*	*24.4*	*8.0*	*<0.5*	*10.9*	*14.8*	*40.4*	*104.1*
Std Dev	*11423*	*7.5*	*-*	*13.2*	*5.6*	*-*	*8.1*	*9.3*	*32.4*	*69.9*
LC Special Care	***N/A***	***30-150***	***1.5-10.0***	***50-500***	***50-500***	***0.5-5.0***	***50-500***	***100-500***	***150-750***	***50-500***
LC Prohibition	***N/A***	***>150***	***>10.0***	***>500***	***>500***	***>5.0***	***>500***	***>500***	***>750***	***>500***
TEL	***N/A***	***7.2***	***0.7***	***52.3***	***18.7***	***0.1***	***15.9***	***30.2***	***124.0***	**-**
PEL	***N/A***	***41.6***	***4.2***	***160.0***	***108.0***	***0.7***	***42.8***	***112.0***	***274.0***	**-**

Table 6.2: Linear regression (y = ax + b) statistics describing the relationships between trace metals (mg/kg) and aluminium (g/kg) in the target dredge areas in the Port of Ngqura. The raw data are listed in Tables 6.1a and 6.1b

Trace Metal	***Equation***		***p***	***r^2***
	Slope(a)	***Intercept(b)***		
Arsenic	0.2768	2.66	0.003	0.176
Chromium	1.1032	8.85	<0.001	0.765
Copper	0.4626	0.63	<0.001	0.843
Nickel	0.6873	0.76	<0.001	0.928
Lead	0.8041	2.50	<0.001	0.897
Zinc	2.7952	-0.39	<0.001	0.980
All LC Annex 2	6.1410	14.73	<0.001	0.974

The apparent lithogenic origin of the majority of the trace metals and the low organic matter concentrations in the sediments observed by Newman *et al* (2001) indicate that trace metals in the target dredge area should not be biologically available. Even if they were, the fact that there were only isolated cases where sediment quality guidelines (TEL, PEL) were exceeded, and that all of the calculated mean trace metal concentrations were, with the exception of arsenic, well within the guideline levels indicates a low probability of deleterious effects on biota in the receiving environment for the dredge spoil.

ANZECC (2000) suggest a low threshold interim sediment quality guideline (ISQG) level concentration of 20 mg/kg for arsenic. This is equivalent to the Effects Range-Low (ERL) threshold of Long *et al* (1995) for south eastern United States coastal and estuarine waters. This was calculated from an extensive data base of concurrent observations of sediment trace metal concentrations and effects on biological species or communities in the field. The ERL threshold represents the 10^{th} percentile of the effects data base and is interpretable as the level below which adverse biological effects are unlikely. As the mean arsenic concentration measured in the Port of Ngqura sediments is ~35% of the ANZECC (2000) ISQG the probability of observable effects on biota and/or biological communities in the dredge area or the dredge spoil dump site would appear to be remote.

Despite it being a recommendation of the initial impact assessment for dredge spoil disposal (CES 2001(b)) no post spoil discharge monitoring of the designated dump site appears to have been conducted for the Phase 1 dredging. As part of the data collection for this assessment sediment samples were taken from the dump site in July 2006 (CSIR 2006). Additionally, the amount of dredge spoil on the dump was estimated from detailed before/after bathymetric surveys.

Measured trace metal concentrations were mainly low (Table 6.3) and, similar to the sediments in the port, below the special care level (DEAT 1998, BCLME 2004). Most of the sediment classified as sand with the exception of two samples where the percentages of silt (ESD < 62.5µm) were 17.2 and 75.4 respectively. These data are similar to those of CES (2001) described above.

Table 6.3: London Convention (LC) Annex 2 trace metal concentrations in surficial sediments obtained in July 2006 from the Port of Ngqura dredge spoil dump site. Included are LC special care and prohibition thresholds (DEAT 1998), sediment quality guideline concentrations (TEL and PEL) taken from BCLME (2004) and trace metal concentrations measured concurrently at the Klages and Bornman's (2003, 2005a, b) reference station (O) off Deal Party. The data are from CSIR (2006).

Sample	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Total Tmetals
DS1a	*7563.2*	*5.6*	*<0.5*	*17.9*	*2.8*	*<0.5*	*4.8*	*7.8*	*21.3*	*60.2*
DS1b	*5819.9*	*5.4*	*<0.5*	*14.3*	*1.8*	*<0.5*	*3.4*	*6.3*	*17.8*	*49.0*
DS1c	*8364.1*	*5.7*	*<0.5*	*20.7*	*3.2*	*<0.5*	*5.8*	*8.2*	*23.5*	*67.2*
DS2a	*3540.4*	*2.1*	*<0.5*	*8.6*	*1.5*	*<0.5*	*2.6*	*3.9*	*9.0*	*27.6*
DS2b	*2272.9*	*2.1*	*<0.5*	*5.8*	*1.1*	*<0.5*	*1.3*	*3.0*	*5.9*	*19.1*
DS2c	*3116.7*	*1.9*	*<0.5*	*8.1*	*1.2*	*<0.5*	*2.1*	*3.9*	*7.3*	*24.6*
DS3a	*3448.8*	*1.7*	*<0.5*	*7.7*	*1.5*	*<0.5*	*2.4*	*4.4*	*8.6*	*26.4*
DS3b	*18831.1*	*5.8*	*<0.5*	*42.6*	*9.9*	*<0.5*	*15.1*	*16.1*	*46.9*	*136.3*
DS3c	*10023.9*	*3.0*	*<0.5*	*21.1*	*4.8*	*<0.5*	*8.3*	*8.8*	*24.5*	*70.4*
Mean	6997.9	3.7	<0,5	16.3	3.1	<0.5	5.1	6.9	18.3	53.4
Std Dev	5180.4	1.9	-	11.5	2.8	-	4.3	4.1	13.0	36.8
TEL	***N/A***	***7.2***	***0.7***	***52.3***	***18.7***	***0.1***	***15.9***	***30.2***	***124.0***	**-**
PEL	***N/A***	***41.6***	***4.2***	***160.0***	***108.0***	***0.7***	***42.8***	***112.0***	***274.0***	**-**
REF (O)	*3258.9*	*4.0*	*<0.5*	*9.2*	*<1.0*	*<0.5*	*2.2*	*4.9*	*16.8*	*37.1*

The effect of the dumped dredge spoil on bottom topography at the designated dredge spoil dump site is shown in Figure 6.3 as net differences (metres) between before and after dump bathymetric surveys. The measurement error, due to absolute differences in sea level between the surveys, is probably ~0.3 m. It is apparent that that the dredge spoil dumping has caused marked increases in topographic features with a large proportion of the seabed at the spoil dump site being elevated by 1.5 m or more.

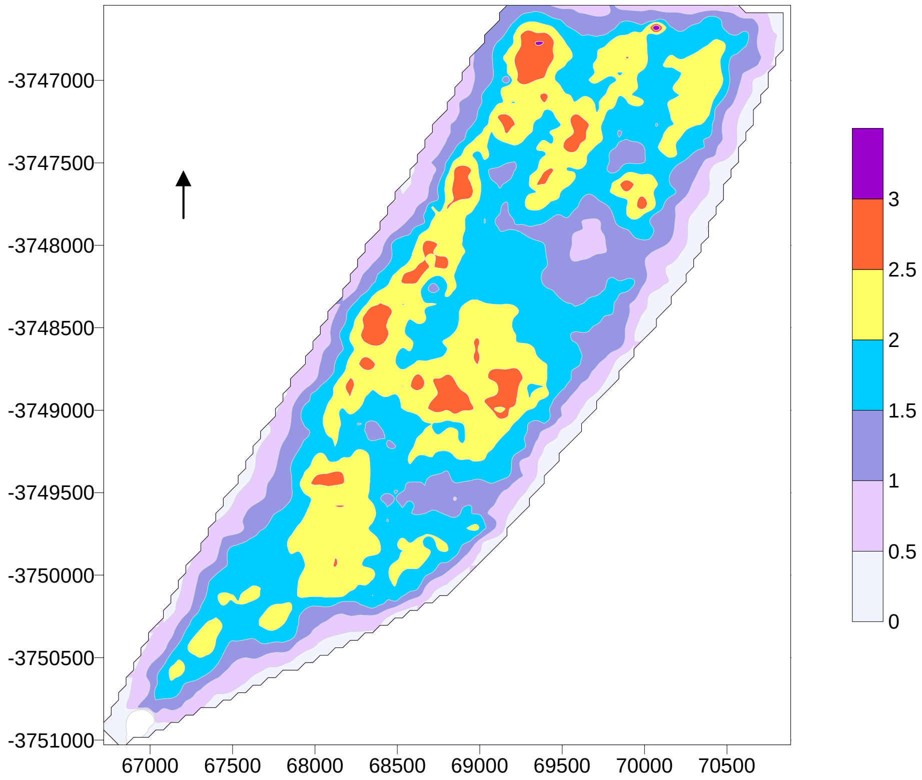

Figure 6.3: Plot of seabed elevation (m) at the dredge spoil dump site due to Phase 1 dredge spoil disposal. The arrow indicates true north. The bathymetric data were supplied by Transnet.

6.3.2.2 Turbidity

Natural (i.e. background) suspended sediment concentrations in Algoa Bay appear to be generally less than 5 mg/l but this may increase to values greater than 30 mg/l[2] in near bottom waters (Schumann and Campbell 1999). Churchill (1995 cited in CES 2001(b)) showed that elevated turbidity measurements (NTU) 5 m above the seafloor may be associated with high waves. Klages and Bornman (2005b) report vertical turbidity profile measurements taken in

[2] Note – There is no universal conversion factor to translate suspended sediment concentrations to nephelometric turbidity units (NTU). This is due to the fact that NTUs are a composite value of light absorption and scatter. The former is predominantly controlled by colour whilst the latter is primarily a function of particle density, size and shape. Suspended sediment concentrations are determined gravimetrically and represent the amount of material present only.

September and November 2003 at nearshore stations adjacent to the Port of Ngqura prior to the commencement of dredging and dredge spoil disposal. These profiles showed that the upper water column typically had NTU values of 5-10 with increases to 15-20 NTU at the bottom of the water column. Dorfler (2002) measured turbidity levels in Algoa Bay in April 1999, June and October 2000 and September 2001, recording surface values between 0.5 and 2 NTU. In these surveys turbidity in the lower portions of the water column fell in the range 3-4 NTU. Dorfler's measurement sites were offshore of those of Klages and Bornman (2005b) and her measurements did not penetrate to the bottom of the water column (due to strictures placed on instrument deployment by DEAT/MCM). Thus although not totally comparable with the Klages and Bornman estimates it is apparent that, prior to dredging and dredge spoil disposal, Algoa Bay turbidity measurements fell into the overall range of 0.5-10 NTU and 3-20 NTU in the surface and bottom waters respectively. During and after dredging (September 2004, January and September 2005) upper water column turbidity remained in the 5-10 NTU range but bottom waters invariably had far higher turbidity at 30 – >150 NTU (Klages and Bornman 2005b). These authors note that the higher bottom water turbidity levels persisted for at least six months after the completion of the dredging programme. Personnel at the Marine Grower's abalone farm state that the increased turbidity levels were present in the region in July 2006 and were readily observable in the nearshore under easterly wind conditions (W. de Wet, Marine Growers Abalone farm, *pers. comm.*). Klages and Bornman (2005b) attribute the high turbidities to the fact that the finer particles in the dumped dredge spoil have not yet been consolidated into the seafloor sediments and are therefore easily resuspended by wave action.

Figure 6.4**:** Aerial photograph of turbid water generated by dredging during the Phase 1 port construction activities (*photograph supplied by D. Phelp, CSIR*).

Aerial photography, e.g. Figure 6.4, indicates that high turbidity levels occurred in the harbour area during dredging. Data from routine compliance monitoring carried out by the dredging contractor over the dredging period are summarized in Figure 6.5. The absolute range of these data is 1.2 – 51.0 mg suspended sediment/l (= 2–135NTU, calculated from the dredging contractor's calibration equation), lower than the peak values reported by Klages and Bornman (2005b). The latter authors observe that the dredging contactor may have overestimated measurement depths and therefore missed the high turbidity levels near the sea floor. If it is accepted that this is true then the contractor's data shown in Figure 6.5 may be taken to represent the worst case in the upper water column while Klages and Bornman's (2005b) measurements represent turbidity values that can be attained in bottom waters adjacent to the port.

Dredging induced turbidity in the upper water column around the port had largely dissipated by September 2005 as measurements at this time had returned to near background levels (Klages and Bornman 2005b). This effect appears to have persisted into 2006 (Klages *et al* 2006) Turbidity at the bottom of the water column in September 2005, however, remained high at >100NTU. This was attributed to resuspension of weakly consolidated or unarmoured fine sediments from the dredge spoil dump site by waves and currents (Klages and Bornman 2005b). Klages *et al* (2006) determined secchi disc depths and did not measure turbidity near the sea floor. Therefore their data are insufficient to determine whether elevated turbidities near the sea floor had dissipated in 2006 or not. It must be noted that highly turbid nepheloid layer water penetrates into the large south coast bays (Jeffries, Seal and Algoa Bays; Dorfler 2002) and therefore the elevated turbidities observed by Klages and Bornman (2005b) in September 2005 cannot be unequivocally attributed to dredge spoil disposal.

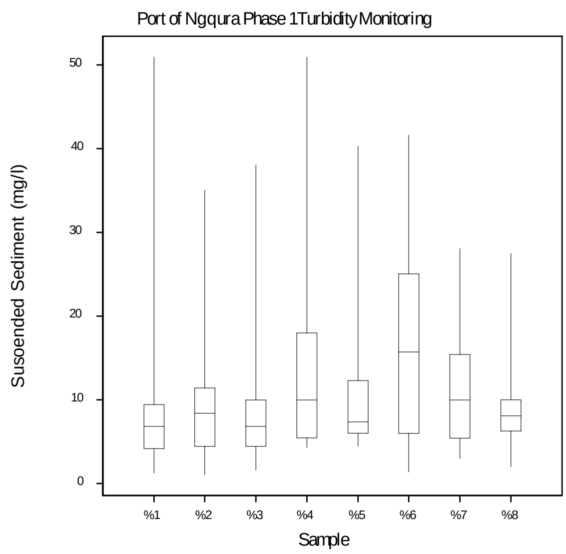

Figure 6.5: Box and whisker plots of daily turbidity measurements at the routine compliance monitoring stations measured during the Phase 1 dredging. The data were supplied by the dredging contractor. The boxes show the 25th and 75th interquartile values, the horizontal bar within the boxes is the mean value and the whiskers show the maximum and minimum values for the specific station. n = 21.

6.3.2.3 Sub-tidal benthic macrofauna

Klages *et al* (2006) report changes in benthic macrofauna community structure at impact and control sites located around the Port of Ngqura over the years 2003 – 2006. In this data set Klages and Bornman (2005b) demonstrated changes linked to proximity to the harbour development and across years but identified some 'recovery' in 2005. These authors and Klages *et al* (2006) reached almost identical conclusions that the observed changes in community structure were 'consistent with an environment that in 2004 had experienced high turbidity and the presence of dredging fines being distributes across the study site from the actual dredge spoil dump site'. Unfortunately their sampling methods and level of taxonomic resolution were not uniform over the period making the interpretation of the observed distributions problematical. Further, the sampling sites that had been designated as controls (ie distant from the disturbance) also showed strong variability over time.

Table 6.4 summarizes macrofaunal compositions at a coarse taxonomic level for each of the four years in which surveys were conducted. All of the major groups persisted through the observation period with polychaetes and crustaceans dominating the fauna. The major change apparent in the table is the large proportional reduction in molluscs between 2003 and 2004; which appears to persist into 2005/2006. Unfortunately the effects of changes in sampling methodologies between 2003 and 2004 cannot be excluded as being responsible for the observed changes between these years. In a meta-analysis of the responses of phyla to organic and chemical pollution Warwick and Clarke (1993) demonstrated that molluscs are relative sensitive to anthropogenic disturbances. This supports the contentions of Klages and Bornman (2005c) and Klages *et al* (2006) on the impacts of the harbour development. However, Warwick and Clarke (1993) also demonstrated that echinoderms were amongst the most sensitive of all of the groups they considered which is supported by Swartz *et al* (1985) who found ophiuroids (echinoderms, brittle stars) to be indicative of non-polluted conditions off southern California. As shown in Table 6.4 echinoderms were relatively stable, in terms of proportions, throughout the sampling period.

Table 6.4: The proportional (%) distribution of broad taxonomic groups in benthic macrofauna samples in the vicinity of the Port of Ngqura in 2003, 2004, 2005 and 2006. Note that sampling methodology changed between 2003 and 2004. The data were drawn from Figure 3.4 in Klages et al (2006).

Taxonomic Group	***Year***				
	2003	***2004***	***2005 (Jan)***	***2005 (Sept)***	***2006 (Mar)***
Polychaetes	26	45	30	37	33
Crustacea	53	32	62	19	27
Molluscs	14	6	<1	3	3
Echinoderms	4	6	4	25	12
'Other' Taxa	3	11	3	16	25

In view of the above and the known spatial and temporal variability in benthic macrofaunal communities over relatively small scales (e.g. Morrisey *et al* 1992a, 1992b), the changes observed during the monitoring cannot be unequivocally attributed to port construction activities.

6.3.2.4 Island intertidal flora and fauna

Intertidal flora and fauna were monitored at St Croix and Jahleel islands in 2000 and subsequently at these two islands and Bird Island in 2003, 2005 and 2006 (Klages and Bornman 2005a, Klages *et al* 2006). Species composition was that expected of intertidal shores in the Algoa Bay region as defined by Bolton and Stegenga (2002) and Emmanuel *et al* (1992). Some temporal variability occurred during the observation period; with the higher shore areas of both Jahleel and St Croix supporting less algal biomass (i.e. cover) after construction than before. Algal species such as *Hypnea tenuis* and *Porphyra capensis* showed declines compared to pre-dredge conditions whilst lower down on the shore *Gelidium pristoides* became more dominant than was the case prior to construction.

The ecological significance of the observed changes is unknown as are any direct or indirect links to disturbance generated by the harbour construction. Dye (1998), in a long term study of variability in intertidal zones on the Transkei coast, demonstrated high 'natural' variability over small horizontal distances and at intra- and inter-annual temporal scales. Klages and Bornman's (2005a) and Klages *et al*'s (2006) observations may also be reflecting such variability and the authors do not propose any mechanistic links to construction activities.

6.3.2.5 Coastal seabirds

DEAT/MCM conducts regular censuses of coastal seabirds around South Africa. Important amongst these are counts of nesting pairs of African penguins *Spheniscus demersus* and total nest area estimates for Cape gannet *Morus capensis* on the Algoa Bay Islands. Gannets appear to have been stable or increasing on specifically Bird Island over the recent past. This may be attributable to an eastward shift in sardine *Sardinops sagax* (Van der Lingen *et al* 2005) and therefore an increase in food availability for this species. Penguins in Algoa Bay, on the other hand, have shown a marked decrease from ~22 000 pairs in the period 1987-2001 to ~11 000 pairs in the period 2003-2006 (Crawford 2006; Figure 6.6). This decline has been most evident at St Croix Island (Table 6.5). Jahleel Island has also shown a decrease in breeding pairs but, because of generally low numbers that utilise this island, the decline has not been as marked.

These declines come in the face of apparently increased food availability in the overall Algoa Bay region as discussed above and demonstrated to an extent by increased sardine catches within Algoa Bay (Figure 6.6). Table 6.5 indicates that penguin numbers at Dyer Island, the other nesting site that should benefit from the eastward shift in sardine, have remained more or less stable over the period 1993-2005. However, whether this indicates low overall mortalities is moot as the Dyer Island nesting population may be replenished from young adults migrating from the currently food limited areas west of the Cape Peninsula (Robben, Dassen Island etc), although this is contrary to the general movements of penguins described by Whittington *et al* (2005a) and generally only a small proportion of birds breed at non-natal islands (Whittington *et al* 2005b).

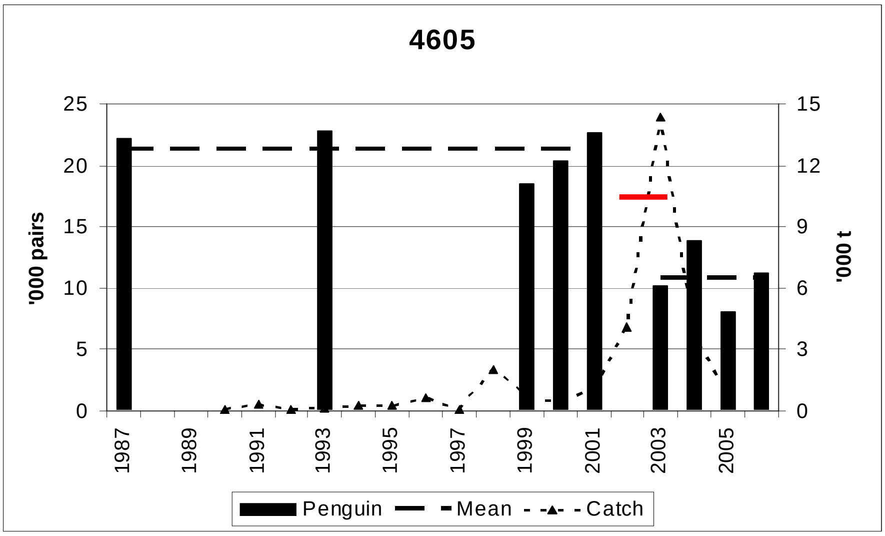

Figure 6.6: Numbers of African Penguins estimated to breed in Algoa Bay, 1987-2006. Dashed lines indicate the average numbers during 1987-2001 and 2003-2006, between which two periods the population approximately halved. The horizontal red line indicates the major dredging and spoil disposal period during the initial phase of the Port of Ngqura development. The annual catch of epipelagic fish in area 4605 is shown for the same period. (From Crawford 2006)

Table 6.5: Variations in numbers of African penguin breeding pairs at islands within Algoa Bay and at Dyer Island (from Crawford 2006)

Year	*Jahleel*	*St Croix*	*Bird*	*Total Algoa Bay*	*Dyer*
1993	549	20 058	2 689	22 747	2 374
1999	243	14 268	4 222	18 490	2 363
2000	538	15 781	4 550	20 331	2 220
2001	No data	16 950	5 745	22 695	2 088
2002	No data	No data	No data	No estimate	2 145
2003	141	9 256	No data	No estimate	1 929
2004	479	10 199	3 266	13 865	2 216
2005	316	4 505	3 545	8 050	2 053
2006	301	8 395	2 893	11 288	No data

Crawford (2006) acknowledges that the causes of the apparent decreases in the Algoa Bay penguin population are uncertain. Factors such as prey abundance and availability play roles in breeding success and the numbers of penguins that breed (Crawford *et al* 2006, Duffy *et al* 1984). The increased sardine landings in Algoa Bay (Figure 6.6) would seem to indicate that both of these requirements were met. Crawford (2006) notes that the decrease in Algoa Bay penguins has broadly coincided with the major infrastructure development phase of the Port of Ngqura but has not explicitly identified any direct or indirect aspect of the development that could be the causative agent. However, it is apparent from Figure 6.6 that the observed decline did not, in fact, coincide with the large dredging programme carried out in the initial period of port development (Phase 1). The dredging was initiated at least one year after the decrease in penguin numbers became evident[3], as shown in Table 6.6. Prior to the inception of the dredging programme port development was limited to on-land earth moving, excavations etc., and it is difficult to see how these could have caused a penguin population decline in the region. It is possible that the disturbance factor was unrelated to harbour development. Candidate reasons include:

- Purse-seine fishing disrupting or displacing sardine shoals and thus reducing foraging success. Figure 6.6 shows that increased sardine landing in Algoa Bay coincided with the dip in numbers of breeding pairs on St Croix Island;
- Adults deserting nests due to heat stress and consequent egg mortality (Randall 1983, but such an effect should be regional rather than apparently island specific);
- Human disturbance.

Table 6.6: Summary of dredging schedule for the construction of the Port of Ngqura (Phase 1)

Construction activity	**Approx. Start Date**	**Approx. Finish Date**
Eastern Breakwater	March 2003	June 2005
Western Breakwater	March 2003	February 2004
Sand Bypass: Construction to Completion of Removal of Temp. Works	March 2003	May 2006
Dredging	February 2004	January 2005

In order to understand the mitigation measure provided in section 6.4.2 to minimize the potential impact of dredging on penguins feeding in the vicinity of the dredge disposal site, it is necessary to provide a brief overview of the lifecycle of the African penguins using the Algoa Bay islands. From October to December, the birds moult, which requires approximately three weeks during which time the birds do not feed and stay on the islands. Thereafter, with their fresh coat of feathers, they generally leave the immediate vicinity of the islands and swim much further offshore to feed. By early January they are returning to the islands to lay eggs, which they incubate for 38 to 41 days, feeding regularly in the immediate vicinity of the islands. Approximately eighty days after hatching, the juveniles take to the sea to feed (Randall and Randall, 1981).

[3] This assumes that the decline had not commenced in 2002, the year for which there are no count data.

None of the data that has been collected or any of the observations made in the environmental monitoring programmes and the semi-annual DEAT/MCM surveys of penguins is sufficient to identify the actual causes of the Algoa Bay population reductions. But, whatever the cause or causes, it must be noted that the global African penguin population is now in a very serious position. The minimum viable population level for the species has been estimated at ~55 000 breeding pairs (Shannon and Crawford 1999). In 2006 the population had diminished to an estimated 39 000 pairs (Crawford 2006); a decrease that may lead to the species being reclassified from vulnerable to endangered according to the IUCN criteria (Birdlife International 2004). Therefore, wherever possible all feasible precautions need to be taken to prevent further losses or disturbances to the African penguin population.

6.3.2.6 Fisheries

Commercial fisheries that operate in Algoa Bay and immediately adjacent areas comprise pelagic (sardine), demersal and line fish and squid. The area appears to be occasionally important for sardine, e.g. ~14 000 tonnes landed in 2003, but relatively unimportant for demersal fish (0.5% of RSA 2004 demersal net hauls, DEAT/MCM data). Squid are the most important of the fisheries as it is ranked third in terms of relative value in South Africa (Sauer *et al* 1997). The fishery is mainly located between Plettenberg Bay in the west and Port Alfred in the east although squid are widely distributed on the South African continental shelf (Roberts 2004). The fishery largely concentrates on spawning aggregations. Spawning occurs throughout the year (Sauer *et al* 1991) but there is a marked summer peak in catches (DEAT/MCM data). Annual catches are variable and range from 2200 tonnes to 10 000 tonnes. Catches in Algoa Bay are similarly variable and range from <10 tonnes to 1 500 tonnes and may comprise 15% – 20% of the fishery.

Monthly catch data for squid in Algoa Bay for the 20 year period January 1985 to July 2005 are shown in Figure 6.7. The highly variable nature of the catches is clearly evident which has been variously attributed to large variations in effort, especially before 1998, and strong dependence on environmental factors (Augustyn 1990, Roberts and Sauer 1994, Roberts 1998, Schon 2000, Dorfler 2002, Downey 2005). Schon (2000) showed that temperature range and turbidity were the more important of the environmental variables affecting squid catches with the latter accounting for 13% of the 32% of the explained catch variability. Dorfler (2002) presented data indicating that turbidity levels exceeding 15 – 20NTU reduced squid catch rates by >90%.

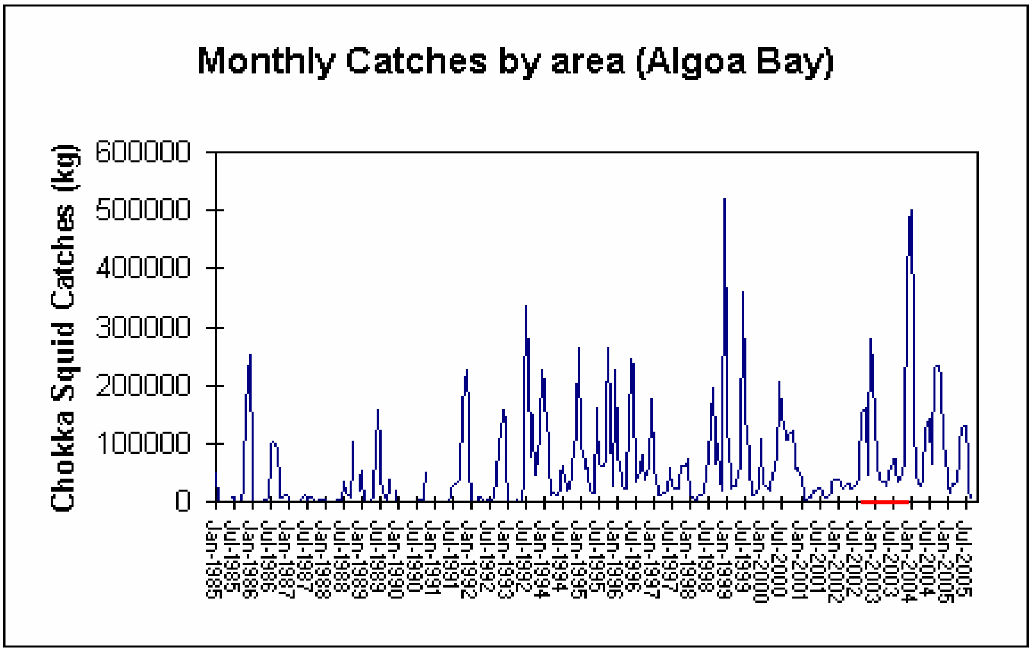

Figure 6.7: Time series of squid (*Loligo vulgaris reynaudii*) catches in Algoa Bay (data from DEAT/MCM). The red line on the x-axis shows the period during which dredging for the Phase 1 port development took place (March 2004 to January 2005).

Figure 6.7 shows that, although variable, there is no apparent fluctuation in squid catches coincident with the Phase 1 port construction and the major dredging accompanying this. Therefore factors that may have impacted squid landings such as increased turbidity of bottom waters and inundation of squid spawning grounds in the preferred 28 m – 32 m depth range (Dr M., Lipinski, DEAT/MCM, *pers. comm.*) by dredge spoil have had no clear expression in the fishery. This tends to support the conclusions of CES (2001) who considered that effects, if any, would be localized. However, fishery independent squid distribution surveys in 2006 showed that squid were displaced to deeper waters in Algoa Bay (>100 m) compared to Seal and Jeffries Bay where the bulk of the population was located in the preferred depth ranges (<50 m; Lipinski and Mqoqi 2006). Possible reasons for this include modification of sediment properties, e.g. granulometry, rendering the historically preferred spawning depth range unsuitable for egg pod attachment and chronically elevated turbidity in bottom waters disrupting spawning behaviour. Communication between squid appears to be via chromatophores (Hanlon *et al* 1994, Sauer and Smale 1993) and highly turbid water would prevent or limit this with associated effects on pairing and mating. Displacement of squid spawning to deeper water may lead to lower production of paralarvae due to lower temperatures prolonging egg development and increasing mortalities (Roberts and Sauer 1994). The implications for the squid population and the fishery are difficult to predict because of the life history of the paralarvae and larval, sub-adult and adult squid migration patterns on the Agulhas Bank (Roberts 2004). One consequence at least may be reduced over all recruitment to the adult stock that is the target of the fishery.

6.4 Assessment of Potential environmental Impacts

6.4.1 Impact assessment approach and methodology

In the marine environment a disturbance can be relatively short-lived (e.g. accidental spill of toxic material which is diluted in the water column below threshold limits within days) but the effect of such a disturbance may have a much longer lifetime (e.g. the toxin affects the gills of fish and thus reduces their survival chances). The assessments and rating procedures below address the effects and consequences rather than the cause or initial disturbance alone. In this report, the word impact thus describes the disturbance and the effect(s) this disturbance may have on the environment.

The standard impact assessment methodology used in this EIA process is provided in Chapter 4. The application of the assessment criteria to determine the significance of potential impacts uses a balanced combination of duration, extent and intensity, modified by probability, cumulative effects and confidence.

When impacts are identified as negative, mitigation objectives are set (i.e. ways of reducing negative impacts), and attainable mitigation actions recommended. In the case where mitigation is not feasible or necessary, this will be stated and the reasons given. When impacts are assessed as positive, actions to enhance the benefit are recommended when applicable. In this chapter on marine impacts, all impacts assessed are negative.

Where the significance of the potential negative impacts (without mitigation) is assessed to be of low significance, then no mitigation measures are recommended. Where negative impacts (without mitigation) are assessed to be on medium or high significance, then mitigation is proposed, and a discussion provided on the expected effectiveness of those measures in reducing the nature of the impact. **A summary of the predicted negative impacts (both with and without mitigation) is provided in Table 6.7.**

Monitoring procedures and review programmes to assess the effectiveness of mitigation are recommended.

In this assessment the risk factors and associated effects on the marine environment listed in Section 6.2 are matched against the environmental attributes and features described in Section 6.3. This allows identification of potential impacts on the marine ecology of the region and their evaluation according to the criteria set out in Chapter 4. In the assessment the potential impacts are partitioned by phase; i.e. construction and operation, and area, i.e. harbour and receiving environment.

6.4.2 Construction phase

6.4.2.1 Harbour area

6.4.2.1.1 Removal of biological communities in the dredge target areas

During the proposed dredging approximately 1.3 million cubic metres of sediment will be dredged from the port. The bulk (~80%) of this will be the fill from the reclaim that has been placed in front of the area in which the extended container berth quay wall will be constructed. This is 'dry land' and therefore has no marine community associated with it. The balance of the material will be dredged from approach channels to the container berths and the administrative craft basin area. These areas will have marine biota associated with them but essentially represent artificial habitats as they are the direct result of the Phase 1 port development. Further, given the comparatively short time that has elapsed since the initial dredging it would appear unlikely that any critical ecological dependency has developed between the organisms that have colonized the harbour sediments and biological communities in the adjacent nearshore area. This is supported to an extent by Klages *et al* (2006) who show that the within harbour sediments were relatively impoverished in terms of abundance and number of taxa in 2005. These were increasing in 2006 which is consistent with Ellis (1996) who indicates possible recovery periods in newly exposed harbour sediments of 1 - 3 years.

Accordingly the potential environmental impact is assessed as:

Nature of impact	Sediments and their associated organisms will be physically removed from the seabed along the path of the dredge head during dredging
Extent	Site specific, the affected area will be ~ 0.3 km^2, and totally contained by the harbour which contains approximately 1.8 km^2 of sediment surface.
Duration	Short, recolonization is predicted to take 1-3 years
Intensity	Low, the majority of the benthic organisms is likely to die or be removed from the dredge areas but this should not have any repercussions at the population levels
Probability	Definite
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to the site specific extent of the impact, the fact that it will occur in an 'artificial' habitat and that recovery periods should be short
Mitigation	Not considered to be necessary (or feasible)

6.4.2.1.2 Effects of turbid plumes generated by sediment resuspended by hopper overwash and dredge head turbulence during dredging on organisms inhabiting harbour sediments and structures

Dredging activities characteristically generate turbid plumes of suspended sediment (e.g. Figure 6.1). High suspended solid concentrations can exert deleterious effects on organisms through light attenuation (phytoplankton and algae), interference with filter feeding (zooplankton, mussels, oysters, barnacles), damage to gills and respiratory processes (mussels, oysters, abalone, fish), reduction of visibility reducing foraging success (cormorants, penguins, predatory fish) but also assisting predator avoidance in fish (Clark 1997), etc. Probyn (2000) reviewed the available scientific literature on the effects of varying suspended sediment concentrations on a range of biota and determined that concentrations <20 mg/l represented little risk, concentrations in the range 20 mg/l – 80 mg/l could be tolerated for short time periods (1 – 3 days), whilst levels >80 mg/l constituted unacceptable risks for biological communities typical of South African coastal environments. Turbidity monitoring conducted during the Phase 1 dredging work (e.g. Figure 6.7) indicated that, at the monitoring points used, suspended sediment concentrations did not exceed 55 mg/l but was greater than 20 mg/l for 13% of the time during the measurement period. This equates to a theoretical maximum time period of 2.73 days, less than the 3 day duration identified by Probyn (2000) as being the critical exposure threshold.

Sediment macrofauna in the harbour was relatively impoverished in 2006 at 9 specimens/0.25 m^2 (Klages *et al* 2006) but not taxonomically different from adjacent biological communities. The biofouling community was also composed of the species that would be expected to be found in this region. In view of this, the measured suspended sediment concentrations during the previous dredging and the fact that the harbour is an artificial environment, the potential environmental impacts of elevated turbidity in the harbour are assessed as:

Nature of impact	Generation of suspended sediment plumes in the dredge area over the dredging period and potential sublethal or lethal impacts on biological organisms and/or communities inhabiting harbour sediments and structures
Extent	Site specific, previous measurements indicate that suspended sediment concentrations in excess of defined risk thresholds do not extend beyond the confines of the port
Duration	Short, potential effects extend should be limited to the duration of the dredging activity
Intensity	Low, adverse effects are experienced generally at suspended sediment concentrations higher (>100 mg/l) than those usually produced by dredging or to longer exposure periods (>2 days) than typical life times of suspended sediment plumes
Probability	Probable, elevated suspended sediment concentrations are a typical by-product of dredging activities and should at least impact the filter feeding component (mussels, barnacles) of the fauna
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to the small extent, short duration and low intensity of the impact
Mitigation	Not considered to be necessary due to the low significance.

6.4.2.1.3 Settlement of material suspended during dredging and alteration of sediment characteristics and effects on sediment biota and ecological processes

The harbour is by design a quite water area and it is likely that the majority of the fines in dredge hopper overwash and those suspended by dredge head turbulence will resettle in the harbour. This may lead to inundation of sediment biota adjacent to the dredge areas possibly altering community structure and/or disrupting ecological processes. As stated above the harbour sediment community is relatively impoverished and probably supports taxa similar to those in adjacent communities that occupy sandy and muddy sand substrates. Typical organisms of such communities are polychaetes, crustaceans, molluscs, echinoderms and other groups such as sipunculid worms. It is also assumed that whatever community is there has developed since the cessation of the previous Phase 1 dredging activities as borne out to an extent by the observations of Klages *et al* (2006).

Hall (1994) has shown that benthic macrofauna can survive short term inundation and Maurer *et al* (1980 1981, 1982) demonstrated that a bivalve mollusc (*Mercenaria mercenaria*) and gastropod (*Nucula proxima*) could migrate vertically up to 16cm when inundated with sand; the crustacean amphipod *Parahaustorius longimerus* and xanthid crab *Neopanope sayi* could migrate through 7 – 30cm and polychaetes *Scoloplos fragilis* and *Nereis succinea* could manage up to 30cm. Therefore given the generally slow sedimentation rates of fine particles (<5 mm/sec, Hill *et al* 1994), the probable non-unique biological community and the ability of benthic macrofauna to survive relatively rapid sedimentation events, significant disruption of the benthos in the harbour area is not expected. Accordingly the impact assessment is:

Nature of impact	sedimentation of the resuspended sediment may smother benthos in the harbour sediments
Extent	Site specific, the effect should be contained within the harbour
Duration	Short, recovery can take from <1 year up to 3 years
Intensity	Low, given shallow layers many organisms may burrow to the surface through the deposited sediment and many filter-feeders are highly adaptable to increased sediment loads
Probability	Definite
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to the small extent of the impact, apparent burrowing abilities of sediment fauna and the fact that the harbour is an artificial environment anyway
Mitigation	Not considered to be necessary due to the low significance

6.4.2.1.4 Remobilization of contaminants and uptake by biological organisms

The resuspension of sediments during dredging can result in trace metals associated with the dredged sediment being released and entering the dissolved reactive phase. Thereafter uptake by organisms may occur through direct absorption from solution, by uptake of suspended matter and/or via their food source. Toxic effects on organisms and food chains may be exerted over the short term (acute toxicity), or through accumulation.

The toxicity of trace metals to organisms is complex and depends on the partitioning of metals between dissolved and particulate phases and the speciation of the dissolved phase into bound (inorganic or organic complexes) or free forms. The most bio-available forms that are potentially toxic to aquatic life are free metals, as well as some weak inorganic complexes. Metals that make up the total concentration are thus not always bio-available and potentially toxic. Frequently, these bio-available metals constitute only a fraction of the total.

With the exception of arsenic trace metal concentrations were very low and below threshold effect levels (TEL: calculated from effect and no effect data and represents a threshold value below which adverse biological effects are considered unlikely (McDonald *et al* 1996, BCLME 2004)). Chromium marginally exceeded the LC special care threshold but was below the identified TEL for the trace metal. Further, regressions of trace metals against aluminium indicated that most of the trace metals were strongly associated with clay minerals (i.e. lithogenic origin) and therefore relatively unavailable to uptake by marine organisms. The relationship for arsenic was weak and that for chromium relatively weak indicating that the former and probably some of the latter trace metal had an anthropogenic source. Despite the individual high concentration the mean concentration for arsenic was well below the TEL level. It is expected that there will be mixing of sediments in the dredging process and therefore potential effects of individual exceedances of accepted thresholds should be ameliorated. Consequently the probability of deleterious effects on biota appears remote.

The potential environmental impact of remobilized trace metals in the harbour area is assessed as:

Nature of impact	Remobilization of contaminants in the dredge area over the dredging period may have toxic effects on organisms
Extent	Site specific, transport out of the harbour area should be minimal or, when it does occur plumes should be diluted
Duration	Short term exposure and short term effects given life-spans of the organisms that are likely to be affected.
Intensity	Low, contaminants concentrations in the sediments are low and should be quickly diluted to background levels
Probability	Improbable, low contaminant concentration in the sediments
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low likelihood
Mitigation	Not considered to be necessary due to the low significance

6.4.2.1.5 Reductions in dissolved oxygen concentrations due to introduction of organic matter previously held in the sediments to the water column and effects on biota

The organic content of the sediments targeted for dredging is low (CSIR 2006). Therefore the amount of organic material resuspended by the proposed dredging will be equally low as will the oxygen demand by any potential remineralization. Depletion of oxygen concentrations in the water column and deleterious effects on organisms or ecological processes will therefore be unlikely. Further, even if oxygen concentrations were to be reduced the effect would be limited to the harbour area which, as stated above, can be considered to be an artificial habitat. Accordingly the impact of reductions in dissolved oxygen concentrations is assessed as:

Nature of impact	Potential depletion of water column oxygen concentration through bacterial decomposition of remobilized organic matter in the dredge area over the dredging period and deleterious effects on organisms/ecological processes
Extent	Site specific, any effect should be limited to the harbour water body
Duration	Short, potential effects may only extend over the duration of the dredging activity due to re-oxygenation by natural processes such as photosynthesis, water volume exchange with the adjacent ocean
Intensity	Low, organic matter concentration in the sediments are low
Probability	Improbable, low organic matter concentration in the sediments
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low likelihood
Mitigation	Not considered to be necessary due to the low significance

6.4.2.1.6 Release of nutrients held in the target dredge area sediments to the water column through dredging and eutrophication of the harbour water body

Nutrients in marine sediments are generally derived from the remineralization of organic matter. As the organic content of the sediments targeted for dredging is low (CSIR 2006) and the sediments have not had a long exposure to marine conditions, the potential for developing high nutrient concentrations in pore waters is considered to be low. Further, the total volume of pore water relative to the volume of the harbour water body is also low and so, even if pore water nutrient concentrations were high the probability of developing nutrient concentrations sufficient for eutrophication should be negligible. Finally, water volume exchange between the harbour and the adjacent open sea through tidal influences has been estimated at 5 days (CSIR 2002). Therefore any nutrients released from the pore water should be relatively rapidly diluted to background levels.

Accordingly the impact of elevations in nutrient concentrations is assessed as:

Nature of impact	Introductions of nutrients to the water column due to release of target dredge sediment pore water may cause eutrophication in the harbour water body
Extent	Site specific, organic content of the target sediments is low and there is a short depositional history

Duration	Short, only during dredging; tidal water volume exchange will constrain the persistence of high nutrient concentrations
Intensity	Low, due to low amounts of organic matter in the sediments nutrient concentrations in pore waters are unlikely to be high
Probability	Improbable, low organic matter concentration in the sediments
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low likelihood
Mitigation	Not considered to be necessary due to the low significance

6.4.2.1.7 The effect of noise from the dredging activities on biological organisms in the harbour

During dredging operations, noise may have an impact on marine organisms in the harbour such as benthic invertebrates and fish; seabirds foraging on fish may also be affected. Noises generated during dredging originate from the dredger's engines, dredging pumps and the clatter of coarse material passing through suction pipes and depositing in the dredger hoppers. Marine invertebrates have been shown to be relatively insensitive to low frequency sound whilst fish appear able to accommodate moderate sound levels (Keevin and Hempen 1997). Foraging seabirds such as cormorants may avoid the sound source should it reach levels sufficient to cause discomfort.

The biological community in the harbour water body does not appear to support any appreciable numbers of predators such as cormorants (personal observations) and is probably not entered into by larger mammals such as the humpback dolphin. The latter species is known to forage in the open water areas adjacent to the harbour but the low frequency noises associated with the dredging should not interfere with their communication or generate sublethal injury (Findlay 1996). Note that these animals are very mobile and can move out of the area if any discomfort is generated. Further, as pointed out above the harbour constitutes an artificial habitat and therefore effects within it should not impinge on ecological processes in the wider marine environment. The effects of dredger generated noise would therefore appear to be negligible. The potential impact is assessed as:

Nature of impact	Noise from the dredging activity may disturb marine invertebrates, fish or seabirds
Extent	Site specific, restricted to the harbour area
Duration	Short, potential effects extend over the duration of the dredging activity
Intensity	Low
Probability	Probable
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low intensity
Mitigation	Not considered to be necessary due to the low significance

6.4.2.1.8 Importation of alien species by dredgers and associated ecological effects

Dredgers may transport alien biota in ballast water, in residual sediment in their hoppers or even attached as biofouling organisms on their hulls. The release of alien species into the Ngqura Port area by dredgers carries the risks of allowing the establishment of populations and potential competitive exclusion (food, space, nutrients) of indigenous species. In the worst case such imports may lead to the development of invasive populations with the capacity to severely disrupt and modify communities and ecological processes.

Despite a long history of international shipping passing through South African ports there are only 10 confirmed cases of alien species becoming established in the country's coastal waters (Robinson *et al* 2005). The best known of these is the Mediterranean mussel *Mytilus galloprovincialis*, currently the mainstay of the local mussel farming industry, the ascidian *Ciona intestinalis*, a biofouling organism common in harbours, and the European shore-crab *Carcinus maenas*. In addition to these 22 species are classified as 'cryptogenic', ie organisms with wide distributions suspected of being alien. The mussel and ascidian can be regarded as invasive in that they have replaced or displaced indigenous fauna and have economic implications. The balance of the species have small restricted populations.

Klages *et al* (2006) report on surveys to detect 'invasive aliens' in the Ngqura Port area prior to Phase 1 construction (2001) and after establishment of port infrastructure (2006). No invasives were found. It thus appears that dredgers conducting the phase I dredging programme did not release such organisms, or that they did not, or have not yet, become established to the point where they may be identified by generally limited biological organism census techniques. These observations coupled with Robinson *et al*'s data indicate that the probability for the import and establishment of alien organisms may be low. The potential impact is assessed as:

Nature of impact	Import and release of alien species by dredgers and their establishment in habitats within the harbour area
Extent	Site specific initially but may become regional with time
Duration	Long term to permanent; once established it is unlikely that alien species would be obliterated by natural processes of competition, predation etc
Intensity	Medium
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium; Alien and invasive alien species have established populations in South African coastal waters even if this is not widespread
Significance (no mitigation)	**Medium**
Mitigation	Definitely required: Apply the ballast water management protocols stipulated in the IMO International Convention for the Control and Management of Ship's Ballast Water and Sediments, together with NPA's own Guidelines for dredgers (which include hopper washing to remove residual sediment), with verification of the application of these protocols and guidelines, as well as ongoing monitoring of marine biota.
Significance	The implementation of the strictures of the IMO Convention and NPA

(with mitigation)	Guidelines should reduce the probability of the impact occurring to improbable. Measurements have shown that the IMO ballast water treatment measures reduce viable organisms by 95%. This is supported by results from surveys conducted by NPA that have not found any alien species in the Port of Ngqura. Therefore, overall significance is assessed to be **Low**.

6.4.2.2 Construction: Receiving environment – Dredge spoil disposal site

CES (2001) identified two candidate sites for receiving the dredge spoil generated by the large scale Phase 1 dredging and port construction: site (a), that was eventually used as the dredge spoil repository, and site (b) located further offshore (refer to Figure 2.6 in Chapter 2). In Chapter 2 of this report, the reasons provided by CES for the choice of site (a) are reviewed and additional supporting evidence included justifying its use for the proposed Phase 2 dredging programme being evaluated here.

6.4.2.2.1 Deposition of discharged sediment and effects on benthic macrofauna

The discharge of ~1.3 million m^3 of dredge spoil to the dredge spoil disposal site will inundate the resident benthos, possibly disrupting ecological processes at the site. The spoil dump site has already received ~15 million m^3 in the period 2004 – 2005 (Klages *et al* 2006). Average inundation depth at the site from this appears to have been 100 cm – 200 cm (refer to section 6.3.2.1). As the planned dredge volume is ~10% of that conducted in the previous phase average inundation depths, given an even spread of dredge spoil on the dump site should be 10cm or less (Figure 6.3 indicates that an even spread of spoil across the designated dump site in the previous spoil dumping). Maurer *et al* (1980, 1981, 1982) and Hall (1994) have shown that most of the major faunal classes in the benthos would be able to withstand such burial depths, and, once the dumped sediment stabilized, it is likely that fauna will both migrate into the spoil dump area and recruit to it (Newell *et al* 1998) with a relatively short recovery period (Ellis 1995). Further, it is highly probable, but not demonstrated due to no post dump monitoring, that discharge of sediment during the Phase 1 dredging programme considerably modified the benthic macrofauna community on the dump site. It is also probable that this community is in a recovery phase (e.g. Ellis 1996) so further discharge of spoil to the site would have the effect of prolonging the recovery phase.

From the above it is evident that there may be site specific impacts on benthos populations (Klages and Bornman 2005a, 2005b; Klages *et al* 2006) through alterations in species richness and community structure. The ecological significance of this is unknown but the geographic scale is relatively small given the dimensions of Algoa Bay. However, the fact that spawning squid prey on benthic macrofauna (Sauer and Lipinski 1991) indicates that there may be important indirect effects at the regional scale associated with the dredge spoil discharge and the area it impacts.

The marine specialist (Carter, 2006) proposed that the dredger should discharge sediment in a manner that results in it being deposited in thin layers onto the seabed, in order to diminish mortality in benthos either recovering within the dredge disposal site or in adjacent areas.

Transnet has indicated that this mitigation measure would not be possible if a rapid dredging operation is undertaken. Rapid dredging, during the October to December period, is recommended in section 6.4.2 as a mitigation measure to reduce potential impacts of dredge disposal on the African penguins feeding in the vicinity of the offshore disposal site.

The potential impact is assessed as:

Nature of impact	Depositing discharged dredge spoil may smother benthos on the dredge spoil discharge site and adjacent areas and disrupt ecological processes
Extent	Site specific in terms of inundation area but the effect may become regional (Algoa Bay) through modifications to benthic food chains and effects on predators, e.g. squid
Duration	Short; research indicates recovery within 1-3 years.
Intensity	Medium, depending on the sediment layer thickness many organisms may burrow to the surface through the deposited sediment and many filter-feeders are highly adaptable to increased sediment loads. However it is likely that biomass will be reduced.
Probability	Definite
Status of impact	Negative
Degree of confidence	High
Significance (no mitigation)	**Medium**; Indirect effects on squid using the Algoa Bay spawning sites may impact the fishery.
Mitigation	Definitely required: Ensure sediment deposition occurs within the designated discharge site, and does spill onto adjacent areas. This mitigation limits the impact to the disposal site, where benthos has already been impacted.
Significance (with mitigation)	If this can be achieved, indirect ecological effects of smothering benthos in adjacent areas should be reduced and the intensity of the effect and significance improved to **Low**.

6.4.2.2.2 Deposition of discharged sediment on the dredge spoil disposal site and effects on squid spawning in Algoa Bay

Squid preferentially spawn in the 28 m – 32 m depth zone (Dr M. Lipinski, DEAT/MCM *pers. comm.*). The previous discharge of dredge spoil at the designated dredge spoil disposal site (Figure 6.1) inundated two of the 26 known squid spawning sites in Algoa Bay (CES 2001(b)). It is apparent that after disposal the spoil did not consolidate rapidly as high turbidity in bottom waters persisted into at least 2005 (as indicated by data in Klages and Bornman 2005b). As squid appear to require at least medium to coarse sand substrates for egg pod attachment it is possible that all of the area over which fine sediments from the discharged dredge spoil advected became unsuitable for egg pod attachment and thus disrupted squid spawning. The area of such an impact is unknown but, given that Klages and Bornman (2005a, 2005b) measured apparently persistently high turbidities extending 10km – 15km alongshore inshore of the designated dump site, it is probable that similar areas were impacted around the 30 m isobath. This is approximately equivalent to 20% – 25% of this specific depth horizon in Algoa Bay. The potential impact area is therefore quite large. The persistence of such an effect is unknown, and possibly unknowable due to measurement difficulties, but appears to be at least 1 – 2 years and may extend longer.

The potential impact of dredge spoil disposal is assessed as:

Nature of impact	Depositing discharged dredge spoil may alter sediment properties in the squid spawning areas in Algoa Bay and disrupt spawning
Extent	Site specific in terms of inundation area but regional (Algoa Bay) through possible effects on the squid population and fishery
Duration	Short to medium term; existing measurements imply persistence of the effect over 1 – 2 years but this may extend, although in diminishing intensity into 3 – 5 years.
Intensity	Medium, squid will relocate for spawning which appears to have occurred in 2005 (MCM data). However spawning outside of the preferred depth zones brings issues such as optimal temperatures for egg development to the fore as well as predation. Thus paralarvae yield per egg pod may decrease and the effect may filter into the population.
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium
Significance (no mitigation)	**Medium**; direct effects on squid spawning success in Algoa Bay spawning sites may impact the fishery.
Mitigation	No practical and effective mitigation measures for the potential effects on squid have been identified. Squid are widely distributed across the Agulhas Bank to as far north as Port Alfred, although they do have apparently preferred spawning locations within the large bays of the Cape south east and south coast. Also, the squid population appears to be variable in size on the scale of years and their availability to the fishery is even more temporally and spatially variable
Significance (with mitigation)	**Medium**

6.4.2.2.3 *Elevated water column turbidity and effects on squid and the squid fishery*

Squid avoid highly turbid water with turbidities above 15 – 20NTU considerably reducing squid catches (Dorfler 2002). Bottom water turbidities at and above this threshold appear to have persisted in at least the inshore region adjacent to the Port of Ngqura for 1 – 2 years post dredging (Klages and Bornman 2005b) and into 2006 (Mr W. De Wet, Abalone Farm, *comm.*). Theoretically therefore squid would have avoided these areas. If this occurred, however, it has not been reflected in the squid landings data for Algoa Bay (Figure 6.4) as catches in the period 2003 – 2005 are not distinguishable from the period 1994 – 2001. Unfortunately there are no corresponding fishing effort data to determine whether catch levels were maintained at the expense of higher fishing intensity. Therefore although the high turbidities associated with the Phase 1 dredging may have had local effects on squid distribution this does not appear to have been translated into any regional effect in the squid fishery and has therefore probably not generated a population level response. Accordingly the impact of the proposed Phase 2 dredging induced turbidity elevation is assessed as:

Nature of impact	Elevated water column turbidity generated by the Phase 2 dredge spoil disposal may affect squid distribution and the Algoa Bay squid fishery
Extent	Site specific in terms of inundation area but regional (Algoa Bay) through possible effects on the squid population and fishery
Duration	Short to medium term; existing measurements imply persistence of the effect over 1 – 2 years but this may extend, although in diminishing intensity into 3 – 5 years
Intensity	Low, squid will avoid highly turbid water and there has been no apparent effect of the considerably larger Phase 1 dredging on regional squid catches
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium
Significance	**Low**
Mitigation	None required due to low significance

6.4.2.2.4 Wave and current suspension of fine sediments generating elevated turbidity near the sea floor and associated effects on benthos

High turbidity levels observed in bottom waters in the vicinity of the Port of Ngqura have been attributed to wave and current resuspension of weakly consolidated fine sediments on the dredge spoil dump site. These levels have exceeded the 80 mg/l suspended sediment concentration limit set for the control of dredging induced turbidity in the dredge area. Monitoring of benthos community structure has indicated that taxonomic composition may have been modified in response to the elevated turbidities. However, it has also been shown that the large Cape south coast bays all experience naturally induced high turbidity events indicating that the biological structure of the region should accommodate such events anyway. Therefore unless the proposed dredging generates chronically elevated turbidities of a semi-permanent nature it would appear that any effects should at worst be of a similar magnitude to those of the initial phase and will probably be of a lower magnitude and more spatially restricted. The impact of elevated turbidity on benthos in the dredge spoil dump area is assessed as:

Nature of impact	Wave and current suspension of fine sediments deposited in the dredge spoil dump site generating elevated turbidity and modifying benthic communities and associated ecological processes
Extent	Site specific and regional, measurements of the Phase 1 dredge spoil disposal indicate that suspended sediment concentrations in excess of defined risk thresholds extend beyond the confines of the dredge spoil area
Duration	Short to medium term, monitoring results indicate persistence of effects on community structure greater than 1-2 years
Intensity	Low, in the Phase 1 dredging there was modification of community structure in the monitored areas such as reduction of bivalve molluscs but the overall abundance did not show any pattern consistent with an

	elevated turbidity effect. Given that the proposed Phase 2 dredging is ~10% of Phase 1 in terms of volumes more drastic community effects are considered to be unlikely.
Probability	Probable, elevated suspended sediment concentrations are a typical by-product of dredging activities and may at least impact the filter feeding component of the benthos community
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to the low intensity of the impact
Mitigation	Not considered to be necessary due to the low significance.

6.4.2.2.5 Release of contaminants and effects on ecological processes

Sediment resuspension during dredging can make contaminants previously isolated in the sediments biologically available. These may exert toxicity effects on organisms and food chains over the short term (acute toxicity), or through accumulation.

With the exception of arsenic trace metal concentrations were very low and below threshold effect levels (TEL: calculated from effect and no effect data and represents a threshold value below which adverse biological effects are considered unlikely (McDonald *et al* 1996, BCLME 2004)). Chromium marginally exceeded the LC special care threshold but was below the identified TEL for the trace metal. Further, regressions of trace metals against aluminium indicated that most of the trace metals were strongly associated with clay minerals (i.e. lithogenic origin) and therefore relatively unavailable to uptake by marine organisms. The relationship for arsenic was weak and that for chromium relatively weak indicating that the former and probably some of the latter trace metal had an anthropogenic source. Despite the individual high concentration the mean concentration for arsenic was well below the TEL level. It is expected that there will be mixing of sediments in the dredging process and therefore potential effects of individual exceedances of accepted thresholds should be ameliorated. Consequently the probability of deleterious effects on biota appears remote.

The potential environmental impact of remobilized trace metals in the dredge spoil discharge area is assessed as:

Nature of impact	Remobilization of contaminants in the dredge spoil dump area over the dredging period may have toxic effects on organisms
Extent	Site specific
Duration	Short term exposure and short term effects given life-spans of the organisms that are likely to be affected.
Intensity	Low, contaminants concentrations in the sediments are low and should be quickly diluted to background levels
Probability	Improbable, low contaminant concentration in the sediments
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low likelihood
Mitigation	Not considered to be necessary due to the low significance

6.4.2.2.6 Altered dissolved oxygen distributions and effects on ecological processes

The organic content of the sediments targeted for dredging is low (CSIR 2006). Therefore the amount of organic material delivered to the dredge spoil dump site will be equally low as will the oxygen demand by any potential remineralization. Depletion of oxygen concentrations in the water column and deleterious effects on organisms or ecological processes will therefore be unlikely.

Accordingly the impact of reductions in dissolved oxygen concentrations is assessed as:

Nature of impact	Potential depletion of water column oxygen concentration through bacterial decomposition of remobilized organic matter in the dredge spoil dump area over the dredging period and deleterious effects on organisms/ecological processes
Extent	Site specific
Duration	Short, potential effects may only extend over the duration of the dredge spoil dumping due to re-oxygenation by natural processes such as photosynthesis, water volume exchange with the adjacent ocean
Intensity	Low, organic matter concentration in the sediments are low
Probability	Improbable, low organic matter concentration in the sediments
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low likelihood
Mitigation	Not considered to be necessary due to the low significance

6.4.2.2.7 Increases in nutrients and effects on ecological processes

Nutrients in marine sediments are generally derived from the remineralization of organic matter. As the organic content of the sediments targeted for dredging is low (CSIR 2006) and the sediments have not had a long exposure to marine conditions, the potential for developing high nutrient concentrations in pore waters is considered to be low. Further, the total volume of pore water relative to that of the receiving water body at the dredge spoil dump site is also low and so, even if pore water nutrient concentrations were high the probability of developing nutrient concentrations sufficient for eutrophication should be negligible.

Accordingly the impact of elevations in nutrient concentrations is assessed as:

Nature of impact	Introductions of nutrients to the water column due to release of target dredge sediment pore water may cause eutrophication or enrichment in the dredge spoil dump site water body
Extent	Site specific
Duration	Short, only during dredge spoil disposal, natural water exchange processes will constrain the persistence of high nutrient concentrations
Intensity	Low, due to low amounts of organic matter in the sediments nutrient

	concentrations in pore waters are unlikely to be high
Probability	Improbable, low organic matter concentration in the sediments
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to low likelihood
Mitigation	Not considered to be necessary due to the low significance

6.4.2.2.8 Introduction of alien species

The release of alien species into Algoa Bay by dredgers carries the risks of allowing the establishment of populations and potential competitive exclusion (food, space, nutrients) of indigenous species. In the worst case such imports may lead to the development of invasive populations with the capacity to severely disrupt and modify communities and ecological processes.

There are currently 10 confirmed cases of alien species becoming established in the country's coastal waters. The best known of these are the Mediterranean mussel *Mytilus galloprovincialis*, the Pacific oyster *Crassostrea gigas,* the ascidian *Ciona intestinalis*, and the European shore-crab *Carcinus maenas*. There are a further 22 species classified as 'cryptogenic', which are suspected of being alien. The mussel and ascidian can be regarded as invasive in that they have replaced or displaced indigenous fauna and have economic implications. The rest of the species have small restricted populations.

Local surveys to detect 'invasive aliens' in the Ngqura Port area prior to initiation of construction (2001) and after establishment of port infrastructure (2006) did not record any However, the presence of alien (exotic) species in the dredge area cannot be excluded as the sampling coverage was not extensive. This notwithstanding the observations indicate that the probability for the import and establishment of alien organisms at the dredge spoil disposal site may be low but wider survey data in RSA show there is a distinct probability for this.

The potential impact is assessed as:

Nature of impact	Import and release of alien species by dredgers and their establishment at the dredge spoil disposal area
Extent	Site specific in terms of initial release and possible establishment but regional (Algoa Bay) should the released alien species become invasive
Duration	Long term to permanent; once established it is unlikely that alien species would be obliterated by natural processes of competition, predation etc
Intensity	Medium
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium; Alien and invasive alien species have established populations in South African coastal waters
Significance (no mitigation)	**Medium**

Mitigation	Definitely required: Apply the ballast water management protocols stipulated in the IMO International Convention for the Control and Management of Ship's Ballast Water and Sediments, together with NPA's own Guidelines for dredgers (which include hopper washing to remove residual sediment), with verification of the application of these protocols and guidelines, as well as ongoing monitoring of marine biota.
Significance (with mitigation)	The implementation of the strictures of the IMO Convention and NPA Guidelines should reduce the probability of the impact occurring to improbable. Measurements have shown that the IMO ballast water treatment measures reduce viable organisms by 95%. Furthermore, surveys conducted by NPA have not found any alien species in the Port of Ngqura. Therefore, if the dredgers enter the local system "clean" after meeting IMO and NPA requirements, the potential for these dredgers to convey alien species to the offshore disposal site is non-existent. The significance is assessed to be **Low**.

6.4.2.3 Construction: Receiving environment – Islands (Jahleel, St Croix)

6.4.2.3.1 Elevated water column turbidity affecting inter- and shallow sub-tidal biological communities

Water column turbidity in the upper water column (0 – 5 m depths) adjacent to Jahleel and St Croix Islands during and immediately after the earlier dredging programme appears to have been <10NTU (~ 25 mg/l suspended sediment) on all occasions monitored by Klages and Bornman (2005a, 2005b) in 2004 and 2005. This approximates the lower threshold level of chronic effects on marine biota put forward by Probyn (2000). Concurrent monitoring of intertidal organisms on the island shores did not show any strong link between the observed variability and any effects that may be caused by elevated turbidity or suspended sediment concentrations (Klages and Bornman 2005a, 2005b; Klages *et al* 2006). The proposed dredging will not be as intense as that of the previous phase and probably of shorter duration (~30 vs. 52+ weeks). It is therefore expected that the turbidity and suspended sediment concentrations that may impinge on the island shores would at worst be of the same magnitude as have already occurred. Consequently the proposed dredging should not generate any more severe effect on the intertidal community.

The potential impact is assessed as:

Nature of impact	Modifications to Jahleel and St Croix Island intertidal community by elevated turbidity and/or suspended sediment concentrations generated by dredge spoil disposal on the dredge spoil dump site
Extent	Regional (Algoa Bay)
Duration	Short term, natural community structuring processes (recruitment, grazing, predation) should return any disturbed community back to natural conditions within 1- 2 years after dredge spoil disposal
Intensity	Low

Probability	Improbable, previous dredge spoil disposal did not generate a direct effect
Status of impact	Negative
Degree of confidence	High; previous observational data exist for the islands
Significance	**Low**, natural variability on such shores is high and any disturbance generated by dredging will probably not be detectable within the range of this variability
Mitigation	None necessary due to the low significance of any impact

6.4.2.3.2 Inundation of island shores by sediment deposition and modification of intertidal communities through smothering and/or abrasion

Disposal of large volumes of dredge spoil at the designated spoil dump site may possibly lead to inundation of island shores by sediment. The bulk of the discharged sediment will be medium sands (250µm – 500µm). This will be deposited at ~30 m depths and would require bed load transport to be advected towards the islands. Measured current velocities in the region indicate that this is very unlikely. Further, wave action on the island shores is vigorous and therefore any sediment deposited there is likely to transported out of the area by wave driven turbulence. It is therefore unlikely that the island intertidal communities will be exposed to any significant smothering or abrasion effects from dredge spoil disposal in the proposed dredging programme.

The potential impact is assessed as:

Nature of impact	Resuspended sediment from the dredge spoil dump site may inundate rocky shores and affect intertidal communities through smothering and/or abrasion on Jahleel and St Croix Islands
Extent	Regional
Duration	Short, limited sand inundation may only occur during the dredging activity and any remaining sand is likely to be washed from the shore due to wave action after cessation of dredging
Intensity	Low
Probability	Improbable, transport mechanisms do not appear to exist
Status of impact	Negative
Degree of confidence	High
Significance	**Low**, due to the low likelihood of the impact occurring
Mitigation	No mitigation required

6.4.2.3.3 Introduction of alien species

Dredgers may release alien species on the dredge spoil dump site area and allow the establishment of populations and potential competitive exclusion (food, space, nutrients) of indigenous species. In the worst case such imports may lead to the development of invasive populations.

There are currently 10 confirmed cases of alien species becoming established in the country's coastal waters which include the Mediterranean mussel *Mytilus galloprovincialis*, the Pacific oyster *Crassostrea gigas,* the ascidian *Ciona intestinalis*, a biofouling organism common in harbours, and the European shore-crab *Carcinus maenas*. There are a further 22 species classified as 'cryptogenic', i.e. organisms with wide distributions suspected of being alien. The mussel and ascidian can be regarded as invasive in that they have replaced or displaced indigenous fauna and have economic implications. The balance of the species have small restricted populations.

No invasives have been found in surveys in the Port of Ngqura and adjacent shores and it thus appears that dredgers conducting the phase I dredging programme did not release such organisms, or that they did not, or have not yet, become established to the point where they may be identified by generally limited biological organism census techniques. These observations coupled with wider survey data in RSA indicate that the probability for the import and establishment of alien organisms may be low.

The potential impact is assessed as:

Nature of impact	Import and release of alien species by dredgers and their establishment on Island habitats
Extent	Regional (Algoa Bay)
Duration	Long term to permanent; once established it is unlikely that alien species would be obliterated by natural processes of competition, predation etc
Intensity	Medium
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium; Alien and invasive alien species have established populations in South African coastal waters
Significance (no mitigation)	**Medium**
Mitigation	Definitely required: Apply the ballast water management protocols stipulated in the IMO International Convention for the Control and Management of Ship's Ballast Water and Sediments, together with NPA's own Guidelines for dredgers (which include hopper washing to remove residual sediment), with verification of the application of these protocols and guidelines, as well as ongoing monitoring of marine biota.
Significance (with mitigation)	The implementation of the strictures of the IMO Convention and NPA Guidelines should reduce the probability of the impact occurring to <u>improbable.</u> Measurements have shown that the IMO ballast water treatment measures reduce viable organisms by 95%. Furthermore, surveys conducted by NPA have not found any alien species in the Port of Ngqura. Therefore, if the dredgers enter the local system "clean" after meeting IMO and NPA requirements, the potential for these dredgers to convey alien species to the islands is non-existent. The significance is assessed to be **Low**.

6.4.2.3.4 Effects on endangered coastal seabirds

St Croix, and to a lesser extent, Jahleel Islands support globally important breeding colonies of African penguin *Spheniscus demersus*. The St Croix Island population has shown a marked decline in breeding population size from ~22 000 pairs in 1987 – 2001 to ~11 000 pairs in 2003 – 2006. This decline immediately preceded the commencement of the Phase 1 Port of Ngqura development (2003 – 2005) and therefore there is no apparent link with the construction activities. Whatever the cause, or causes, the global African penguin population is now in a very serious position. The minimum viable population level for the species has been estimated at ~55 000 breeding pairs (Shannon and Crawford 1999). In 2006 the population had diminished to an estimated 39 000 pairs (Crawford *et al* 2006a); a decrease that may lead to the species being reclassified from vulnerable to endangered according to the IUCN criteria (Barnes 1998). In view of the letter and the spirit of RSA's own legislation, the Biodiversity Conservation Act of 2002, and its commitments to the International Convention on Biodiversity Conservation it would be prudent to apply the precautionary principle, as required under both NEMA and the Biodiversity Conservation Act of 2002, to any activities that may further compromise the penguin population. Accordingly the potential impact of the proposed dredging and dredge spoil disposal on coastal seabirds is assessed as:

Nature of impact	Dredging and dredge spoil disposal may compromise environmental conditions in important foraging areas for penguins breeding on Jahleel and St Croix Islands leading to reduced breeding and overall declines in the penguin population
Extent	Site specific, direct disturbance effects on penguins in the dredge spoil dump area; regional (Algoa Bay), the Algoa Bay population levels suffer marked declines; nationally, South Africa's national commitment to conserving biodiversity is compromised; and internationally, the long term survival of a flagship coastal seabird is further compromised
Duration	Long term to permanent; at present population recovery is uncertain, further losses carry increasing risks of extinction in the wild for the species
Intensity	High
Probability	Probable
Status of impact	Negative
Degree of confidence	Low to Medium; the observations indicate a real decline but explicit links are lacking
Significance (no mitigation)	**High**
Mitigation	Conduct the majority of the proposed dredging programme rapidly, timing it to coincide with the period when penguins are largely independent of feeding in the immediate vicinity of the islands (i.e. during moulting and thereafter when they swim further offshore to feed). In Algoa Bay the optimum period would be October to December (Dr R. J. M. Crawford, DEAT/MCM pers. comm.). This can possibly be extended to include the latter half of September and the first half of January.

	Furthermore, in the port area stringent controls on turbidity levels emanating from the port would need to be implemented through, e.g., the use of silt curtains or associated management interventions.
Significance (with mitigation)	The application of the above mitigation would reduce the probability of impacts occurring from probable to improbable; and the significance would be reduced to **Medium**.

6.4.2.4 Marine Growers Abalone Farm

6.4.2.4.1 Increased abalone mortality due to entrainment of fine particles

During the previous dredging programme the abalone farm at Hougham Park experienced abalone mortalities. Autopsies indicated that the abalone had suffered lacerations to gill tissue which were attributed to high suspended sediment loads in the seawater being entrained into the abalone farm. For this material to pass through the sand filtering systems used on the farm and the sand bed that generally lies above the seawater intake points in the sumps requires the particles to be < 30µm ESD. The proposed dredging will remove minor amounts of sediment in this size range (CSIR 2006) and therefore exposure risks at the farm should be reduced. Further, sediment volumes to be dredged in this phase are an order of magnitude less than those previously which will further moderate the risks.

The impact on the abalone farm is assessed as:

Nature of impact	Increased abalone mortalities on the Marine Growers abalone farm located at Hougham Park due to entrainment of fine sediment particles generated by the proposed dredging and dredge spoil disposal.
Extent	Site specific, confined to the abalone farm
Duration	Short term, mortalities and the associated financial losses can be worked out of the farm through stock replenishment within the farm's production cycle which is approximately 42 months (C. Muller, Marine Growers, *pers. comm.*).
Intensity	Low
Probability	Improbable, although the previous dredging generated an effect both sediment volumes and durations in the proposed Phase 2 dredge programme are significantly reduced
Status of impact	Negative
Degree of confidence	High
Significance	**Low**
Mitigation	Should not be necessary but can be achieved through financial compensation for proven mortalities and production disruption.

6.4.2.4.2 Introduction of alien organisms that may be pathogenic to abalone

South African abalone farms have not experienced effects due to alien organisms and/or pathogens affecting inventories. The reverse has occurred, however, with a sabellid polychaete worm *Terebrasabella heterouncinata* being introduced from South Africa to Californian abalone farms (Finley *et al* 2001), while there is a possibility of toxic phytoplankton affecting local farms (e.g. Pitcher *et al* 2001). Given that dredgers represent a possible source of alien organisms the impact is assessed as:

Nature of impact	Import and release of alien species pathogenic to abalone by dredgers and their establishment in the Marine Growers abalone farm
Extent	Site specific, confined to the abalone farm
Duration	Medium; eradication of sabellid infestations on South African abalone farms has proven to take in excess of 5 years (own observations)
Intensity	Medium
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium; Alien and invasive alien species have established populations in South African coastal waters but none have yet been shown to affect abalone farms
Significance (no mitigation)	**Low to Medium**
Mitigation	Definitely required: Apply the ballast water management protocols stipulated in the IMO International Convention for the Control and Management of Ship's Ballast Water and Sediments, together with NPA's own Guidelines for dredgers (which include hopper washing to remove residual sediment), with verification of the application of these protocols and guidelines, as well as ongoing monitoring of marine biota.
Significance (with mitigation)	The implementation of the strictures of the IMO Convention and NPA Guidelines should reduce the probability of the impact occurring to improbable. Measurements have shown that the IMO ballast water treatment measures reduce viable organisms by 95%. Furthermore, surveys conducted by NPA have not found any alien species in the Port of Ngqura. Therefore, if the dredgers enter the local system "clean" after meeting IMO and NPA requirements, the potential for these dredgers to convey alien species to the abalone farm is non-existent. The significance is assessed to be **Low**.

6.4.3 Operational phase

6.4.3.1 Harbour area

The proposed developments will allow a higher number of ships to load and unload cargoes in the Port of Ngqura and facilitate their management in terms of the provision of piloting and tug services. By definition the increased shipping will be container vessels. The environmental risks associated with these vessels are linked to possibly higher exposure to shipping accidents due to increased ship traffic, damage to containers and consequent breakage and possible losses of hazardous cargoes during container handling and increased volumes of wastes such as machinery oils etc. These risks have been considered in the initial environmental assessments for the port and mitigation, where necessary, incorporated (CES 2001(b)). Examples are ship waste handling facilities and procedures, modern and proven container handling and management systems, etc. Additionally, the standard practice for South African Ports of ship traffic management systems coupled with real time environmental monitoring (waves and currents) will be implemented to reduce possibilities of shipping accidents such as collisions and running aground. Therefore these 'operational' risks are not assessed here.

Operational risks associated with the administrative craft do not appear to have been addressed, however. Given their nature the most severe of the risks that the operation of such vessels pose is fuel spills during refuelling. Refuelling facilities are to be provided in the Administrative Craft basin but it has not yet been specified whether this would be by holding tanks and a bowser system or by having fuel tanker trucked in on demand. In both instances fuel can be lost to the harbour water body. The fuel type would probably be dieseline and any volumes lost should be relatively small.

The impact is assessed as:

Nature of impact	Hydrocarbon spills whilst fuelling tug boats and other administrative craft and associate ecological damage in the port
Extent	Site specific, confined to the harbour as potential spill volumes are small
Duration	Short; episodic events, the light fuels should dissipate rapidly through evaporation and photolysis
Intensity	low
Probability	Probable
Status of impact	Negative
Degree of confidence	High, Modern fuel supply systems with automatic flow cut-offs will be used
Significance	**Low** (assuming implementation of current “best practice” in SA ports)
Mitigation	Transnet will apply the current “best practice” for all SA ports to avoid spills and associated contamination, i.e.: (i) avoid overfilling vessels with fuel; (ii) ensure that there are spill containment areas on the vessels at the point of filling (e.g. “funnel” design around refuelling point), (iii) and use automatic fuel flow cut-off systems.

6.4.3.2 Adjacent environment

No risks over and above the potential for shipping accidents are foreseen. This has been assessed in the initial environmental impact studies (CES 2001(b)) and is not pursued further here.

6.4.4 Cumulative Impacts

Cumulative impacts considered here are those that exacerbate and/or or prolong effects generated by the Phase 1 port construction and dredging activities. These are partitioned into those associated with the Phase 2 construction activities and those that may be generated during port operations.

6.4.4.1 Construction phase

The proposed construction and dredging operations will take place in an environment that has been considerably modified by the overall Port of Ngqura development. The major physical effects of the latter included:

- Modification to the shoreline,
- The removal of ~15 million m^3 of sediment from the port basin and approach channels and its discharge at the 30 m deep dredge spoil disposal site, and
- Chronically elevated turbidity in the system which, although mainly dissipated by September 2005 appears to be still present in bottom waters in the area as observed by the abalone farm operators at Hougham Park.

The biological effects apparently resulting from these physical disturbances were:

- The development of biofouling communities on hard structures within the harbour
- Modification to benthic macrofauna community structure in sediments adjacent to the port
- Apparent displacement of squid from their 'normal' breeding depths in Algoa Bay, and
- Abalone mortalities in the abalone farm.

A marked reduction in African penguins breeding at St Croix Island appears to have immediately preceded port development and it is possible that environmental degradation through increased turbidity and ship movements has exacerbated this. However there is no direct evidence of this.

The proposed Phase 2 development of the Port of Ngqura qualitatively mirrors that of Phase 1 but is at approximately 10% of the scale. Despite the large quantitative difference it is considered to be probable that the proposed activities can exacerbate the effects of Phase 1 by:

- Prolonging the apparent modification of sediment properties in the dredge spoil dump site and adjacent areas through discharge, re-suspension and redistribution of fine sediments. The associated biological effects may include further disturbance to benthic communities and possible extension of the period in which preferred squid spawning areas remain unsuitable for egg pod attachment.
- Regenerating high turbidity levels in bottom water. This may extend the period during which squid are displaced from their preferred depth ranges in Algoa Bay with associated effects on the squid fishery and further exacerbate problems caused by entrainment of high suspended sediment load water into the abalone farm with concomitant financial losses
- Extend the period in which turbidity levels in the upper water column are elevated with possible consequences for penguin foraging success and potential reductions in breeding.

6.4.4.2 Operational phase

Possible cumulative effects on marine ecology attributable to the operational phase for the additional container ship berths and administrative craft basin are those generated by increased container ship traffic, container handling and administrative craft operations. The risks are not different to those addressed under 6.2.1 above, i.e.:

- Higher exposure to shipping accidents due to increased ship traffic
- Increased chances of incidents of damage to containers and consequent breakage and possible losses of hazardous cargoes during container handling
- Increased discharges of wastes such as machinery oils, and
- Accidental fuel spills during refuelling of administrative craft.

The possible repercussions of the above are pollution effects on primarily the biological communities in the harbour. Shipping accidents can, of course, also occur outside of the immediate harbour port area and generate 'far field' effects through leakage of fuel oils, loss of containers and/or groundings and break-up. The most severe ecological effects would be those linked to fuel oil losses such as oiling of African penguins and other seabirds and oil pollution of island and mainland shores.

The environmental significance of these is assessed below:

Nature of impact	Acute and/or chronic environmental disturbances generated within the harbour by the increased container ship traffic using new berths D102 & D103 through increased accidental discharges of waste oils and/or cargo spillages associated with damage to containers during cargo handling, and accidental fuel spillages during administrative craft refueling
Extent	Site specific, the disturbances and effects thereof should be limited to the immediate harbour area
Duration	Short to medium term; Effects on harbour biota may be sufficient to cause the harbour community to become depauperate in community structure
Intensity	Low
Probability	Probable
Status of impact	Negative
Degree of confidence	Medium
Significance	**Low**, due to the site specific extent coupled with the fact that the harbour area is an artificial environment and there is no current dependency of the adjacent marine and coastal environment on the harbour area
Mitigation	As advised in the initial EIA (CES 2001(b)) the port authorities need to implement a rigorous environmental management and control plan to limit ecological risks from operational accidents as well as ensuring efficient and safe operation of the port.

Nature of impact	Ecological damage from shipping accidents linked to higher container vessel shipping traffic in the approaches to the Port of Ngqura
Extent	Local and regional for damage to island and mainland shores, national and international for deleterious effects on seabirds, especially African penguins
Duration	Short-term for effects on benthos, medium to long term for population level effects on the African penguin
Intensity	Low for benthos, high for penguins
Probability	Possible
Status of impact	Negative

Degree of confidence	Low, the degree of impact will be strongly related to the areas affected by lost fuel oils etc. Not every shipping accident generates oil spills
Significance (no mitigation)	**High**
Mitigation	Mitigation measure include: (i) Ensure shipping movements into and out the Ports is efficiently managed with compulsory pilotage and vessel traffic separations schemes; (ii) Ensure port control is informed by real time weather and sea state information used in the control of shipping movements; and (iii) Develop procedures for emergency assistance to ships in the port by use of harbour tugs.
Significance (with mitigation)	**Medium**

6.4.5 Impact Summary Table

The negative environmental impacts that may be generated by the proposed Phase 2 construction and dredging activities at the Port of Ngqura and the operation of the constructed infrastructure are summarized in Table 6.7.

Table 6.7: Port of Ngqura Phase 2: Marine ecology, sediment toxicology and dredging impact summary

Nature of Impact	***Extent***	***Duration***	***Intensity***	***Probability***	***Significance (no mitigation)***	***Significance (with mitigation)***
Construction Phase: Harbour area						
Removal of biological communities in the target dredge area	Site specific	Short	Low	Definite	Low	N/a
Suspended sediment plumes generated by dredging will exert sub-lethal or lethal effects on organisms or communities inhabiting harbour sediments and structures	Site specific	Short	Low	Probable	Low	N/a
Sedimentation of sediment suspended by dredging may smother benthos in harbour sediments	Site specific	Short	Low	Definite	Low	N/a
Remobilization of contaminants in the dredge area may have toxic effects on organisms	Site specific	Short	Low	Improbable	Low	N/a
Depletion of dissolved oxygen concentrations over the dredging period exerts effects on organisms and/or ecological processes	Site specific	Short	Low	Improbable	Low	N/a
Release of nutrients in dredge sediment to water column may cause eutrophication in the harbour water body	Site specific	Short	Low	Improbable	Low	N/a
Noise from dredging disturbs marine invertebrates, fish or seabirds in the harbour	Site specific	Short	Low	Probable	Low	N/a
Import and release of alien (exotic) species by dredgers and their establishment within the harbour area	Site specific	Long term – Permanent	Medium	Probable	Medium	Implement ballast water control according to IMO. The probability should improve to improbable and significance reduce to low

Table 6.7 (cont.)

Nature of Impact	***Extent***	***Duration***	***Intensity***	***Probability***	***Significance (no mitigation)***	***Significance (with mitigation)***
Construction: Receiving Environment – Dredge spoil disposal site						
Discharged dredge spoil smothers benthos on the dredge spoil disposal site and disrupts ecological processes	Site specific and regional (Algoa Bay)	Short	Medium	Definite	Medium	Ensure that dredge spoil is deposited within the discharge site, this will reduce the intensity and significance to low
Depositing discharged dredge spoil may alter sediment properties in the squid spawning areas in Algoa Bay and disrupt spawning	Site specific and regional (Algoa Bay)	Short to medium term	Medium	Probable	Medium	No practical mitigation measures. Significance remains medium.
Elevated water column turbidity generated by spoil disposal may affect squid distribution and the Algoa Bay squid fishery	Site specific and regional (Algoa Bay)	Short to medium term	Low	Probable	Low	N/a
Wave/current suspension of fine sediments deposited on the dredge spoil dump site generates elevated turbidity and modifies benthic communities and ecological processes	Site specific and regional	Short to medium term	Low	Probable	Low	N/a
Remobilization of contaminants in the dredge spoil dump area over the dredging period exerts toxic effects on organisms	Site specific	Short	Low	Improbable	Low	N/a
Depletion of dissolved oxygen concentrations over the dredging period exerts deleterious effects on organisms and/or ecological processes	Site specific	Short	Low	Improbable	Low	N/a
Introduction of nutrients to the water column due to the release of target dredge sediment pore water may cause eutrophication or enrichment in the dredge spoil dump site water body	Site specific	Short	Low	Improbable	Low	N/a
Import and release of alien species by dredgers and their establishment at the dredge spoil disposal area	Site specific to regional	Long term to permanent	Medium	Probable	Medium	Implement IMO ballast water controls and NPA dredger guidelines. The probability should improve to improbable and significance reduces to low.

Table 6.7 (cont.)

Nature of Impact	***Extent***	***Duration***	***Intensity***	***Probability***	***Significance (no mitigation)***	***Significance (with mitigation)***
Construction: Receiving Environment – Islands (Jahleel, St Croix)						
Modifications to the Jahleel and St Croix Island intertidal community by elevated turbidity and/or suspended sediment generated by dredge spoil disposal	Regional (Algoa Bay)	Short	Low	Improbable	Low	N/a
Resuspended sediment from dredge spoil disposal inundates rocky shores and affects intertidal communities on Jahleel and St Croix Islands	Regional (Algoa Bay)	Short	Low	Improbable	Low	N/a
Import and release of alien species by dredgers on the dredge spoil dump site and their establishment on Island habitats	Regional (Algoa Bay)	Long term to Permanent	Medium	Probable	Medium	Implement IMO ballast water controls and NPA dredger guidelines. The <u>probability</u> should improve to <u>improbable</u> and significance reduces to <u>low.</u>
Dredging and dredge spoil disposal compromises environmental conditions in important foraging areas for African penguins breeding on the islands leading to reduced breeding and overall declines in the penguin population	Site specific, regional (Algoa Bay), national and international	Long term to permanent	High	Probable	High	Conduct majority of dredging rapidly, during the time when penguins are mostly independent of the islands (Oct – Dec). Apply strict controls on turbidity being exported from the port area. The application of the above mitigation actions will reduce the probability of the impact occurring from <u>probable</u> to <u>improbable</u>. Overall significance reduced to <u>medium</u> for penguins.

Table 6.7 (cont.)

Nature of Impact	***Extent***	***Duration***	***Intensity***	***Probability***	***Significance (no mitigation)***	***Significance (with mitigation)***
Construction: Receiving Environment – Marine Growers Abalone Farm						
Increased abalone mortalities due to entrainment of fine sediment generated by the dredging programme	Site specific	Short	Low	Improbable	Low	N/a
Import and release of alien species pathogenic to abalone and their establishment in the farm	Ste specific	Medium	Medium	Probable	Low to medium	Implement IMO ballast water controls and NPA dredger guidelines. The probability should improve to improbable and significance reduces to low.
Operational Phase: Harbour area						
Hydrocarbon spills whilst refuelling administrative craft and associated ecological damage in the port	Site specific	Short	Low	Probable	Low	Significance remains low.
Cumulative Effects of the proposed Phase 2 activities						
Prolonged acute and chronic environmental disturbance with possible implications for benthos, squid and the squid fishery, African penguins and the Marine Growers abalone farm	Site specific, regional (Algoa Bay), national and international	Short to permanent	Low for benthos, medium for squid and squid fishery, high for penguins	Probable	Low for benthos, Medium for squid, High for penguins	Conduct majority of dredging rapidly, during the time when penguins are mostly independent of the islands (Oct – Dec). Apply strict controls on turbidity being exported from the port area. The application of the above mitigation actions will reduce the probability of the impact occurring from probable to improbable. Overall significance reduced to medium for penguins.
Acute and chronic effects generated within the harbour by increased shipping through increased accidental oil discharges, cargo spillages and/or accidental fuel spills during refuelling administrative craft.	Site specific	Short to medium term	Low	Probable	Low	Risks and effects will be further reduced by a rigorous environmental management plan within the port.
Ecological damage from shipping accidents linked to higher container vessel shipping traffic in the approaches to the Port	Local and regional, national and international	Short-term (benthos), medium to long-term for penguins	Low for benthos, high for penguins	Probable	High	Apply standard traffic management systems for RSA ports, provide tug assistance timeously. These mitigation steps should reduce the probability to improbable but the significance will remain high.

6.5 Monitoring recommendations

Monitoring requirements for the proposed Phase 2 construction and dredging activities fall into the following three categories:

- Precautionary – monitoring to ensure that set guidelines are not exceeded during Phase 2 operations
- Compliance – monitoring in compliance with regulatory body requirements, and
- Observational – monitoring to demonstrate whether the actual environmental impacts of the Phase 2 activities and associated mitigation were as predicted in the environmental assessments.

Recommended monitoring for each of these categories is set out below.

In addition to these categories it is expected that routine monitoring of oil spills, accidental discharges etc will be conducted within the port as part of port management.

6.5.1 Precautionary monitoring

The primary environmental risk for marine ecological structure and function outside of the immediate dredge area for the proposed Phase 2 activities is compromised water quality through turbidity. CES (2001) set suspended sediment concentration thresholds for the control of the Phase 1 dredging and devised a monitoring protocol. It is recommended that this be applied to Phase 2 in a modified form. The modifications are:

- The monitoring should be conducted at the outer extremity of the Port between the offshore ends of the breakwaters
- Continuous measurements of turbidities at this point should be conducted by an automated measurement system (surface buoy, moored turbidity sensors, data loggers and data communication systems) that sends 'real time' estimates of upper and lower water column turbidity to an independent Environmental Control Officer (ECO).
- Regular calibration measurements should be made in the proximity of the moored sensors which can be achieved during servicing
- The control thresholds defined by Probyn (2000) should be applied but only for the upper portion of the water column; i.e. if turbidity (suspended sediment concentrations) exceeds 20 mg/l for three consecutive days the dredging should be halted or management interventions made to allow turbidity levels to decrease below the threshold 20 mg/l level. If turbidities exceed 80 mg/l for more than 6 hours continuously then dredging should either be halted or other management interventions such as the emplacement of silt screens applied to allow levels to decrease below the set level. This practice should limit possibilities of generating adverse effects outside of the harbour. The practice accepts that communities within the harbour may be compromised but rests on the fact that these are not strongly ecologically linked with adjacent communities in terms of trophic dependencies etc. Thus effects, if any,

will be confined to the harbour area.

- All monitoring must be done under the direct supervision of an independent environmental control officer and the results audited episodically by a supervisory committee.

Note that similar monitoring for the Phase 1 dredging indicated that maximum turbidities were ~50 mg/l and that these did not persist for long (days) periods. The recommended controls are therefore not overly stringent from the dredger operator's viewpoint.

An alternative to the above method is that applied during the Phase 1 dredging and construction, i.e. boat based water column profiling of turbidity as described in CES (2001). This approach is not recommended here because it cannot provide continuous coverage and 'real time' control is problematic. Further, the monitoring approach is expensive, especially if independence of the monitoring agency is an absolute requirement, as it should be.

In addition to the above it is expected that the Marine Growers abalone farm will establish trends of farm performance so that any problems that occur concurrent to the proposed Phase 2 activities can be timeously investigated.

6.5.2 Compliance Monitoring

6.5.2.1 Dredge spoil dumping

The designated spoil dump site in Algoa Bay can be conceived as a sacrificial zone for receiving dredge spoil and any contaminants it may hold. However, it is essential that all spoil dumping occurs within the confines of the specified area. Therefore all navigation tracks for spoil dump round trips and locations of spoil release must be supplied by the dredge operator to the designated environmental control officer on at least a weekly basis. This officer will then check that spoil is firstly being released within the confines of the designated site and advise the dredge operator(s) when apparently uneven discharge patterns are developing. These data are to be reported to the supervisory committee.

6.5.2.2 Dredge spoil behaviour on the designated spoil dump site

The London Convention and the 96 Protocol (Annex 2), which recently came into force and to which South Africa is a signatory, requires that the fate of the dumped dredge spoil on the designated dump site be monitored. The interest here is to identify short and longer term dredge spoil behaviour to determine whether deleterious effects of the dredge spoil may be exercised outside of the area selected for dumping.

Monitoring of dredge spoil behaviour can include:

- Determination of dump site and sediment properties (detailed bathymetry, particle size distributions and contaminant concentrations) prior to dredge spoil discharge
- The above immediately on completion of the dredging programme and spoil dumping and then at, e.g., six, 12 and 24 months post dredging.

- Turbidity levels, distributions and dissipation associated with dredge spoil disposal.

These data should be reported to DEAT/MCM at appropriate intervals.

6.5.3 Observational Monitoring

The current biomonitoring programme as reported by Klages *et al* (2006) should continue through and beyond the proposed Phase 2 activities. However it is apparent that some variables are being jettisoned from this programme and there are some gaps. These are compromising the utility of the programme. The variables that should be included or reincorporated are:

- Trace metals/contaminants in biological tissue (i.e. mussel watch component) on port infrastructure, the Hougham Park intertidal wave cut terrace and island shores. Coverage should be winter and summer and samples should be sufficient for robust statistical comparisons between sites and times
- Harmful algal bloom (HAB) and HAB species occurrences should be monitored in collaboration with the DEAT/MCM HAB programme
- Commercial fishing effort and catch in Algoa Bay from, e.g., Sundays River mouth to Cape Recife with special focus on squid. This should also be done in collaboration with DEAT/MCM
- African penguin breeding on the islands (monitored routinely by DEAT/MCM) but also numbers of penguins moulting on the islands. The latter would provide a more direct estimate of penguin numbers in the region and may also show proportions of non-breeding adults.

These data can be reported in the same manner as the established biomonitoring programme but it should be ensured that syntheses are done at appropriate intervals so that temporal and spatial trends can be identified and information appropriately disseminated.

6.6 Permit requirements

The project proponent, Transnet, will have to obtain permissions from DEAT/MCM to conduct the dredging and dispose of dredge spoil as envisioned in the proposed Phase 2 port development activities of container berth and administration craft basin construction.