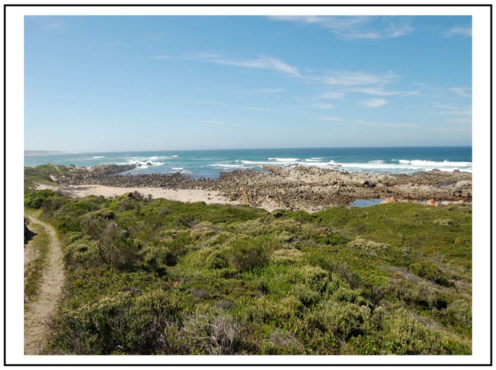
Eskom Holdings Limited

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR-1') AND ASSOCIATED INFRASTRUCTURE



Marine Ecology Study

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EXECUTIVE SUMMARY

This specialist study was undertaken to assess the possible impacts of a 4 000 MW capacity power station on the marine environment at one of three potential sites along the Eastern and Western Cape coasts. Such a development at Duynefontein, Bantamsklip or Thyspunt will have a variety of potential impacts. These include:

- Disruption of surrounding marine habitats. When associated with the construction of the cooling water uptake and release system, this effect will be focused within the construction phase and will be localised and of short duration. However, when associated with the potential discarding of spoil, disruption to the marine environment is significant and of high consequence. When mitigated by disposing spoil offshore (and by using only a medium pumping rate at Thyspunt), the impact is reduced to one of medium consequence, although the significance remains high.
- The entrainment and death of organisms associated with the intake of cooling water. At Duynefontein and Thyspunt entrainment it is not anticipated to have important ecological impacts. However, at Bantamsklip it is likely to have significant negative effects on stocks of the abalone *Haliotis midae*.
- The release of warm water used for cooling purposes. A tunnelled design of the release system mitigates potential negative impacts through multiple points of release to aid dissipation of excess heat, by releasing cooling water above the sea bottom to minimise effects on the benthic environment and by utilising a very high flow rate at the point of release to maximise mixing with cool surrounding water. Comprehensive oceanographic modelling has demonstrated that the effects of elevated temperature are expected to be focused on the open water habitat. This is of particular relevance at Bantamsklip and to a lesser degree at Thyspunt, as it would help to mitigate impacts on abalone and chokka squid egg capsules respectively. It is, however, strongly recommended that at Bantamsklip an offshore tunnel outfall be utilised for the release of warmed water in an effort to further mitigate impact on abalone. Importantly a channel release system at this site is considered to pose an unacceptable risk to abalone populations.
- The release of desalination effluent. During construction small volumes of hypersaline effluent will be released directly into the surf zone where high energy water movement will result in adequate mixing with surrounding seawater to ensure minimal impact on the marine environment. During the operational phase the desalinisation effluent will be co-released with cooling water. As brine will be

diluted to undetectable levels prior to release no impact on the marine environment is predicted during this phase of the development.

- The unintentional release of radiation emissions. Technical design of the cooling system has minimised this risk, so that this impact is rated as having low consequence and low significance.
- The additional protection of organisms from exploitation due to a safety exclusion zone. The only site which would benefit from such an exclusion zone would be Bantamsklip, as this could be of great benefit to what are currently illegally harvested abalone populations. However, for such a benefit to be realised adequate enforcement of the exclusion zone should be provided.
- The release of treated sewage effluent. This effluent will meet the standards set by the Department of Water Affairs and Forestry and as such no impact on the marine environment is expected.
- Pollution of the marine environment by the discharge of groundwater polluted by organic, bacterial or hydrocarbon compounds. As this impact is unlikely to occur and will be spatially and temporally restricted, it is considered to be of low consequence and significance.

Besides the impacts of the proposed development on marine habitats, organisms in the marine environment may also impact on the development. This would take the form of fouling of cooling water pipes. This impact is anticipated to be most significant at Duynefontein, due to its location along the west coast, where jellyfish blooms appear to be increasing in frequency.

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ABBREVIATIONS

DEA	Department of Environmental Affairs (previously Department of Environmental Affairs and Tourism)
KNPS	Koeberg Nuclear Power Station
NPS	Nuclear Power Station
ppt	Parts per thousand

GLOSSARY

Benthic habitat	The area inhabited by organisms living on and in the seafloor sediments
Benthos	The biological communities inhabiting the benthic environment
Chlorination	The production of sodium hypochlorite (chlorine) from seawater

Demersal	Occurring on or near the sea floor
Dolosse	Concrete structures used to stabilise the seaward edge of reclaimed land
Entrainment	The unintentional intake of organisms along with cooling water
Fouling	The growth marine organisms on infrastructure. Also referred to as biofouling
Pelagic	Occurring in the middle and surface layers of the ocean
Sessile	Organisms living permanently attached to hard substratum (e.g. mussels on rocks)
Thermocline	The zone between layers of water of different temperatures

1 INTRODUCTION

1.1 Background

In the context of increasing economic growth and social development South Africa's energy demands have increased dramatically over the last decade. Despite substantial energy efficiency advancements, Eskom is currently experiencing increasing demand in excess of four percent per year. In order to help meet this ever-increasing demand for energy, while minimising South Africa's greenhouse gas emissions, Eskom has proposed the development of a fleet of Nuclear Power Stations (NPS), with a power generation capacity of up to 20 000 MW. It is envisaged that this 20 000 MW capacity will be composed of a 4 000 MW station (Nuclear-1) followed by Nuclear-2, -3, -4 and -5.

This specialist study was undertaken to assess the possible impacts of the development of Nuclear-1 on the marine environment at three potential sites along the coast. Impacts occurring during the construction, operation and decommissioning stages of development are considered. In particular, the impacts of disruptions to surrounding marine habitats during construction, the effect of abstraction of seawater for cooling purposes, the subsequent release of warmed water and the release of brine emanating from desalinisation, the implications of the creation of new habitat and the effects radioactive releases on the marine environment are evaluated.

1.2 Study Approach

The information included in this report consists of dedicated field surveys at the proposed development sites, combined with a review of the extensive body of relevant scientific research that has been conducted along the South African coast, as well as information gained from international peer reviewed works in the field of marine biology. Additionally, the large body of knowledge that has been gathered following the establishment of Koeberg Nuclear Power Station (KNPS) offers insight into the impacts of a nuclear power station on the marine environment in a South African context.

Field surveys were undertaken between August and October 2007. Where possible at each site, an exposed and sheltered rocky shore was sampled, as well as a long open beach and a pocket beach. This was to account for well established differences in the biological communities which inhabit these physically different habitats.

The impacts of a nuclear power station, viz. Nuclear-1 producing 4 000 MW output of power is assessed.

1.2.1 Assumptions and limitations

The conclusions drawn in this report are based on the following assumptions:

- The temperature of released cooling water will be 12ºC above ambient sea temperature.

- A safety exclusion zone will be imposed around the proposed power station but as far as possible access to the marine environment by the public will be maintained.
- The chlorination regime applied to abstracted cooling water will consist of sodium hypochlorite produced by electrolysis of inlet seawater to produce an estimated 2 mg/kg of chlorine on a continuous basis.
- Screens of similar specification to those used by KNPS will be used to prevent the intake of large marine organisms such as kelp, fish and jellyfish along with abstracted cooling water.
- Should disposal of spoil occur at sea, the spoil will be placed at the same location as that modelled by Prestedge *et al.* (2009a) the volumes disposed of will not exceed those considered in the models and sediment disposed of at sea will not contain organic matter. Should any of these constraints not be met, refinement of the current models should be undertaken prior to commencement of disposal.

Although six alternative options for discarding spoil at sea were modelled by Prestedge *et al.* (2009a) and were subsequently assessed in this report, it is important to note that the logistical and economic feasibility of these options have not been established. As a necessity recommendations made in this report assume technical feasibility.

2 DESCRIPTION OF AFFECTED ENVIRONMENT

Due to the design of the proposed development the impacts on the marine ecosystem will be focused within the nearshore environment. A detailed description of the potentially affected marine habitats at the three alternate sites is given below.

2.1 Duynefontein

Figure 1. The sandy beach at the proposed Duynefontein site

2.1.1 General Description

The area under consideration is located north of Melkbosstrand on the west coast towards the southern limit of the relatively uniform Namaqua marine biogeographic region, which extends north as far as southern Namibia. This region is dominated by the cold Benguela Current system, in which high biological productivity is supported by the upwelling of cool nutrient rich waters (Bustamante *et al.* 1995a, b, Walmsley *et al.* 2007). However, this section of coast is characterised by low marine species richness and very low endemicity (Awad *et al.* 2002). Nonetheless, some south coast species extend to this site, giving it slightly elevated species richness and endemicity rates, when compared to northern areas along this coast. No sites of special biological significance occur within the area (Jackson and Lipschitz 1984).

This site is typified by long sandy beaches, interspersed with short stretches of rocky-shore (Currie and Cook 1975). Such beaches are notable for the low number of species they support, and the fact that they are physically controlled. As a result of the dominance of physical parameters, such as water movement, these beaches are very resilient to disturbance. All the beach species found here have extensive geographical distributions. There are no sites of special conservation value for marine species within the immediate area.

2.1.2 The Intertidal Zone

The intertidal zone in the vicinity of KNPS is dominated by sandy shores. To the north of the plant is a 10 km long sandy beach, which is very wave exposed and as a result consists of coarse-grained quartz sand and weathered shell. To the south is a shorter beach, which is more sheltered due to the presence of the Koeberg harbour breakwater. This shore consists of finer sediment and has a wider intertidal zone. Invertebrate species found on both these beaches are typical of the west coast (Appendix 1). During sampling at this site only a single species endemic to South African shores was recorded i.e. the amphipod *Talorchestia quadrispinosa*. This species, however, has a range spanning from False Bay up the entire west coast. High-shore macrofaunal communities are dominated by crustaceans (isopods and amphipods), while lower down the shore communities become dominated by polychaete worms (Griffiths and Robinson 2006). Although not numerically dominant, the White sand mussel *Donax serra* also occurs in the low shore. This species is common on exposed sandy beaches along the west and south coast. Due to the dynamic nature of exposed sandy shores they demonstrate high tolerance to disturbance and are thus rated as a low sensitivity habitat.

Very little natural rocky shore is present in the area under consideration and the two Koeberg harbour breakwaters represent the largest section of hard substratum available in the intertidal zone. On the seaward side the breakwaters are protected by concrete dolosse and loose rocks and the intertidal zone is very exposed with biological communities that are dominated by two alien species i.e. the mussel *Mytilus galloprovincialis* and the barnacle *Balanus glandula* (Appendix 2). A single South African endemic species, the whelk *Burnupena lagenaria* was also recorded. On the inside, the breakwaters are built up with rocks of assorted sizes, sloped to form a gentle intertidal zone. Communities within this sheltered habitat are far more diverse, but still include the alien mussel and barnacle recorded on the exposed side of the breakwater. Community biomass is dominated by *M. galloprovincialis,* the limpet *Scutellastra granularis* and numerous algae. All species recorded in the rocky intertidal zone are common on the west coast and none have ranges restricted to less than 100 km. Although more sensitive than sandy shores, the rocky shores at this site also represent a low-sensitivity habitat.

Figure 2. The exposed seaward side of the Koeberg breakwater

2.1.3 The Benthic Environment

Both rocky and sandy bottoms occur in the nearshore environment in the immediate vicinity of Koeberg Nuclear Power Station (Cook 1984a). These habitats were not sampled as part of this study. This is due to the fact that there has been relatively sparse sampling of the nearshore subtidal benthos off the South African coast and as such it would be almost impossible to say how representative the habitats present at each of the proposed Nuclear-1 sites might be even if they were sampled. This is not considered a fatal flaw as:

(1) sufficient information relating to commercially important benthic resources such as abalone exists to enable a scientifically rigorous evaluation the relative importance of the sites; and

(2) warm water effluent from the proposed development will be concentrated near the surface and is unlikely to impact these habitats. This approached has been endorsed by Professor GM Branch (Appendix 3).

Communities inhabiting rocky substrata are dominated by the sea urchin *Parechinus angulosa*, the mussel *Choromytilus meridionalis* and gastropods of the genus *Burnupena*. All species are typical of the South African west coast and are widely distributed. Both abalone *Haliotis midae* and West Coast rock lobster *Jasus lalandii* were recorded on nearby shallow reefs in the 1980s (Cook 1984a) and are likely to still occur there, due to the protection offered by the two nautical mile 'no go' safety area surrounding the power station. Sandy bottom communities in this area support no species of special note and are characterised by large numbers of polychaete worms, burrowing anemones and small crustaceans. This environment demonstrated medium sensitivity to disturbance.

2.1.4 The Open Water Environment

While the South African west coast supports highly productive fisheries, these are focused offshore. Nearshore fish productivity remains high, but diversity is low. A number of fish have been recorded in the harbour of KNPS, the most common of which are the Southern harder *Liza richardsoni* and the catshark *Poroderma africanum* (Cook 1984b). While a number of marine mammals are known to frequent the west coast, only the South African fur seal *Arctocephalus pusillus pusillus* has been recorded spending extended periods in the immediate area of the power station.

The high productivity characterising the west coast region is driven primarily by high densities of phytoplankton and zooplankton. Blooms are, however, localised and transient and depend to a large degree on prevailing weather and oceanographic conditions. Although a large number of species have been identified in the vicinity of the area under question, taxonomy of these groups is notoriously difficult and a large number of smaller species remain undescribed.

Marine mammals are not common along this section of coast, although Dusky dolphin *Lagenorhynchus obscurus*, Long-beaked common dolphin *Delphinus capensis* and less frequently, individual Southern right whales *Balaena glacialis* and Humpback whales *Megaptera novaeangliae* are seen in the vicinity.

This environment demonstrates relatively high tolerance to disturbance and is thus rated as having low sensitivity.

2.1.5 Avifauna

A number of marine birds are known to breed in the intertidal zone around the KNPS. These include Hartlaub's gull *Larus hartlaubii*, the Swift tern *Sterna bergii bergii* the 'Endangered' Bank cormorant *Phalacrocorax neglectus*, the 'Near-threatened' Crowned cormorant *P. coronatus*, Cape cormorant *P. capensis* and the 'Near-threatened' African black oystercatcher *Haematopus moquini*. Of these, three species are endemic to the region (Hartlaub's gull, the Bank cormorant and the African black oystercatcher). Recent research has identified the Koeberg harbour and surrounding reserve as an area of significant conservation importance, which meets the criteria for both the Ramsar convention and an Important Bird Area (Parsons 2006). In particular, the protection offered by the Koeberg reserve has resulted in a notable increase in density of breeding pairs of the African black oystercatcher, which has recently been recategorised as 'Near-threatened' after being rated at 'Endangered' for a number of years. Besides the marine birds occurring at the power station African penguin and other seabird colonies are located at Robben Island, about 15 km to the south.

2.2 Bantamsklip

2.2.1 General Description

This site is located just to the east of Pearly Beach in the Western Cape Province and as such falls within the Agulhas marine bioregion. Marine invertebrate species richness in this region is dramatically higher than that along the west coast (and the Koeberg site), but somewhat lower than in the Thuyspunt region. Very few range-restricted species are reported from this region (Awad *et al.* 2002) and no rare or endangered marine species are known from this location. Besides the important Dyer Island seal and bird colonies, which lie approximately 10 km to the west of Bantamsklip, no sites of special biological significance are known from the area (Jackson and Lipschitz 1984).

The shoreline at Bantamsklip consists of strongly-dissected exposed rocky shores, interspersed with small pocket beaches, upon which large quantities of kelp wrack are cast ashore. This kelp originates from the dense beds of *Ecklonia maxima* and *Laminaria pallida*, which dominate shallow subtidal areas at this site (Barker 1988). The broader region supports a number of significant fisheries (e.g. anchovy, sardine, abalone and lobster), as well as marine tourism activities such as white shark diving and whale watching. Much of this activity is centred at Gansbaai, 20 km west of the site.

Figure 3. The shoreline at Bantamsklip

2.2.2 The Intertidal Zone

At this site the intertidal zone is dominated by strongly dissected exposed rocky shores. In the high-shore the small gastropods *Afrolittorina africana* and *Tricolia capensis* dominate communities, while lower down the shore algae such as *Bifurcaria brassicaeformis* become important (Appendix 2). Sampling of this site revealed nine South African endemic species, all of which have extensive ranges along the coast. Although currently only harvested on a recreational basis, recent studies have considered the potential of commercial harvesting of the giant winkles *Turbo sarmaticus* (alikreukel), *Turbo cidaris* and *Oxystele sinensis* in this area (Pulfrich and Branch 2002). Sandy beaches along this section of coast take the form of small pocket beaches located between rocky outcrops. Faunal communities on these beaches are typical of sandy shores in the region and support large numbers of the polychaete worm *Scololepis squamata* in the low-shore (Appendix 1). No species of special conservation interest were recorded in the intertidal environment at this site (Appendix 4 & 5). The rocky and sandy shores at this site are considered to be tolerant to disturbance and thus demonstrate low sensitivity.

Figure 4. A pocket beach at Bantamsklip

2.2.3 The Benthic Environment

The nearshore benthic environment in the Bantamsklip area is represented by both rocky and sandy habitats. In rocky areas floral communities are typified by dense beds of the kelps *Ecklonia maxima* and *Laminaria pallida*. *E. maxima* occurs in the sublittoral fringe and has a canopy of fronds that lie on the water surface. In contrast *L. pallida* occurs beneath the *E. maxima* canopy and extends to deeper waters (8-15 m). Both these species are commercially exploited along the South African coast. Management of seaweed resources along the south and west coast is implemented through the designation of concession areas. Bantamsklip falls within area 5 (Uilenkraal River mouth to Cape Agulhas). This concession area supports a considerable *E. maxima* resource of 498 ha (Anderson et al. 2007) and the extent of *L. pallida* has not been quantified. For *E. maxima* this area supports 27% of south coast stock and less than 10% of overall stocks (calculated from figures given in Anderson *et al.* 2007). The present right-holder is permitted to collect any beach-cast kelp and harvest a maximum of 2625 tonnes of whole kelp (or 1313 tonnes frond material) annually (R. Anderson, Marine & Coastal Management, DEA Pers. Comm.). Harvesting is only allowed from the shore or a boat and diving is not permitted. As fresh fronds are sold to abalone farms for about R 950.00 per tonne, kelp represents a valuable resource in this area (R. Anderson, Marine & Coastal Management, DEA Pers Comm).

Closely associated with the above kelp beds is the abalone *Haliotis midae*. This gastropod is of extremely high commercial value and has been intensively harvested on a commercial, recreational and illegal basis along the South African coast. This fishing pressure, combined with ecosystem changes such as a dramatic eastward extension of predatory rock lobster stocks in recent years, has resulted in the dramatic reduction in wild stocks of *H. midae* since the early 1990s (Maharaj *et al.* 2008). Fisheries Independent Abalone Surveys conducted by the Department of Environmental Affairs and Tourism have recorded a decrease in abundance (per 60 m^2) from 35.7 (± 13.4 SE) in 1995 to 6.2 (± 1.7 SE) in 2007 (G. Maharaj, Marine & Coastal Management, DEA Pers Comm). As a result the entire fishery was officially closed by the Minister of Environmental Affairs and Tourism as of 1 February 2008. The long-term objective of this closure is to allow rebuilding of the resource with a view to re-opening the fishery once the resource has recovered sufficiently. A few key areas have been identified for total protection to allow such rebuilding and Bantamsklip occurs within one such area (i.e. from Quoin Point to Danger Point). This area is one of the few that still contains viable abalone populations that have the potential to recover to significant levels (G. Maharaj, Marine & Coastal Management, DEA Pers Comm). While the benthic environment as a whole demonstrates medium tolerance to disturbance (and hence medium sensitivity), the abalone population is considered highly sensitive.

Although no site-specific study of sandy bottom community composition has been undertaken, no species of special conservation importance (besides the abalone) are known from the area.

2.2.4 The Open Water Environment

The rich diversity of fish along the Southern Cape coast supports both commercial line and pelagic species, as well as significant recreational fishing activities. As the pelagic fisheries (such as those for Pilchards and Anchovy) occur offshore, they are not likely to be impacted by the development of a power station at Bantamsklip so are not considered further within this report. The commercial lineboat fishery, as well as shore anglers, target species such as Kob (*Argyrosomus hololepidotus*), White steenbras (*Lithognathus lithognathus*), Musselcracker (*Sparodon durbanensis*), Galjoen (*Dichistius capensis*), Cape salmon (*Atractoscion aequidens*) and Yellowtail (*Seriola lalandi*) (Attwood and Farquar 1999). All of these species have extensive ranges along the South African coast and none breed in the area around Bantamsklip, but most are considered to be overexploited, some severely so (Attwood and Farquar 1999).

Since the protection of White sharks (*Carcharodon carcharias*) in 1991, the area between the Bantamsklip site and Gansbaai has become one of three shark cage diving sites along the South African coast. In particular, the area around Dyer Island, which supports a large seal colony, is a common viewing spot. Although no recent assessment has been completed of the numbers of White sharks in South African coastal waters, over 1200 different individual sharks were identified in the Gansbaai area between 1998 and 2005 (Kock and Johnson 2006). Sharks in this region show seasonal trends in abundance, with overall numbers peaking in winter. However, sharks are recorded near inshore areas most frequently from August to November (Kock and Johnson 2006).

Four marine mammals, the Southern right whale (*Balaena glacialis*), Indo-Pacific bottlenosed dolphin (*Tursiops aduncus*), Long-beaked common dolphin (*Delphinus* *capensis*) and South African fur seal (*Arctocephalus pusillus pusillus*), are regularly observed in the vicinity of Bantamsklip. Southern right whales occur mainly within 1 km of the shore from April to January, with peak abundances in September - October (Barker 1988). During the later part of this yearly cycle inshore populations are dominated by cows with calves. This species is not believed to feed while in the region (Barker 1988). While no major calving area occurs close to Bantamsklip, Walker Bay (to the west) has been identified as an important mating ground (Barker 1988). Although Indo-Pacific bottlenosed and Long-beaked common dolphin occur close to the shore, their distribution extends to the edge of the continental shelf. Schools of both species move great distances and are common both along the South African coast and internationally. Two breeding colonies of South African fur seal occur in the vicinity of Bantamsklip, those at Geyser Rock, which is adjacent to Dyer Island, and Quion Rock to the east. Although five breeding colonies exist along the south coast the abundance of this species is much lower in this region than along the west coast (Barker 1988). Numbers of individuals on the islands peak during the breeding season, which runs from late November to early January (Barker 1988). It is during this time that colonies are most sensitive to disturbance, with mothers abandoning pups if disturbance levels are too high. In contrast the colonies are least sensitive during October and early November, when most cows spend time at sea prior to the birth of their pups (Barker 1988). The area under consideration is unlikely to be of importance to feeding adult seals as they forage offshore, but in their first year juveniles may forage in the areas surrounding the breeding colonies.

Plankton productivity is dramatically lower on the south coast than on the west coast. Nonetheless, inshore waters tend to experience moderate sporadic spring blooms, followed by strong episodic coastal upwelling, which gives rise to intense blooms in summer (Mitchell-Innes *et al.*1999).

The open water environment is considered a low sensitivity environment due to its dynamic nature and high tolerance to disturbance.

2.2.5 Avifauna

To the west of Bantamsklip, Dyer Island supports colonies of African penguin (*Spheniscus demersus*), Roseate terns (*Sterna dougallii*), Whitebreasted (*Phalacrocorax carbo*), Cape (*P. capensis*), Bank (*P. neglectus*), and Crowned cormorants (*P. coronatus*), Kelp gulls (*Larus dominicanus*), Hartlaub's gulls (*L. hartlaubii*) and Swift terns (*Sterna bergii bergii*) (Waller and Underhill 2007). Huge roosts of migratory Common (*S. hirundo*) and Sandwich terns (*S. sandvicensis*), occur in summer. Kelp gulls (*Larus dominicanus*), African black oystercatchers (*H. moquini*) and a variety of Terns (Family Sternidae) frequent the intertidal zone at this site. The conservation rating of each of these species in the Red Data Book for South Africa is given in Table 1.

Table 1. Conservation rating in the Red Data Book for South Africa of marine birds occurring at Dyer Island and Bantamsklip

Species	**Conservation rating**	**Distribution**
African penguin	Vulnerable	
Roseate tern	Endangered	
Whitebreasted cormorant	N/A	
Cape cormorant	N/A	
Bank cormorant	Endangered	
Crowned cormorant	Near-threatened	
Kelp gull	N/A	

Hartlaubs gull	N/A	Endemic to SA
Swift tern	N/A	
Common tern	N/A	
Sandwich terns	N/A	
African black oystercatchers	Near-threatened	Endemic to SA

A colony of Cape cormorant *Phalacrocorax capensis* has been observed roosting at this site. This is the most common of the cormorants found along the South African coast and breeds between Namibia and Port Elizabeth. This species is of no special conservation concern.

2.3 Thyspunt

2.3.1 General Description

Situated just to the west of Cape St. Francis within the Eastern Cape Province, Thyspunt falls within the warm-temperate Agulhas bioregion. Although the general area is one of high marine species richness and high rates of endemicity (Awad et *al.* 2002) site surveys detected no rocky or sandy shore species endemic to the south coast. No rare or endangered species are known from the site, and no sites of special biological significance occur within the designated area (Jackson and Lipschitz 1984), although fish traps of historical interest occur to the west of the site.

The shoreline at Thyspunt consists mainly of very exposed intertidal habitat, including both rocky and sandy shores. Due to the restricted access at this site these shores have been protected from all forms of utilisation. A lucrative fishery for chokka squid *Loligo vulgaris* is located in inshore waters along this region of coast.

Figure 5. Sandy and rocky shores at Thyspunt

2.3.2 The Intertidal Zone

Rocky shores at Thyspunt are steep and strongly dissected. The high-shore zone is dominated by the algae *Porphyra capensis* and the tiny gastropod *Afrolittorina africana* (Appendix 2). The mid-shore forms a distinct band dominated by the barnacle *Chthamalus dentatus,* but also supports low densities of the alien mussel *M. galloprovincialis.* In contrast low-shore communities are dominated by a variety of algae, all of which are common in this region. Three rocky-shore endemic species were recorded at this site, each with an extensive range along the South African coast (Appendix 5). Although not recorded during recent surveys, the giant periwinkle *Turbo sarmaticus* (alikreukel) occurs in the vicinity of Thyspunt, where it is harvested in large numbers on a recreational basis (Bruton et al. 1991). The exposed sandy beaches at this site consist of course sand and support a very low diversity of organisms (i.e. only four species were recorded, Appendix 4). The most common of these was the plough shell *Bullia digitalis* and no endemic species were recorded. No species of special conservation interest were recorded in the intertidal environment at Thyspunt. As for the other two sites, the intertidal zone (consisting of both sandy and rocky shores) is considered highly tolerant to disturbance, due to the natural variability which typifies these shores. As such the intertidal zone is considered a low sensitivity habitat.

Figure 6. The exposed rocky shore at Thyspunt

2.3.3 The Benthic Environment

Both sandy and rocky bottoms are present in the vicinity of Thyspunt (Nuclear Site Investigation Programme; Eastern Cape 1988). Species composition and abundance in these habitats are typical of the region. Rocky reef communities are dominated by colonial ascidians, hydroids and sponges, with coralline algae being important to a depth of about 20 m (Nuclear Power Investigations; Eastern Cape 1988). The benthic environment demonstrates medium tolerance to disturbance and as a result is rated as a medium sensitivity habitat.

2.3.4 The Open Water Environment

Since the mid 1980s a coastal jigging fishery for chokka squid *Loligo vulgaris* has developed along the south coast, although this species occurs from southern Namibia to approximately East London (Augustyn 1989). Spawning occurs mainly, although not exclusively, in shallow bays along the South African south coast (Augustyn 1991), with the most important spawning grounds occurring between

Plettenberg Bay and Algoa Bay. It is on these spawning grounds that squid are targeted by the fishery. Egg capsules are deposited mainly on low-profile reef or fine sandy bottoms of large, relatively sheltered bays, such as that to the east of Thyspunt. Generally egg deposition occurs at depths of less than 50 m, but during years of severe winter storms, elevated swell and turbidity result in spawning at greater depths (Roberts and Sauer 1994). During these times the squid are lost to the jig fishery. Surveys conducted between 1985 and 1992 failed to detect egg beds in the area immediately surrounding Thyspunt (Augustyn et al. 1994), but the current status in this area is unknown.

Shore and skiboat based recreational angling occurs extensively along the Eastern Cape coast, including in the general Cape St. Francis area. Species of importance to these fisheries include Dusky kob (*Argyrosomus japonicus*), Silver kob (*A. inodorus*), Cape salmon (otherwise known as Geelbek, *A. aequidens*), Shad (otherwise known as Elf, *Pomatomus saltatrix*), White steenbras (*Lithognathus lithognathus*) and Bronze bream (*Pachymetopon grande*) (Brouwer and Buxton 2002). Although both demersal and pelagic fisheries operate in the area offshore from Thyspunt, these fisheries occur outside the area that will be impacted by the development of a power station and so are not considered further within this report.

While marine mammals such as Indo-Pacific bottlenosed dolphin (*Tursiops aduncus*), Long-beaked common dolphin (*D. capensis*) and far less frequently Humpback (*Megaptera novaeangliae*) and Southern right whales (*B. glacialis*) are observed in the general vicinity of Thyspunt, these species are transient within the area. Unlike at Bantamsklip, the appearance of Southern right whales in this area is random and not linked to the birth of calves (Best 2000). No seal colonies occur near Thyspunt.

Although plankton productivity is not considered to be high in this area, when compared with the west coast, nearshore waters are subjected to moderate sporadic coastal upwelling and resulting plankton blooms during summer (Mitchell-Innes *et al.* 1999). The highly dynamic nature of the open water environment translates into low sensitivity to disturbance.

2.3.5 Avifauna

Rocky shores in the vicinity of Thyspunt support a variety of coastal birds, which are typical of such shores in the Eastern Cape region. Species most often observed include the Kelp gull *L. dominicanus* and the African black oystercatcher *H. moquini*. On sandy shores Sandwich terns (*S. sandvicensis*) and Common terns (*S. hirundo*) are common in summer months. All of the above species are widely distributed and are of no special conservation concern.

3 IMPACT IDENTIFICATION AND ASSESSMENT

The development of a nuclear power station at Duynefontein, Bantamsklip or Thyspunt will have a variety of potential impacts on the marine environment. These include disruption of surrounding habitats during the construction phase, the entrainment of organisms during the intake of cooling water, the release of warmed cooling water, the release of desalination effluent, the unintentional release of radiation emissions and contaminated groundwater. In addition to the impacts of the development on marine habitats, the marine environment may also impact the development. This would take the form of fouling of the cooling water system by marine organisms.

3.1 Duynefontein

3.1.1 Disruption of the marine environment during construction

To fulfil the need for cooling water for the condensers and auxiliary systems of the proposed power station, seawater will be utilised. A tunnel system is being considered at this site. As part of such a system two intake pipes will be tunnelled from a land-based cooling water reservoir out to sea. At a water depth of roughly 25 m the pipes will emerge from the seafloor and water will be taken in via intake structures. Although some disruption to the benthic environment will occur during the construction of this intake system, a much smaller area will be affected than for the construction of an intake basin, resulting in significantly less disruption than that associated with the construction of KNPS. The proposed outflow system consists of three to four three to four outflow pipes which are laid beneath the sea floor with cooling water being released offshore. In order to lay the outflow pipes, a temporary dam extending just over 400 m out from the intertidal zone will be build during the construction phase. Following the laying of the pipes, the walls will be collapsed, burying the pipes, except for the release point. Regardless of the outflow system chosen, the effects on the subtidal benthic habitat due to the construction process will be the same. Impacts will be confined to the immediate area, with organisms being lost due to the physical disturbance of the sediment and smothering. This effect will, however, be of short duration.

As dolphin and whales are sensitive to human activity and noise, they may avoid the area surrounding the development during the construction phase, particularly during tunnelling for the intake pipe and the building of the dam. However, none of the species that occur along this section of coast are reliant on the area and all are likely to return, as they did following the construction of the original KNPS.

The disruption to the marine environment described above will occur only during the construction phase, and is likely to be localised.

Additionally, spoil from the excavation of the intake tunnel, intake basin, nuclear island and turbine hall may be discarded out at sea. At this site 6.48 million m^3 of sand will need to be discarded, either at sea or on land. When disposed at sea this sediment will essentially have two impacts:

- firstly as a sediment plume within the water column (consisting mainly of fine muds), which may block light penetration and block filtering apparatus of filter feeders; and

- secondly as a layer covering the sea bottom (consisting mainly of courser sands) which will burry the current benthic environment.

The nature these two impacts and how they are affected by currents and local water movement have been modelled by Prestedge *et al.* (2009a). These models considered the disposal of both the full volume and half the volume of spoil at both a shallow and deep site. In addition both a medium and high discharge rate were considered. The details of the various disposal alternatives are given in Prestedge et al. (2009). At this site Alternatives 4 (i.e. disposal of all the spoil at a deep site using a high discharge rate), 5 (i.e. disposal of all the spoil at a deep site using a medium discharge rate) and 6 (i.e. disposal of half the spoil at a deep site using a medium discharge rate) are considered acceptable from a marine ecology perspective. As the most severe impacts are associated with Alternative 4 this alternative is assessed. For this option the maximum suspended sediment concentration reaches levels above 80 mg/l near the water surface over a very limited area at any time during or after disposal (Prestedge *et al.* 2009a). This is considered acceptable as this sediment plume will occur offshore and avoids any potentially sensitive areas such as nearshore kelpbeds. The level of 80 mg/l has previously been identified as a threshold above which probable adverse ecological effects will occur, while 100 mg/l has been used as a critical value above which proven negative impacts occur (Cater 2006). These levels were applied in the environmental impact assessment of the deepening of the Ben Schoeman Doc Berth on the marine ecology of the Table Bay region. In addition, an area of only 0.5 km² will experience these elevated turbidity levels for longer than two days. The fact that this west coast region is exceptionally productive and this impact will be both spatially and temporally limited (and avoid sensitive areas) results in turbidity having little impact on the open water environment. Initial disposal of spoil will cover an area of 3 km² with sediment layered 2.95 m high, resulting in a dramatic affect on benthic communities, which will be totally smothered. This will occur over a limited area and will not affect any organisms of conservation importance. While recolonisation from surrounding areas is expected to occur, this will be over the long-term. In the first five years after disposal, the sediment on the sea bottom is expected to spread very little to cover an additional area of just 4.5 km² in greater than 5 cm of sediment. Very importantly, only 1 km² of this additional area will be covered by more than 10 cm of sediment (Prestedge *et al.* 2009a). In the period of six to ten years following disposal, sediment on the sea floor will continue to spread to cover 12.7 km² in more than 5 cm of sediment, with 60% of this area covered in sediment as shallow as 5 – 10 cm of sediment. While benthic communities at the initial disposal site will still not have recovered, a variety of species are likely to have become established on the disposal mound by this time and areas covered in less than 10 cm of sediment are expected to support communities similar to those of undisturbed areas. As the offshore benthic environment at this site is almost totally dominated by sandy bottoms, disposal of sediment will not affect rocky reefs.

While spoil will be discarded only during the construction phase, the open water environment will be affected in the short term but the benthic environment will be negatively impacted for many years.

3.1.2 Abstraction of cooling water and subsequent entrainment of organisms

As part of normal operations cold sea water will be extracted from the marine environment for use in the cooling system of the proposed plant. One of the problems associated with the use of marine water in this way is biological fouling of the cooling water system. In an effort to minimise such fouling, a number of measures will be employed by the proposed plant. These include continuous low-level chlorination of the intake water to discourage settlement of sessile organisms and the use of screens to prevent the intake of larger marine organisms, such as fish. In addition, the technical design of the intake system will result in water being drawn into the pipe at a rate of only 1 m/s. This slow rate of intake means that large organisms, such as fish and marine mammals, will easily be able to swim against the flow and will avoid entrainment without difficulty. Should an intake tunnel system be chosen for this site, the precise location of the intake point has no implications from a marine ecology perspective.

Chlorination of cooling waters is commonly used by power plants throughout the world (Huggett and Cook 1991). It is, however, very difficult to isolate the effects of chlorination from those of entrainment itself, as during entrainment organisms are also exposed to heat and physical stress, such as mechanical buffeting, acceleration and changes in hydrostatic pressure (Marcy *et al.* 1978). Thus, in this report, all the above impacts will be considered collectively as impacts resulting from entrainment of organisms. As part of the assessment of the environmental impacts of the KNPS the combined effect of chlorination, heat and physical stress on plankton entrained within the cooling system were quantified (Cook 1984a, Huggett 1987, Huggett and Cook 1991). These studies revealed mortality rates of between 17 and 26 % for zooplankton and between 55 and 67 % for phytoplankton. These impacts are, however, very localised and are considered unlikely to have a significant negative impact on the receiving environment (Huggett and Cook 1991). Entrainment is also unlikely to have a negative impact on reproduction success of fish species, as 87% of fish eggs were found to survive passage through the cooling system (Huggett and Cook 1991). Also few commercially important fish are abundant near KNPS. Although thermal stress is not considered important under average conditions, it is likely to become locally significant during times of high ambient sea temperature, when the increase in temperature due to entrainment may result in water temperatures rising above the thermal tolerances of many west-coast plankton species. It is important to note, however, that sea surface temperatures along the South African west coast have in fact declined over the last two decades as a result of climate change (Rouault *et al.* 2009). This trend is opposite to the general prediction of a global rise in sea surface temperature (IPCC 2007), and is driven by intensifying upwelling, which is in turn related to changes in wind regimes (Reason and Rouault 2005, Rouault *et al.* 2009). As a result, warm water anomalies are likely to decrease in frequency and any chlorination affects are likely to be localized and unlikely to have detectable effects on productivity far beyond the power station (Huggett 1987). While 16 species of fish have been recorded in the screens that filter intake water at KNPS, no impact on commercially important or conservationally sensitive species has been recorded (Cook 1984b). It is expected that this impact would be greatly reduced in the proposed development due to the very low rate at which water will be drawn into the cooling system.

Although the volume of water to be utilised by a 4 000 MW plant is roughly twice that of KNPS, the above conclusions are still deemed valid, as the extent of the impact is localised, heat and chlorine dissipate quickly beyond the outfall area (Huggett 1987) and plankton populations regenerate very rapidly, especially along the west coast (Huggett and Cook 1991). This impact will occur during the operational phase of the development.

3.1.3 Release of warmed cooling water

After being pumped through the cooling system, warmed cooling water is to be released directly back into the ocean. KNPS uses a shore based channel to jet the warmed water beyond the surf zone in an effort to achieve good mixing with cold seawater. This warm water plume appears as a jet core of fairly uniform temperature within 200 m of the outfall. Outside of the surf zone the heated water rises to the surface layer and spreads laterally and the exact shape, extent and dispersion characteristics of the warm water plume depends mainly on the power station status and the prevailing currents and sea state at the time (Koeberg Site Safety Report 2006), but even under the worst conditions the affected area is unlikely to extend more than 1 km from the outfall (Rattey and Potgieter 1987). Oceanographic modelling has demonstrated that in order to prevent recirculation of warmed water into the KNPS cooling system, cooling water from the Nuclear-1 development must be released via an offshore tunnel outfall (Prestedge *et al.* 2009b). It is important to note that downward penetration of the plume is limited by the buoyancy of the warmed water. Should cooling water be released four hundred metres from the shore from six release pipes buried 12m below the surface, the high velocity at which the water will leave the pipes ($4.5 m.s^{-1}$) will maximise mixing with cold seawater. This design prevents warmed water being released at a single point source (the more release points, i.e. the more outlet pipes, the better) and releases the cooling water above the sea bottom, so as to minimise thermal pollution of the benthic environment. This will be further enhanced by the buoyancy of the warm water. This design will minimise impacts on the benthic environment. The exact location of the outlet pipes is not of importance from a marine ecology perspective.

In regular monitoring, spanning the last 26 years, no significant effects of thermal pollution have been detected in sandy beach communities (Koeberg Site Safety Report 2006). While the number of species recorded during bi-annual sampling of sandy beaches has varied dramatically between six and 28 over the last 16 years, these changes are likely to reflect the natural long-term variability, which typifies sandy shore communities (Griffiths and Robinson 2006). To date no invasion of warm water species has been recorded, with only a single typically South coast species, the Angular surf clam *Scissodesma spengleri* (normal range False Bay to East London) being found on a single occasion in 2003. Although regular monitoring of communities inhabiting the artificial rocky shore formed by the intake basin has not been conducted, surveys were conducted as part of the ecological baseline studies for KNPS (Cook 1984a) and again in 2007 as part of field surveys for the present environmental assessment. The only differences detected between the two time periods were the appearance of the alien barnacle *Balanus glandula* and the absence of the mussel *Choromytilus meridionalis* in the latter survey. This mussel has, however, disappeared from many west coast shores due to the extensive invasion of the alien mussel *Mytilus galloprovincialis* (Robinson *et al.* 2007). As such, this change cannot be ascribed to the release of warmed cooling water by the power station. Benthic habitats at this site also appear unaffected by the release of cooling water, as Cook (1984a) recorded no differences between benthic communities in areas that differed in their exposure to the warm water effluent. It should, however, be noted that this study took place before the power station was fully operational and no follow-up study has been undertaken subsequently. Nonetheless, the spatially limited extent of the warm water plume, together with these initial findings, suggest that no significant impact on subtidal benthic communities is likely.

Based on the lack of significant impacts caused by the release of cooling water by KNPS, it unlikely that the release of water warmed to 12ºC above ambient sea temperature by the proposed development will have significant impacts on the marine environment. Oceanographic modelling (Prestedge et al. 2009b) backs this conclusion as a mean rise in sea surface temperature of 1ºC will be limited to an area of roughly 0.75 km² for a 4 000 MW plant, regardless of the release system chosen. Importantly, no area of the seafloor will experience mean temperatures raised above 1ºC. The cooling water that will be released by the proposed Pebbled Bed Modular Reactor (should that development occur) will be released along with that of KNPS and will raise the temperature of the released water by only 1.5ºC. Thus cumulative impacts are considered to be of low significance. Climate change related changes in sea temperature are not expected to alter the impact of released cooling water on the marine environment at this site. As sea temperatures appear to be cooling in this region (Rouault et al. 2009) any localised rise in sea temperature is unlikely to force any species above their thermal tolerance ranges. Any impacts from the release of warm water effluent will affect the marine environment during the operational phase of the development and will cease during the decommissioning phase.

3.1.4 Desalination

Unlike KNPS, the proposed development will require a desalination plant. During construction, a fast track portable desalination plant will be installed to provide for all freshwater needs. This initial smaller plant will use beach wells for the intake of seawater and will discharge the brine into the breaker zone to facilitate mixing. A permanent desalinisation plant will function during the operational phase to provide demineralised water to the plant. Simply put, such desalination entails the removal of all salts from abstracted seawater. Typical pre-treatment of seawater required for the desalinisation process includes the use of both chlorination and de-chlorination, the addition of anti-scalant agents and surfactants, and the adjustment of pH through the addition of strong acids. The end result is purified water and a highly saline effluent, which could contain a variety of chemicals including sodium hypochlorite, ferry chlorite, sulphuric or hydrochloric acid and odium hexamethaphosphate. It is important to note that the chemicals in the release water are approved by the United States Environmental Protection Agency for use in drinking water systems, at similar concentrations as those found in desalination effluent (Einav *et al.* 2002). This effluent will be released into the ocean. Hopner and Windelberg (1996) divide the global marine habitats into 15 categories according to their sensitivities to the effects of desalination plants. According to their hierarchy, Duynefontein falls within the category of sites ranked as fourth most suitable for the construction of desalination plants, due to its location on a high-energy coast with associated upwelling. As such this site is considered the most suitable for the siting of a desalination plant.

When released independently, the impacts of hypersaline effluent are focused on benthic communities, as brine has a higher density than seawater and thus settles on the sea bottom, where dispersion is limited (Einav *et al.* 2002). Under such conditions any impacts on benthic biodiversity are likely to be focused around the release site. However, as the brine will be released into the surf zone during the construction phase, physical mixing with surrounding sea water will result in dilution to 1 g/L above ambient salinity within 110 m from the point of release (Prestedge *et al.* 2008). Any ecological impacts will be focused within the water column due to the high energy of the surf zone.

During the operational phase of this development, desalination effluent is not expected to affect the marine environment. This is due to the combination of hypersaline discharge with the discharge of heated cooling water. Although the brine is expected to have a salinity of 58 ppt (in comparison with seawater which has a salinity of 35 ppt) this effluent will account for less than 1% of the water released. As such the hypersaline brine will be diluted to undetectable levels within the outflow pipes prior to release (Prestedge *et al.* 2008). While no defined standards exist for the discharge of desalination plant effluent in South Africa, the South African Water Quality Guidelines for Coastal Marine Waters states a target range of 33 ppt to 36 ppt for salinity of effluents entering the sea (Department of Water Affairs and Forestry 1995). These guidelines will be met by this development during the operational phase. Although they will not be met during the construction phase, dilution will occur within 110 m of the point of release.

3.1.5 Radiation emissions

A major concern associated with the development of any nuclear facility is the release of radiation emissions into the surrounding environment. In South Africa the National Nuclear Regulator controls radiation emissions released into the environment. As such the proposed plant will be legally required to meet the regulators dose limits prior to approval. At the design level this risk has been minimised as the seawater in the cooling system never comes into direct contact with the reactor and simply cools a secondary coolant. It is important to note that at no stage is there direct contact between the reactor and the coolant or between the coolant and the sea water.

During routine environmental monitoring designed to detect radioactive releases into the marine environment from the KNPS, West Coast rock lobster, sediment and seawater samples have been found to be free of non-naturally occurring radionuclides (Alard 2005). Activation and fission products have, however, been detected in abalone, black mussel, fish and White sand mussel (Alard 2005). Importantly, as equivalent levels of radioactivity have previously been recorded in these species under natural conditions, these findings are not considered indicative of any significant effect on the surrounding marine environment (Griffiths and Robinson 2005).

The likelihood of a nuclear accident affecting the marine environment is very low, as such an incident would require a breach of the entire cooling system. However, should such an event take place, the impacts are likely to be reflected in mortality focused in the general area of the power station. Highly mobile species, such as fish, exposed to low to intermediate levels of radiation may, however, move great distances. This could pose a threat to the general public if these fish were later caught and consumed.

Contamination of the marine environment by radioactive radionuclides is most likely to occur during the operational phase of this development.

3.1.6 Closure of the site to exploitation

Unlike at KNPS, there is no certainty that a mandatory security exclusion zone will not be imposed in the marine habitat seawards of the proposed NPS. Instead a much smaller safety zone (800 m around the power station and 1 km out to sea) is likely to be implemented. The exact dimensions of the safety zone out to sea are yet to be decided upon and are dependent on a recommendation by the National Intelligence Agency. As this site falls within the footprint of the KNPS, exploitation of marine resources is already prohibited in the area and no additional benefit will be gained from a further security exclusion zone.

3.1.7 Release of sewage effluent

During the construction and operational phases a sewage waste water treatment plant will treat 750 m^3 of water per day on site. Following treatment this effluent will be discharged into the ocean via the cooling water outfall tunnels. As required by the Department of Water Affairs and Forestry this water will meet the required standards as set out in the South African Water Quality Guidelines for Coastal

Marine Waters at the point of release. As such no impact on the marine environment is anticipated.

3.1.8 Unintentional discharge of polluted groundwater

The geohydrological specialist study has indicated that due to the proximity of the site of the proposed development to the coastline, it is located in a groundwater discharge zone. As a result, any polluted groundwater will discharge to the sea. Nonetheless, the study indicates that any pollution may be focused in a small area, and contaminants will dissipate. During the construction and operational phases potential pollution of groundwater and the subsequent contamination of the marine environment may originate from leaks and spillages from both on-site sanitation facilities as well as from fuel, oil and grease storage facilities.

Organic enrichment of the marine environment along the South African west coast is associated primarily with the release of fish offal and mariculture operations in harbours such as Saldanha Bay (Kruger *et al.* 2005). Such enrichment leads to a reduction in species diversity with numerical dominance of a few well adapted species (Carvalho *et al.* 2006). Although the effects of organic enrichment of sheltered marine habitats such as bays and harbours can be dire, it is unlikely that such impacts will be observed along the highly wave exposed shoreline around the proposed development. This is due to the extremely exposed nature of the coastline and the resulting mixing of nearshore waters which would quickly dissipate any contaminants. Should pollution of groundwater by accidental spills of fuel, oil or grease occur the possibility exists that contaminants could be passed through to the marine environment. Such pollution has been demonstrated to dramatically affect organisms in both intertidal and benthic habitats with recovery only occurring after a number of years in some cases (Lu and Wu 2006). Again the dynamic nature of the recipient nearshore environment is likely to aid in the dilution and dissipation of any contaminants.

3.1.9 Impacts of the environment on the proposed development

The potential impacts of marine biota on the proposed plant stem from the blockage of water intakes by jellyfish and floating kelp and the fouling of cooling pipes. Such impact will be focused within the operational phase. Medusae of the phylum Cnidaria (jellyfish) and planktonic forms of the phylum Ctenophora (comb-jellies) are well known to cause blocking of power station cooling systems when they reach high densities (Mills 2001). During initial studies on the entrainment of plankton at KNPS, Huggett (1987) recorded medusae of the species *Obelia, Bougainvillia* and *Muggiaea* and a number of ctenophores with *Pleurobrachia pileus* being the dominant species. While large individuals of both groups were effectively excluded from intake water by screens, smaller individuals were taken up (Huggett 1987). Entrainment mortality of both medusae and ctenophores is surprisingly low and high survival rates may be explained by a remarkable tolerance of these organisms to the chlorination and temperature changes associated with entrainment. Considering the noticeable increase in jellyfish along the South African west coast since the 1970s (Mills 2001) and the high probability of this being linked to climate change (Richardson et al. in press), the probability of high densities of these organisms blocking the cooling water system of a proposed power station in this area appears to be increasing.

3.2 Bantamsklip

3.2.1 Disruption of the marine environment during construction

At this site either an intake pipeline or basin will be used to supply cooling water to the proposed power station and either a near shore channel or three to four outflow pipes will be used to release the warmed cooling water back into the marine environment. As described for Duynefontein, the tunnelling process and the building of a temporary dam or basin will result in temporary disruption to the marine environment.

Additionally, the benthic habitat is at risk due to potential discarding of 10.07 million m³ spoil from the excavation of the intake tunnel, intake basin, nuclear island and turbine hall. Oceanographic modelling of the characteristics of the turbidity plume and the sediment on the sea floor resulting from the discard of spoil was undertaken by Prestedge *et al.* (2009a). In order to avoid impacting the highly threatened abalone *H. midae* at this site, disposal of spoil must occur offshore. Considering this constraint, Alternatives 4, 5 and 6 (i.e. either the full or half the volume of spoil disposed offshore at either a medium or high flow rate) are assessed. For these alternatives the area near the sea floor exposed to turbidity above 80 mg/l for greater than two days is expected to vary between 16.4 (Alternative 4) and 3.8 (Alternative 6). Following placement on the seabed, roughly 3 m of sediment will cover an area of 1.5 or 3 km² depending on whether only half or the full volume of sediment is disposed of. Following disposal, local water movement will result in shifting of the spoil. As no major currents flow in this region, oceanographic modelling indicated that within the first five years following disposal the sediment is likely to spread to cover an area of between 6 km² (Alternative 4) and 3.5 km² (Alternative 6) in more than 10 cm of sediment. Importantly as much as 32 % and 40 % of this covering of sand is expected to be between 5 cm and 10 cm deep. Due to the slow moving nature of this sediment and the lack of organic content, this sediment is expected to be colonised by sandy bottom species and support communities similar to those of surrounding undisturbed areas.

Both the above impacts are of particular concern for the abalone *Haliotis midae,* which will experience mortality due to physical damage to individuals and smothering by fine sediments. This gastropod has been severely over-fished along the South African coast and in an effort to protect dwindling wild stocks the fishery has been closed. As Bantamsklip falls within a small area that currently supports the largest remaining stocks of this species (G. Maharaj, Marine & Coastal Management, DEAT Pers Comm) the loss of any potential recruits is very undesirable. Thus, it is vital that disposal of spoil occur offshore to minimise impacts on the abalone population.

Disruption due to tunnelling and the laying of pipes will be focussed within the construction phase and is likely to be localised and short-lived. The impact will be the same regardless of the output of the plant. In contrast, the discarding of spoil during the construction phase will have long-lived effects. The impact will be the same regardless of the output of the plant.

Depending on the final location of the nuclear plant, the construction process may disrupt a flock of Cape cormorant *Phalacrocorax capensis*, which roost at this site. This is the most common cormorant species found along the South African coast, supporting breeding colonies from Namibia to Port Elisabeth. This impact will be temporary and confined to the construction phase.

3.2.2 Abstraction of cooling water and subsequent entrainment of organisms

Although the impacts of cooling water abstraction and the resulting impacts on plankton have not been quantified for this site, as they have been for Duynefontein, the Koeberg experience does still offer useful insight into possible effects. Nonetheless it should be noted that the effect of chlorination is likely to be more important at this site, as the toxicity of chlorine will be elevated by higher ambient sea temperatures (Huggett and Cook 1991) (maximum sea surface temperature for this site is 21.3ºC compared to 19ºC at Duynefontein (Shillington 2007). Nonetheless, climate change induced long-term decreases in nearshore sea surface temperatures have been recorded for this section of coast (Rouault *et al*. 2009) and may help to offset the negative effects of the higher water temperatures at this site. As the productivity of south coast nearshore waters does not match that of the west coast, entrainment of plankton at Bantamsklip is less likely to occur and is not likely to have a significantly negative impact on the marine environment in general. It is likely that fish eggs from this area will demonstrate similar resilience to entrainment as has been recorded at KNPS. However, entrainment of eggs, sperm or larvae of the abalone *H. midae* is of great concern. Despite the presence of screens to exclude organisms from the cooling system and the low flow rate of intake water, eggs, sperm and larvae of this species will be impossible to exclude, due to their small size. However the further offshore the intake pipes are located the less likely eggs, sperm and larvae are to be entrained.

The impacts resulting from abstraction and entrainment will occur during the operational phase of the development.

3.2.3 Release of warmed cooling water

The impacts of releasing thermal effluent remain untested for this site, as no comparable operation has functioned in this area to date. The species most at risk due to thermal pollution are those that occur near the upper limits of their thermal range. As few species in this area have distributions predominantly along the cold west coast (only two rocky shore and no sandy shore species with such distributions were recorded during field surveys) it is unlikely that many organisms fall within this category.

Again the species of greatest concern is the abalone *H. midae.* Along the west coast this species demonstrates a temperature tolerance range of 8-24ºC, while temperatures above 26ºC have been found to induce acute temperature stress with mortality following rapidly (Department of Water Affairs and Forestry 1995). Although thermal tolerance levels have not been established for individuals along the south coast, there is no reason to suspect any differences in temperature tolerance between regions. It should be noted that no thermal tolerance has been established for gametes and larvae of this species. While *H. midae* occur to depths of 23 m (Newman 1969), along this section of coast approximately 80% of the population occurs in the 0-5 m depth range (Tarr 1993). The above adult distribution, combined with the fact that the degree of larval dispersal is thought to be fairly limited as spawned ova stay in suspension for only a few minutes and *H. midae* has a short planktonic larval stage (Genade 1988), temperature changes in the depth range of 0-5 m are of greatest concern.

Based on a background temperature of 17ºC (i.e. the temperature used in the oceanographic models by Prestedge *et al.*2009b) *H. midae* adults will be able to tolerate a maximum temperature increase near the sea bottom of 7ºC.

Oceanographic modelling indicates that for an offshore tunnel releasing at a depth of 25m the mean increase in temperature will not exceed 1ºC near the seabed (Prestedge *et al* 2009b). However, for a nearshore channel release a mean increase of 7ºC near the seabed will affect an area of roughly 0.1 km² for a 4 000 MW plant and 0.4km of shoreline will experience an maximum increase of 7ºC or more at depths of 0-10 m. As such it is clear that a channel release system will cause mortality of *H. midae* adults in the immediate area of the outlet. What is unclear is the effect that elevated temperatures will have on the gametes of this species, although the impact is likely to act over a larger area as gametes occur in the water column where temperature increases will be greater. The release of cooling water further offshore will significantly reduce the impacts on this species. Although significant climate change induced decreases in sea surface temperature have been measured in this region and are predicted to continue (Rouault *et al*. 2009), these decreases are unlikely to reduce the severity of this impact as temperatures have declined at a rate of less than 1 ºC in the last two decades.

The release of warmed cooling water is not expected to have a dramatic impact on nearshore fish species, as excess heat will be focused around a small area at the point or points of release and at the water surface. Many species currently caught by anglers at this site in fact breed in the warm waters of KwaZulu-Natal and so, while avoiding the point of release where water temperatures will be highest, are very unlikely to experience thermal stress. A similar scenario is likely to face the White shark *Carcharodon carcharias.* These mobile predators may avoid the source of warm water release, but will not be forced to the limits of their thermal tolerance once the heat has begun to dissipate. Although the exact temperature tolerance range for this species has not been established, the fact that it occurs in areas both warmer (off the warm Mozambique coast) and colder (off the cold South African west coast) than Bantamsklip is indicative of its broad temperature tolerance. Oceanographic modelling of the warm water plume has indicated that the temperature around Dyer Island (a popular site used by the shark cage diving industry) will not be affected. None of the marine mammals that occur in the vicinity of Bantamsklip (South African fur seal *Arctocephalus pusillus pusillus*, Southern right whale *Balaena glacialis*, Indo-Pacific bottlenosed dolphin *Tursiops* and Long-beaked common dolphin *Delphinus capensis*) are expected to be negatively impacted by the warmed water. This is due to the localised extent of the warmed water relative to the extensive ranges of these large species, combined with their mobility and ability to avoid undesirable conditions. As such, these species are likely to avoid the elevated temperatures immediately around the outfall, but are not expected to avoid the area in general. A similar response is likely to be demonstrated by some coastal fish, but no species are expected to be lost to the area. In fact, exploited fish species may benefit from the development (see section 3.2.6 below). Pelagic fisheries will not be affected by the release of warmed water as they are focused further offshore than the outfall plume will reach.

Although never recorded at KNPS the potential does exist for the establishment of warm-water species which do not currently occur at this site.

Impacts due to the release of warm water effluent will occur during the operational phase of the development.

3.2.4 Desalination

The potential impacts of desalination on the marine environment have been described above for the Duynefontein site and remain the same for Bantamsklip.

3.2.5 Radiation emissions

As described above the most likely pathway for the release of radiation into the marine environment is through the release of contaminated cooling water. The does limits allowed are, however, set by the National Nuclear Regulator and the development will not be approved if these are not met by the plant. The lack of any such releases occurring at KNPS in over 20 years of operation indicates that such radiological release is unlikely and thus the same could be said for Bantamsklip. It is, however, essential that monitoring of marine species be carried out so as to maintain a close watch on the levels of non-naturally occurring radionuclides. In particular, radionuclide levels should be monitored in the abalone *H. midae* due to the extremely high commercial value of, and demand for, this species.

This impact has the potential to affect the marine environment throughout the operational phase.

In the unlikely event of a nuclear accident affecting the marine environment, mortalities will be focused in the general area of the power station. Highly mobile species, such as fish or sharks, exposed to low to intermediate levels of radiation may, however, move great distances. This could pose a threat to public health if these fish were later consumed.

3.2.6 Closure of site to exploitation

The closure of Bantamsklip to exploitation of marine resources due to the implementation of a safety zone around the proposed power station could offer much needed protection to the abalone *H. midae.* It should be noted, however, that the level of organisation and the brazenness of poachers in this area will necessitate dedicated active policing of this exclusion zone if this benefit is to be realised. It is anticipated that while Eskom will be responsible for monitoring access to the area (regulated assess by the public may well occur), the South African Police Services will be responsible for law enforcement in the zone. While this indirect approach has worked well at KNPS, the level of organised crime associated with abalone poaching in this region has resulted in this practise occurring relatively unchecked despite the best effort of the police. As such the degree of benefit derived by abalone populations remains unclear. Depending on the conditions associated with regulated access to the safety zone, shore anglers may be excluded from this prominent fishing area. Although a detailed assessment of the line fish stocks in this area has not been made, Attwood and Farquar (1999) found these species to be significantly depleted in the area to the west of Bantamsklip, between Cape Hangklip and Walker Bay. As there is no reason to assume that stocks are in a better state at this site, an exclusion zone could offer a protected area for these species. This impact would act throughout the operational, decommissioning and closure phases.

3.2.7 Release of sewage effluent

This impact is described above for Duynefontein and remains the same for Bantamsklip.

3.2.8 Unintentional discharge of polluted groundwater

As at Duynefontein the potential exists for the discharge of organic, bacterial and hydrocarbon contaminants into the marine environment via polluted ground water. Potential impacts on marine habitats are described above for Duynefontein and remain the same for Bantamsklip.

3.2.9 Impacts of the environment on the proposed development

Unlike at Duynefontein, the potential impacts of the marine environment on the proposed plant do not include the threat of blockage of water intakes by jellyfish, as high densities of these species are restricted to the west coast. However, the extensive kelp beds in the area do pose a threat, especially after winter storms, when drift kelp is common.

3.3 Thyspunt

3.3.1 Disruption of the marine environment during construction

As at the other sites, the construction of an intake and outflow system for cooling water will result in temporary disruption to the marine environment. Under such circumstances the benthic habitat and in particular egg beds of the chokka squid *Loligo vulgaris* are at risk of damage due to smothering, while turbidity may result in adults temporarily moving out of the area. This disturbance will be focussed within the construction phase and is likely to be localised and of short duration.

Additionally, potential discarding of an estimated 6.37 million m^3 of spoil from the excavation of the intake tunnel, nuclear island and turbine hall poses a threat to the marine environment. As described for the previous two sites mentioned in this report both the physical and biological marine environment would be affected. From a biological perspective impacts would occur due to increased turbidity in the water column as a result of the suspension of fine particles and due to smothering of the benthic habitat by spoil placed on the sea floor. The characteristics of these two components and how they are affected by oceanographic conditions have been modelled by (Prestedge *et al.* 2009a). These models considered the disposal of both the full volume and half the volume of spoil at both a shallow and deep site. In addition both a medium and high discharge rate were included. At this site only Alternatives 5 and 6 (i.e. disposal of all or half the spoil at a deep site using a medium discharge rate) are considered acceptable from a marine ecology perspective. The exclusion of Alternative 4 at this site is due to the fact that this option makes use of a high discharge rate which elevates turbidity in the water column. This is important as the mating of adult *L. vulgaris* squid may be disrupted in the immediate area as they avoid turbid areas. For these alternatives the maximum suspended sediment concentration is not expected to reach levels above 80 mg/l near the water surface at any time during or after disposal (Prestedge *et al.* 2009a) and will be confined to less than 1.4 km² near the seafloor. In addition, these turbidity levels will be very temporally limited outside the actual disposal site occurring for a maximum of two days (Prestedge *et al.* 2009a). Following disposal on the seafloor, roughly 3 m of sediment will cover an area of 1.5 or 3 km² depending on whether only half or the full volume of sediment is disposed of. Following disposal, local water movement will result in shifting of the spoil in a north easterly direction towards Seal Point. Within the first five years following disposal the sediment is likely to spread to cover an area of between 8.3 km² (Alternative 5) and 6 km² (Alternative 6) in sediment of between 5 and 10 cm. In the next five years loose sediment originally placed on the disposal site is expected to continue to spread in towards Seal Point. If Alternative 5 (i.e. disposal of the full volume of sediment) is employed this spoil is likely to spread to cover a small area in the small bay east of Seal Point in 5 – 10 cm of sediment. If Alternative 6 (i.e. disposal of only half the volume of spoil) is utilised, this area will not be affected. While the initial disposal site will be lost as a breeding area to Chokka squid *L. vulgaris* the areas to which sediment spreads are unlikely to affect these squid as they lay eggs on both sand bottoms and rocky reefs. Unlike at the other two sites, sandy bottom communities establishing within sediment originating from the disposal of spoil are likely to be dissimilar to those of surrounding areas. This is due to the fact that this site is dominated by consolidated sands (Prestedge *et al.* 2009a) which will naturally support different biotic communities to those occurring in loose sediments such as those derived from spoil.

3.3.2 Abstraction of cooling water and subsequent entrainment of organisms

As with Bantamsklip, the effects of cooling water abstraction and the resulting impacts on plankton have not been quantified for this site. Again higher ambient water temperatures than those occurring at KNPS (i.e. maximum and minimum sea surface temperatures of 22.5 and 16.6ºC respectively (Shillington 2007))are expected to increase the toxicity of chlorination (Huggett and Cook 1991) when compared to the west coast site. However, long-term climate change induced decreases in sea-surface temperatures along this section of coast (Rouault *et al*. 2009) may reduce this effect in the long term. The lower productivity of nearshore waters in this area is, however, expected to result in less entrainment of organisms and little effect on the marine environment at Thyspunt. No species of commercial value are likely to be affected by entrainment. As at the other potential sites technical design aspects and screens will prevent the intake of larger marine organisms such as squid, fish and marine mammals. The exact positioning of the intake pipes is not of importance from a marine ecology perspective. The impacts resulting from abstraction and entrainment will occur during the operational phase of the development.

3.3.3 Release of warmed cooling water

No input of warmed water comparable to that of the proposed development exists along this section of coast. As this site lies at the warm end of the Agulhas Bioregion it could be argued that a portion of species occurring here may be near the upper end of their temperature tolerance range and hence could be particularly vulnerable to further temperature increase. Although theoretically possible, this is however, unsubstantiated.

The fishery of greatest importance in the Thyspunt area is the coastal jigging fishery for chokka squid *Loligo vulgaris.* The major spawning grounds of this species occur between Plettenberg Bay and Algoa Bay and it is here that these squid are targeted during the spawning season. Adult chokka squid are adapted to a wide temperature range of between 8 and 22ºC and are able to cope with rapid changes in water temperature, which allow them to easily move through thermoclines (Augustyn *et al*. 1994). As such it has been recognised that temperature is probably not a primary factor affecting the distribution of adults, but rather the distribution of their food source. This is reflected in catches peeking following drops in temperature resulting from coastal upwelling (Sauer *et al*. 1991). It should be noted that it is not the drop in temperature which drives this change, but rather the process of upwelling. As such, elevated water temperatures resulting from the release of cooling water will not as a matter of course result in lower catches by the fishery. The egg capsules of this species are deposited directly onto the seafloor and develop optimally at temperatures between 12 and 20ºC (Augustyn *et al*. 1994). At temperatures above 22ºC egg development is retarded and mortality increases (Sauer *et al*. 1991) and above 24ºC, 100% mortality is reached (Augustyn *et al*. 1992). Based on a background temperature of 19ºC (i.e. the temperature used in the oceanographic models by Prestedge *et al.* 2009b) egg beds will be able to tolerate a maximum temperature increase near the sea bottom of 3ºC. Oceanographic modelling indicates that while a mean increase of 3ºC near the seabed will be limited to an area of roughly 0.2km² around the outlets of a 4

000 MW plant, an area of 0.5km² will experience an maximum increase of 3ºC or more, if a nearshore pipeline outfall is used (Prestedge *et al.* 2009b). This temperature increase will be focused at depths shallower than 15m. Modelling also showed that should a channel outflow system be used for a 10 000 MW plant, a mean increase of 3ºC would affect less than 0.1km² but about 2.5km² would experience a maximum increase of 3ºC or more (Models were not constructed to consider this release system for a 4 000 MW plant, but its impact would be less than that of the larger 10 000 MW plant. As egg beds are laid down predominantly in areas shallower than 50 m (unless unfavourable conditions force adult squid offshore) (Roberts and Sauer 1994), a certain amount of egg mortality is expected, although precise estimates cannot be made as the exact location of egg beds is not known. Nonetheless, the area to be affected is in fact a tiny portion of the spawning ground which is centred between Plettenberg Bay and Algoa Bay (Augustyn 1991). In order to minimise impacts on egg beds the cooling system outflow should be located at a depth of more than 50m.

As at Bantamsklip, the release of warmed water is not predicted to have a significantly negative effect on fish, or marine mammals. This is due to their mobility and ability to avoid the localised warm water plume. In addition all of these species have wide-ranging distributions which extend far beyond the Thyspunt area. Although these species are likely to avoid the elevated temperatures immediately around the outfall, they are not expected to avoid the area in general.

At Thyspunt there is notable potential for the establishment of new warm water species, due to the already high ambient sea temperatures at this site and its proximity to the sub-tropical Natal marine bioregion, which could act as a source of immigration of warm-water species. Climate change related declines in sea surface temperature in this region (Rouault *et al*. 2009) are unlikely to reduce the risk of establishment of warm water species as water temperatures have declined by less than 1ºC over the last two decades. Should the establishment of warm water species occur, it is, however, unlikely to have dramatic impacts on the local ecology as immigrant species will be restricted to a small area warmed to within their thermal tolerance range by the plume.

3.3.4 Desalination

The potential threats to the marine environment resulting from desalination are described above for the Duynefontein site and remain the same for Thyspunt.

3.3.5 Radiation emissions

As described for both Duynefontein and Bantamsklip the most likely source of radiological releases into the marine environment is the release of contaminated cooling water. These releases will, however, be controlled by the National Nuclear Regulator. The KNPS experience has demonstrated that such radioactive contamination is very unlikely. It is, however, vital that monitoring of radionuclide levels in marine species be carried out. In particular, radionuclide levels should be monitored in chokka squid *Loligo vulgaris*, which are caught in the area.

This impact may affect the marine environment during the operational phase of the development.

In the improbable event of a nuclear accident affecting the marine environment, mortalities are expected to be focused in the general area of the power station. Highly mobile species, such as fish, exposed to low to intermediate levels of radiation may, however, move great distances. This could pose a threat to public health if these fish were later consumed.

3.3.6 Closure of the site to exploitation

As access to this site has been restricted for well over a decade, no additional benefit will be gained by closure of this site to exploitation. Development of a power station at this site will, however, prevent future exploitation of marine resources within any safety exclusion zone. This exclusion zone is not anticipated to significantly affect the chokka squid fishery, due to its small size relative to the vast area over which this fishery operates (efforts are focused but not restricted to the area between Plettenberg Bay and Algoa Bay (Augustyn *et al*. 1992)). This impact would act throughout the operational, decommissioning and closure phases of the development.

3.3.7 Release of sewage effluent

This impact is described above for Duynefontein and remains the same for this site.

3.3.8 Unintentional discharge of polluted groundwater

Potential impacts associated with the release of ground water containing organic, bacterial or hydrocarbon contaminants have been described for the Duynefontein site and remain the same for Thyspunt.

3.3.9 Impacts of the environment on the proposed development

As at Bantamsklip, jellyfish do not pose a large threat to the cooling water system of a proposed power station, as these organisms simply do not reach high enough densities along this section of coastline. Kelp is also absent from this region The dominant threat to the proposed development from the marine environment at Thyspunt is the blockage of pipes by settlement of sessile organism, such as mussels and barnacles. This impact will act throughout the operational phase of the development.

4 ENVIRONMENTAL ASSESSMENT

The following section offers an assessment of the potential impacts identified in Section 3 above. Impacts were accessed in accordance with Government Notice R.385 of 2006, promulgated in terms of Section 24 of the NEMA and the criteria drawn from the IEM Guidelines Series, Guideline 5: Assessment of Alternatives and Impacts, published by the DEAT (April 1998).

The decommissioning phase is not formally considered as it will not impact on the marine environment.

4.1 Duynefontein

4.1.1 Disruption of the marine environment during construction

Disruption due to construction of the cooling water intake and outflow systems

Due to mortality of organisms as a result of construction of the cooling water system this impact will exert a negative effect on benthic marine habitats. The impact will occur in the medium term and will be restricted in extent. Thus it is considered to be of low consequence. As disruption to marine habitats will definitely occur during the construction process this impact is rated as having medium significance (Table 2). The cumulative impacts are considered low as the marine environment will maintain its ability to respond to future changes.

Disruption due to discarding of spoil

This impact will negatively affect the marine environment. Acting with high intensity, the discarding of spoil will have long term effects resulting in this impact being rated as having high consequence and high significance even if the disposal site is restricted to 3 km².

4.1.2 Abstraction of cooling water and subsequent entrainment of organisms

The intake of cooling water and the resulting entrainment of marine organisms will have a negative impact on the environment which will act throughout the operational life time of the proposed power station, albeit with low intensity. The consequence of this impact is rated as low, with low significance (Table 2). No irreplaceable resources will be impacted upon. Due to the highly productive nature of this coastline the cumulative impacts are rated as low even in the context of their effects being additive to those of KNPS and the proposed Pebble Bed Modular Reactor development.

4.1.3 Release of warmed cooling water

Regardless of the release system chosen the impact of the release of warmed cooling water is expected to have low consequence and be of medium significance due to the small area which will be affected by elevated temperatures as well as the high resistance of this site to changes induced by the release of cooling water. Due to the proximity of the proposed development to KNPS (and the proposed Pebble Bed Modular Reactor) the cumulative impact of the release of cooling water is rated as medium.

4.1.4 Desalination

As desalination during the operational phase of the development will not have an impact on the marine environment only impacts associated with the construction phase will be considered. As the brine will be sufficiently diluted within 110 m from the point of release (Prestedge *et al.* 2008) any impacts will be extremely localised. The intensity of the impact is rated as low as few species are restricted to the surf zone. As a result this impact is considered to be of low consequence and medium significance.

4.1.5 Radiation emissions

The unintentional release of radio nuclides is considered improbable due to the design of the proposed nuclear plant. The threat of this impact will operate in the long term (i.e. throughout the operational phase of the development). Should the marine environment be contaminated, the extent of the impact would be local. As such the consequence and significance of this impact are ranked as low. Due to the very low risk associated with this development as well as with KNPS and the proposed Pebble Bed Modular reactor the cumulative impact is considered to be low.

4.1.6 Closure of the site to exploitation

This impact would have no effect on the marine environment at this site.

4.1.7 Release of sewage effluent

As the effluent to be released will meet the standards set out in the South African Water Quality Guidelines, no impact on the marine environment is expected.

4.1.8 Unintentional discharge of polluted groundwater

The discharge of organic bacterial and hydrocarbon contaminants into the marine environment will occur only as a result of accidental pollution of ground water. This will have negative effect over a small area and will be of short duration as dilution will rapidly occur. As such both the consequence and significance of this impact are considered to be low.

4.1.9 Impacts of the environment on the proposed development

As this impact focuses on how the marine environment may affect the development, the standard methodology for impact assessment is not appropriate. This threat will persist throughout part of the construction phase (i.e. during the intake of seawater for desalination) and throughout the operational phase. See section 3.1.7 for a full description.

4.2 Bantamsklip

Note: Where cumulative impacts for this site have been rated as high, it is due to these impacts acting on already severely depleted stocks of the abalone *Haliotis midae.*

4.2.1 Disruption of the marine environment during construction

<u>Disruption due to construction of the cooling water intake and outflow systems</u>

This impact will have a negative effect on benthic marine habitats, acting in the medium term, but will be restricted in extent to the local area. The intensity of the impact is rated as medium, due to effects on the abalone *H. midae.* Thus it is considered to be of medium consequence. Disruption to marine habitats will definitely occur during the construction phase and this impact is rated as having high significance (Table 3). Note: Although the overall rating of the impact remains the same regardless of the design chosen, the use of a tunnel-based intake will have less affect on the marine environment than the construction of an intake basin.

<u>Disruption due to discarding of spoil</u>
This impact will negatively affect the marine environment. Due to the high intensity of this impact and long term affects resulting from the discarding of spoil on the benthic habitat this impact is rated as having high consequence and high significance.

4.2.2 Abstraction of cooling water and subsequent entrainment of organisms

While this impact will be restricted in extent, it will affect the marine environment over the long term (i.e. the operational life of the proposed power station) and will be of medium intensity. This intensity rating relates to the intensity of the impacts on local abalone populations. As a result this impact is rated as having medium consequence and high significance.

4.2.3 Release of warmed cooling water

The release of heated cooling water is expected to affect the marine environment within a contained area, although over the long term. The intensity of the impact is rated as medium, due to affects on local abalone populations. As such this impact is considered to be of medium consequence and high significance.

4.2.4 Desalination

As desalination during the operational phase of the development will not have an impact on the marine environment only impacts associated with the construction phase will be considered. As the hypersaline effluent will be sufficiently diluted within 110 m from the point of release (Prestedge *et al.* 2008) any impacts will be extremely localised. Nonetheless the abalone *H. midae* may be affected within this area. Thus the intensity of the impact is rated as medium with medium consequence and high significance.

4.2.5 Radiation emissions

The unintentional release of radiation into the marine environment is considered very unlikely to occur. The negative impacts associated with this are rated as having low consequence and low significance.

4.2.6 Closure of the site to exploitation

At this site there is the potential for the removal of exploitation pressures on the marine environment due to a safety exclusion zone. This would positively impact the marine environment in the long-term, particularly with regards to the abalone *H. midae.* This impact is considered to have medium consequence and medium significance.

4.2.7 Release of sewage

No impact on the marine environment is expected as the effluent to be released will meet the standards set out in the South African Water Quality Guidelines.

4.2.8 Unintentional discharge of polluted groundwater

The release of polluted ground water into the marine environment is unlikely to occur. However, should this impact be realised both the consequence and significance would be low as the effect would be restricted in extent and duration.

4.2.9 Impacts of the environment on the proposed development

As this impact focuses on how the marine environment may affect the development, the standard methodology for impact assessment is not appropriate. This threat will persist throughout part of the construction phase (i.e. during the intake of seawater for desalination) and throughout the operational phase. See section 3.2.7 for a full description.

4.3 Thyspunt

Note: Due to the absence of other pressures on the marine environment at this site, the cumulative impact is rated as low for all identified impacts.

4.3.1 Disruption of the marine environment during construction

Disruption due to construction of the cooling water intake and outflow systems

This impact of disrupting the marine environment during tunnelling and laying of pipes for the cooling system will have a negative effect on benthic marine habitats due to physical damage and smothering or organisms. This impact will act in the medium term. This impact will be restricted in extent to the area in the immediate vicinity of the cooling water system infrastructure. The intensity of the impact is, however, rated as low. Thus, it is considered to be of low consequence. Disruption to marine habitats will definitely occur during the construction phase and this impact is rated as having medium significance (Table 4).

Disruption due to discarding of spoil

This impact will negatively affect the marine environment. Acting with high intensity, the discarding of spoil will have long term effects resulting in this impact being rated as having high consequence and high significance.

4.3.2 Abstraction of cooling water and subsequent entrainment of organisms

The intake of cooling water and the concurrent entrainment of organisms will occur with low intensity in the long term. The consequence of this impact is rated as low as is the significance. No irreplaceable resources will be affected and the reversibility of the impact is considered to be high.

4.3.3 Release of warmed cooling water

As warmed water will be released into the marine environment throughout the operational phase of the development, although at a local level and with low intensity, this impact is rated as having low consequence. No irreplaceable resources will be affected and the reversibility of the impact is rated as high. Thus the significance of the impact is considered as low.

4.3.4 Desalination

As desalination during the operational phase of the development will not have an impact on the marine environment only impacts associated with the construction phase will be considered. As the brine will be sufficiently diluted within 110 m from the point of release (Prestedge *et al.* 2008) any impacts will be extremely localised. The intensity of the impact is rated as low as few species are restricted to the surf zone and chokka squid will not be affected. As a result this impact is considered to be of low consequence and medium significance.

4.3.5 Radiation emissions

The negative nature of this impact is rated as having low consequence and low significance due the fact that it is improbable that it will occur.

4.3.6 Closure of the site to exploitation

As access to this site has been restricted for well over a decade, no additional benefit will be gained by closure of this site to exploitation, thus the nature of this potential impact is considered to be neutral.

4.3.7 Release of sewage effluent

Due to the fact that the effluent to be released will meet the standards set out in the South African Water Quality Guidelines no impact on the marine environment is expected.

4.3.8 Unintentional discharge of polluted groundwater

As at the other two sites pollution of the marine environment via seepage of polluted ground water is considered unlikely to occur. Any negative effects would be short lived and spatially limited, resulting in the consequence and significance of this impact being rated as low.

4.3.9 Impacts of the environment on the proposed development

As this impact focuses on how the marine environment may affect the development, the standard methodology for impact assessment is not appropriate. This threat will persist throughout part of the construction phase (i.e. during the intake of seawater for desalination) and throughout the operational phase. See section 3.3.7 for a full description.

4.4 The no-go Alternative

While the no-go alternative will reduce the negative impact on the marine environment at Dynefontein and Thyspunt (although only from a low level), at Bantamsklip it may result in the loss of the potential positive impact associated with the exclusion of abalone poaching at this site. It is important to note, however, that there is uncertainty about how effective the policing of the exclusion zone will be and thus how much of a positive impact would be derived at Bantamsklip.

4.5 Relevant legislation

The following South African legislation is relevant to the proposed development at all three of the alternate sites in the context of loss / modification of habitat:

- National Environmental Management Act, 1998 (Act No. 107 of 1998)
- The Environment Conservation Act, 1989 (Act No. 73 of 1989)
- The Sea-Shore Act, 1935
- The Development Facilitation Act, 1995
- White Paper for Sustainable Coastal Development in South Africa (2000)
- White Paper for Environmental Management Policy (1997)

Should spoil be discarded out to sea a water usage licence from the Department of Water Affairs and Forestry is likely to be required.

5 MITIGATION MEASURES

While a variety of potential impacts on the marine environment are associated with the proposed power station, most of these are inherently mitigated through the technical design of the plant. The discussion below applies to nuclear power plants of 4 000 MW output and to all three alternate sites, unless otherwise stated.

5.1 Mitigation objectives: what level of mitigation is being targeted?

5.1.1 Disruption of the marine environment during construction

The impacts associated with tunnelling for intake pipes and laying of outlet pipes will occur only within the construction phase. No mitigation measures are possible but due to the localised and short-lived nature of this impact this is considered acceptable.

In contrast the impacts resulting from the discarding of spoil are of high consequence and high significance and will act over the long-term. Nonetheless, the placement of disposal sites offshore (and the use of a medium pumping velocity at Thyspunt) will mitigate these impacts to a point of medium consequence although significance will remain high.

5.1.2 Abstraction of cooling water and the subsequent entrainment of organisms

The technical design of the intake system will result in water being drawn into the intake pipe at a rate of 1 $m.s^{-1}$. This very slow rate of intake means that large organisms, such as fish and marine mammals, will easily be able to swim against the flow and will avoid entrainment without difficulty. In addition, the use of screens will further help to prevent the intake of large organisms. Despite the above, eggs, sperm and larvae will be impossible to exclude, due to their small size. While this is of concern in the context of the abalone *Haliotis midae* at Bantamsklip, no measures can be applied to mitigate this impact without compromising the efficiency of the cooling system.

Due to the sound design of the intake system no further mitigation measures are possible to further reduce entrainment of marine organisms.

5.1.3 Release of warmed cooling water

At Duynefontein and Thyspunt current design of the release system does in itself significantly mitigate negative impacts associated with the release of warmed cooling water i.e. multiple points of release to aid dissipation of excess heat, release of cooling water above the sea bottom to minimise thermal pollution of the benthic environment and a very high flow rate at the point of release to maximise mixing with cool surrounding water. Due to the low consequence and medium significance of this impact at these sites, no further mitigation measures are recommended. However, due to the impacts on the abalone *H. midae*, it is recommended that at Bantamsklip an offshore tunnel outflow be used to prevent the thermal pollution of the nearshore benthic environment which would be associated with a nearshore channel outflow.

5.1.4 Desalination

The effect of the release of hypersaline effluent will be avoided during the operational phase of the development as desalinisation effluent will be co-released with cooling water and adequate mixing will occur prior to release from the outflow pipe. During the construction phase brine will be released independently but into the surf zone to ensure mixing with surrounding seawater. Sufficient dilution will be achieved within 110m from the point of release. Due to the effectiveness of this design in minimising impacts on the marine environment no additional mitigation measures are required.

During the normal operation of the plant, routine maintenance will require that the cooling system be shutdown and brine will continue to be released. As this will occur for limited periods only the impact is considered negligible and no mitigation measures are deemed necessary.

5.1.5 Radiation emissions

At a design level the risk of radiological releases into the marine environment has been minimised through the incorporation a ‘double cooling system’ whereby at no stage is there direct contact between the reactor and the coolant or between the coolant and the sea water. Besides these measures imposed by the technical design of proposed development no further mitigation measures are necessary.

5.1.6 Closure of site to exploitation

This impact has the potential to have a positive effect on the marine environment. In particular a safety exclusion zone at Bantamsklip may be of great benefit, as it could offer much needed protection to the abalone *H. midae.* However, the level of organisation and the brazenness of poachers in this area will necessitate dedicated active policing of this exclusion zone if this benefit is to be realised. It should be noted that this positive impact will not compensate for the negative impacts on the abalone. No additional benefit will be gained at the Dynefontein and Thyspunt sites. Should no development occur and the sites were reopened to exploitation and development, no significant negative impact is anticipated for any of the sites.

5.1.7 Release of sewage water

As the effluent to be released will meet the standards set out in the South African Water Quality Guidelines no further mitigation measures are necessary.

5.1.8 Unintentional release of polluted groundwater

In order to reduce environmental risks it is recommended that mitigation measures ascribed in the hydrogeological specialist study to minimise organic, bacterial and hydrocarbon pollution of groundwater (and subsequently the marine environment) should be applied. No further mitigation measures are necessary.

5.1.9 Impacts of the environment on the proposed development

The potential impacts of marine biota on the proposed plant stem from the blockage of water intakes by jellyfish and the biofouling of cooling pipes. Due to the tolerances of these organisms, physical removal from the water column surrounding the intake pipe offers a first line of defence. This would, however, be labour intensive and may not be viable at times of extreme jellyfish densities. Chemical shock treatment may offer a more practical option for decreasing the impacts of jellyfish. However, laboratory testing would be required to isolate the appropriate chemical that would have the desired effect on the jellyfish, while having as small an effect as possible on the surrounding environment. The use of exclusion screens and diversion of trapped debris offer an effective method of clearing debris from intake water, while low-level chlorination regimes can effectively control fouling of pipes. Such mechanisms are well established at KNPS and can be utilised at any new plant.

Table 2. Assessment of impacts on the marine environment at the Duynefontein site.

	Cumulative impacts	**Nature**	**Extent**	**Intensity**	**Duration**	**Consequence**	**Probability**	**Reversibility**	**Impact on irreplaceable resources**	**Confidence level**	**Significance**
Disruption during construction Due to construction of the cooling water intake and outflow systems	Low	Negative	Local	Low	Medium	Low	Definite	High	No	High	Medium
Disruption during construction Due to discarding of spoil	Low	Negative	Local	High	Long	High	Definite	Medium	No	High	High
Disruption during construction Due to discarding of spoil offshore	Low	Negative	Local	Medium	Long	Medium	Definite	Medium	No	High	High
Abstraction of cooling water & entrainment of organisms	Low	Negative	Local	Low	Long	Low	Definite	High	No	High	Medium
Release of warmed cooling water	Med	Negative	Local	Low	Long	Low	Definite	High	No	Medium	Medium
Desalination during the construction phase	Low	Negative	Local	Low	Medium	Low	Definite	High	No	High	Medium
Radiation emissions	Low	Negative	Local	Low	Long	Low	Improbable	High	No	High	Low

	Cumulative impacts	Nature	Extent	Intensity	Duration	Consequence	Probability	Reversibility	Impact on irreplaceable resources	Confidence level	Significance
Unintentional discharge of polluted groundwater	Low	Negative	Local	Low	Medium	Low	Improbable	High	No	High	Low

Table 3. Assessment of impacts on the marine environment at the Bantamsklip site.

	Cumulative impacts	Nature	Extent	Intensity	Duration	Consequence	Probability	Reversibility	Impact on irreplaceable resources	Confidence level	Significance
Disruption during construction Due to tunnelling for intake pipe and laying of outlet pipes	High	Negative	Local	Medium	Medium	Medium	Definite	Medium	No	High	High
Disruption during construction Due to discarding of spoil	High	Negative	Local	High	Long	High	Definite	Medium	No	High	High
Disruption during construction Due to discarding of spoil offshore	Low	Negative	Local	Medium	Long	Medium	Definite	Medium	No	High	High
Abstraction of cooling water & entrainment of organisms	High	Negative	Local	Medium	Long	Medium	Definite	Medium	No	High	High
Release of warmed cooling water	High	Negative	Local	Medium	Long	Medium	Definite	Medium	No	Medium	High
Release of warmed cooling water with mitigation	Med	Negative	Local	Low	Long	Low	Definite	High	No	Medium	Medium

	Cumulative impacts	Nature	Extent	Intensity	Duration	Consequence	Probability	Reversibility	Impact on irreplaceable resources	Confidence level	Significance
Desalination during the construction phase	Low	Negative	Local	Medium	Medium	Medium	Definite	High	No	High	High
Radiation emissions	Low	Negative	Local	Low	Long	Low	Improbable	High	No	High	Low
Closure to exploitation	Not relevant	Positive	Local	Medium	Long	Medium	Possible	Not relevant	No	High	Medium
Unintentional discharge of polluted groundwater	Low	Negative	Local	Low	Medium	Low	Improbable	High	No	High	Low

Table 4. Assessment of impacts on the marine environment at the Thyspunt site.

	Cumulative impacts	Nature	Extent	Intensity	Duration	Consequence	Probability	Reversibility	Impact on irreplaceable resources	Confidence level	Significance
Disruption during construction Due to tunnelling for intake pipe and laying of outlet pipes	Low	Negative	Local	Low	Medium	Low	Definite	High	No	High	Medium
Disruption during construction Due to discarding of spoil	Low	Negative	Local	High	Long	High	Definite	High	No	High	High
Disruption during construction Due to discarding of spoil offshore at a medium velocity	Low	Negative	Local	Medium	Long	Medium	Definite	Medium	No	High	High

	Cumulative impacts	**Nature**	**Extent**	**Intensity**	**Duration**	**Consequence**	**Probability**	**Reversibility**	**Impact on irreplaceable resources**	**Confidence level**	**Significance**
Abstraction of cooling water & entrainment of organisms	Low	Negative	Local	Low	Long	Low	Definite	High	No	High	Medium
Release of warmed cooling water	Low	Negative	Local	Low	Long	Low	Definite	High	No	Medium	Medium
Desalination during the construction phase	Low	Negative	Local	Low	Medium	Low	Definite	High	No	High	Medium
Radiation emissions	Low	Negative	Local	Low	Long	Low	Definite	High	No	High	Low
Unintentional discharge of polluted groundwater	Low	Negative	Local	Low	Medium	Low	Improbable	High	No	High	Low

5.2 Recommended mitigation measures

5.2.1 Effectiveness of mitigation measures

In the context of this study no performance criteria are applicable.

5.2.2 Recommended monitoring and evaluation programmes

Monitoring of thermal pollution

At each site both the benthic and intertidal habitats should be sampled before construction, after construction, but before the onset of the operational phase, annually during operation and then for a minimum of five years after closure of the power station. Both benthic and intertidal sites predicted to be impacted (i.e. based on oceanographic modelling of the release plume) should be paired with comparable control sites. If suitable sites exist both sheltered and exposed rocky shores should be considered. At Bantamsklip special note should be taken of the abalone *H. midae* and dedicated surveys should be conducted to assess the densities of this gastropod. At Thyspunt surveys should be conducted to monitor for the presence of egg capsules of the Chokka squid *Loligo vulgaris.* Note: the use of indicator species is not recommended as the densities of marine invertebrates often varies dramatically through time, while changes in overall community composition are far more relevant. While sampling need not be repeated in different seasons it is important that annual monitoring take place at the same time each year.

Monitoring of spoil disposal sites

Prior to disposal of spoil at sea, benthic communities at the disposal site, and in the areas predicted to be affected by spoil in the first ten years following disposal (Prestedge *et al.* 2009a) should be sampled for at least two years. Following disposal of spoil, these sites should be sampled at the same time of the year as the initial samples for at least ten years. Importantly, communities establishing on the actual spoil site should be monitored to establish to what extent these communities recover through time.

Monitoring of radiation emissions

An environmental surveillance programme should be implemented to monitor for radiation emissions in the marine environment. This would form part of the strict requirement of the National Nuclear Regulator Act. The design of such a programme is outside our area of expertise, but is likely to follow the Eskom Radiation Protection Environmental Surveillance Standard. Organisms which we recommend for inclusion in such a monitoring programme are the abalone *H. midae* at Bantamsklip and the chokka squid *Loligo vulgaris* at Thyspunt, as both are consumed commercially.

Monitoring of sewage effluent

A routine monitoring programme of water exiting the cooling water outlets should be established to ensure that sewage effluent entering the sea meets the standards set by the Department of Water Affairs and Forestry.

Monitoring of organic, bacterial and hydrocarbon pollution resulting from polluted groundwater

Should pollution of groundwater be detected, monitoring of seawater quality in the area of groundwater discharge should commence immediately to ensure the safety of public health.

Monitoring of African penguin (*Spheniscus demersus*) populations on Dyer Island

A long-term monitoring programme should be established to track populations of African penguins on Dyer Island near the Bantamsklip (Prof L. Underhill, University of Cape Town, Pers Comm.). Monitoring should take place before, during and after construction. Such monitoring should take place inconjunction with the penguin monitoring programme which is currently underway on the island and is run by the Avian Demography Unit at the University of Cape Town.

6 CONCLUSIONS AND RECOMMENDATIONS

The development of a nuclear power station at Duynefontein, Bantamsklip or Thyspunt will have a variety of potential impacts on the marine environment. These include disruption of surrounding habitats during the construction phase, the entrainment of organisms during the intake of cooling water, the release of warmed cooling water, the release of desalination effluent, the unintentional release of radiation and organic, bacterial or hydrocarbon pollution due to seepage of polluted ground water and the protection of organisms from exploitation due to a safety exclusion zone. Experience at KNPS has shown that many of these impacts can in fact have minimal effect on marine habitats and although the proposed plant will be larger than the Koeberg plant (4 000 MW in comparison with 1 800 MW), the findings at KNPS offer a sound base from which to assess potential impacts.

In summary the effects of disruption to the marine environment during construction are associated with two processes. Firstly, the construction the cooling water intake and outflow system. This impact will be localised and of short duration. Secondly, disturbance will be associated with the potential discarding of spoil from excavation of the take tunnel, intake basin, nuclear island and turbine hall. This impact will have a highly significant and negative affect on the marine environment which will act in the long term. In an effort to minimise this impact, it is recommended that spoil only be discarded offshore and that at Thyspunt only a medium pumping rate be used. This would limit ecological impacts particularly on abalone at Bantamsklip and chokka squid at Thyspunt.

At Duynefontein and Thyspunt the entrainment of organisms along with cooling water is not anticipated to have significant ecological effects, as plankton populations are able to rapidly regenerate and the low intake rate of water, along with the use of screens, will help prevent the intake of larger marine organisms, such as fish and marine mammals. However, at Bantamsklip such entrainment could have significant effects on the early stages of the abalone *H. midae*.

Comprehensive oceanographic modelling has demonstrated that the effects of elevated temperature are expected to be focused on the open water habitat if a tunnelled release system is used. This is of particular relevance at Bantamsklip and to a lesser degree at Thyspunt, as it would help to mitigate impacts on abalone and chokka squid egg capsules respectively. However, at Bantamsklip it is strongly recommended that the cooling water release pipes be placed offshore to further mitigate this impact. Importantly, a channel release system at this site is deemed to pose an unacceptable risk to abalone populations.

During the construction phase small volumes of hypersaline effluent will be released directly into the surf zone. Physical mixing in this high energy environment will result in sufficient dilution of the brine so as to ensure minimal impacts on the marine environment. During the operational phase the hypersaline effluent will be co-released with cooling water. As brine will be diluted to undetectable levels prior to release no impact on the marine environment is predicted during this phase of the development.

The most likely source of radiological releases into the marine environment is through the unintentional release of contaminated cooling water. This risk has been minimised through the technical design of the cooling system. This approach has proved adequate at KNPS, where no radionuclide release has been detected.

The site that would benefit from an exclusion zone would be Bantamsklip, as this could benefit abalone populations if supported by adequate enforcement.

Sewage from the proposed development will be treated and then released via the cooling water outlet pipe. At the point of release this effluent will meet the standards set by the Department of Water Affairs and Forestry. Thus no impact on the marine environment is expected.

Accidental pollution of groundwater by organic, bacterial or hydrocarbon compounds may result in pollution of the marine environment as ground water releases into the ocean. Should this occur the impact would be minimal as only a small area would be affected and contaminants would rapidly be diluted and dispersed by water movement.

Besides the impacts of the proposed development on marine habitats, the marine environment may also impact the development. This would take the form of blockage of water intakes by jellyfish and floating kelp and the fouling of cooling pipes. This impact is anticipated to be most significant at Duynefontein, due to its location along the west coast, where jellyfish blooms appear to be increasing in frequency.

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8 APPENDICES

Appendix 1: Density (per 0.027m³) of species recorded in the high-, mid- and low-shore on sandy shores at the three sites.

Duynefontein

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Bullia digitalis		0	0	0	0	0	0	0	0	0	0	1	0	0	2	0
Donax serra		0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Eurydice longicornis		8	5	4	3	2	0	0	0	1	0	2	0	0	0	0
Gastrosaccus psammodytes		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pontageloides laticeps		0	1	0	0	0	8	11	5	1	2	0	1	0	0	0
Scololepis squamata		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Talorchestia quadrispinosa	SA endemic	17	0	5	13	9	0	0	0	0	0	0	0	0	0	0

Bantamsklip

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Bullia digitalis		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Clasybranchus spp.		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Eurydice longicosta		0	4	3	1	1	6	0	0	0	0	1	1	3	0	0
Gastrosaccus psammodytes		0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
Pontageloides laticeps		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Scololepis squamata		3	0	0	0	0	2	47	15	64	49	0	32	4	30	51
Urothoe grimaldii		0	0	0	0	0	0	0	0	0	0	0	0	2	1	0

Thuyspunt

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Bullia digitalis		1	0	2	0	2	4	4	3	7	2	1	4	3	0	0
Donax serra		0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Euridice longicornis		0	0	0	0	0	4	6	0	0	0	0	0	0	0	0
Pontageloides laticeps		1	1	0	0	0	0	0	0	1	0	4	0	1	0	0

Appendix 2: Biomass (kg.m^{-2}) of species recorded in the high-, mid- and low-shore on rocky shores at the three sites.

Duynefontein

Exposed Site

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Balanus glandula	Alien	3.45	5.75	1.15	0.00	1.15	1.61	2.30	8.05	11.50	12.65	0.00	0.00	0.00	0.00	0.00
Aulactinia reynaundi		0.00	0.00	0.00	0.00	0.00	3.20	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00
Burnupena lagenaria	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
Helcion pectunculus		0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mytilus galloprovincialis	Alien	0.00	0.19	0.00	0.00	0.00	4.89	3.52	8.81	5.87	6.85	0.00	0.00	0.00	0.00	0.00
Afrolittorina africana		10.64	16.80	1.68	0.56	5.04	0.00	0.63	7.28	5.60	8.40	0.00	0.00	0.00	0.00	0.00
Nucella dubia		0.00	0.96	0.00	0.00	0.08	0.16	0.08	0.08	1.04	1.04	0.00	0.00	0.00	0.00	0.00
Porphyra		0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ralfsia verrucosa		0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scutellastra granularis		0.00	0.20	0.39	0.00	0.00	0.46	0.72	0.20	0.07	0.26	0.00	0.00	0.00	0.00	0.00
Ulva		0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sheltered Site

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Actinia equina		0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aeodes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.19	1.24	3.71	0.00	0.00	4.95	0.00
Balanus glandula	Alien	1.15	1.15	3.45	0.23	0.23	4.60	2.30	5.75	0.00	8.05	0.23	0.00	0.00	0.00	0.00
Aulactinia reynaundi		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.80	0.00	0.00	1.20	0.00	1.20
Burnupena lagenaria		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.75	0.50
Caulacanthus ustulatus		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00
Cymbula granatina		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.28
Gigartina polycarpa		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.92	2.92	4.38	2.92	0.00	36.53	0.00
Sarcothalia stiriata		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helcion pectunculus		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Mytilus galloprovincialis	Alien	0.19	0.19	0.00	0.00	0.00	9.79	16.64	3.92	0.98	3.92	20.10	23.87	2.51	22.61	22.61
Oxystele tigrina	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Patiriella exigua		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.16	0.08
Porphyra		38.25	25.50	8.50	0.00	0.00	4.25	0.00	0.85	4.25	2.55	0.00	0.00	0.00	0.00	0.00
Scutellastra granularis		0.07	0.20	0.00	0.00	0.00	0.39	0.00	1.82	0.65	0.07	0.52	0.00	0.00	0.00	1.63
Ulva		0.00	0.00	0.00	0.00	0.00	6.09	0.00	21.31	0.00	0.00	0.61	0.00	0.61	1.83	0.61

Bantamsklip

Exposed Site

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Aeodes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acanthochitona garnoti		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Bifurcaria brassicaeformis	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.94	27.13	29.06	7.75	31.00
Burnupena cincta		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00
Burnupena lagenaria	SA endemic	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.06	0.00	0.00	0.06	0.13
Caulacanthus ustulatus		0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ceramium diaphanum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Codium lucassi		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	0.00	0.00	0.00
Cymbula granatina		0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Cymbula oculus		0.00	0.00	0.00	0.00	0.00	0.07	0.09	0.00	0.00	0.00	0.09	0.00	0.05	0.00	0.09
Encrst. Spongites yendoi		0.00	0.00	0.00	0.00	0.00	0.16	0.32	0.00	0.16	0.00	3.20	3.20	2.40	1.60	1.60
Gibbula multicolor	SA endemic	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.05	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Gunnarea capensis		0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	1.43	3.57	3.57	0.71	4.99
Helcion dunkeri		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.02	0.00	0.00	0.05	0.00
Helcion pectunculus		0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.59	0.08	0.21	0.00	0.00	0.00	0.05	0.00
Hildenbrandia lecannellierii	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00
Leathesia difformis		0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00
Afrolittorina africana		0.05	0.15	1.12	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nucella dubia		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Octomeris angulosa	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00
Oxystele sinensis	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Oxystele variegata		0.02	0.00	0.00	0.00	0.00	0.33	0.41	0.13	0.00	0.26	0.00	0.00	0.00	0.00	0.00
Plocamium cornutum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53	0.00
Porphyra		0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	2.55	0.00	0.00	0.00	0.00	0.00
Ralfsia verrucosa		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Scutellastra longicosta	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.07	0.17	0.20	0.07
Scutellastra cochlear		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
Scutellastra granularis		0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.54	0.03	0.00	0.00	0.00	0.00	0.00
Siphonaria serrata	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Tetraclita serrata		0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.00	720.00	270.00	0.00	0.00	0.00	0.00	0.00
Tricolia capensis		0.07	0.00	0.00	12.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Turbo sarmaticus	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Thuyspunt

Exposed Site

Species	Status	High 1	High 2	High 3	High 4	High 5	Mid 1	Mid 2	Mid 3	Mid 4	Mid 5	Low 1	Low 2	Low 3	Low 4	Low 5
Gymnogongrus polyclada	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.28	25.10	2.09	18.83	18.83
Caulacanthus ustulatus		0.00	0.00	0.00	0.00	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ceramium pumosa		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.30	13.50	0.00
Centroceras clavulatum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.44	4.86	2.43	0.00	14.58
Chthamalus dentatus		0.00	0.00	0.00	0.00	0.00	17.10	12.60	8.10	5.40	5.40	0.00	0.00	0.00	0.00	0.00
Coralline spp		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.53	1.50	0.08	0.00
Encrst. Spongites yendoi		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	1.60	0.00
Epymenia capensis		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00
Helcion pruinosus		0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Hildenbrandia	SA endemic	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hypnea spicifera		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00
Mytilus galloprovincialis	Alien	0.00	0.00	0.00	0.00	0.00	0.59	0.20	0.98	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Afrolittorina knysnaensis		1.40	2.38	1.71	0.98	2.10	0.00	5.88	1.96	2.52	3.36	0.00	0.00	0.00	0.00	0.00
Nothogenia erinacea		0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxystele variegata		0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Pterosiphonia cloiophylla		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00
Porphyra		42.50	0.85	0.85	0.85	0.00	0.00	0.00	6.80	3.40	0.00	0.00	0.00	0.00	0.00	0.00
Siphonaria serrata	SA endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Scutellastra granularis		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Ulva		0.00	0.00	0.00	0.00	0.00	0.61	0.61	0.00	0.00	0.00	0.61	0.61	0.00	0.61	0.00

Appendix 3: Letter from Professor GM Branch referring to the sampling methodology applied to the benthic environment.

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To whom it may concern:

It is my professional opinion that with respect to the Nuclear 1 EIA, sampling of subtidal marine benthic communities was not is not a necessary part of the procedure. There are four reasons for my conclusion.

First, there has been very limited sampling of the subtidal benthos in the regions involved. As a result it would be difficult to know how representative the ecosystems at each of the proposed Nuclear 1 sites might be, or to identify unique or vulnerable ecosystem features that need preservation.

Second, sufficient information already exists in the report that has been submitted to evaluation the relative importance of the sites with respect to individual commercially important benthic resources such as abalone.

Thirdly, effluent from nuclear power stations releases warmed water that will concentrated near the surface, so I would not expect any major impact on the subtidal benthos. This contrasts with the intertidal benthos, which will be prone to the effects of effluents and a useful indicator of any impacts, and was thoroughly surveyed and reported on as part of the EIA.

Fourthly, on a purely logistic note, it is an arduous process to sample the subtidal benthic communities in a manner that is sufficiently quantitative to compare statistically among sites or to be used to monitor potential impacts. Working under water is taxing. It would take several years to complete sufficient replicate samples that are adequately stratified by depth to obtain a statistically valid number of samples - and to span any seasonality that exists in the benthos. For this to be useful in the future one a nuclear station is established, the surveys would have to be repeated on a sufficiently regular basis to monitor any changes. All of this could be done, but it is not a trivial exercise. If I felt that this information was necessary for the EIA and subsequent monitoring, I would not hesitate to recommend that it be done, irrespective of the time and cost involved; but I do not. There are better ways of assessing the rival merits of the sites and of monitoring any impacts.

Finally, I would note that it was I who undertook the review of the report submitted on the marine component of the EIA, and I indicated that I was satisfied by the coverage and scope of that report.

George M Branch
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Marine Biology Research Centre & Zoology Department
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Appendix 4: Diversity and status of sandy shore species recorded at the three sites.

	Duynefontein	Bantamsklip	Thuyspunt
Total spp number	7	8	4
Number of west coast endemics	0	na	na
Number of south coast endemics	na	0	0
Number of SA endemics	1	0	0
Number of alien spp	0	0	0
Number of spp restricted to < 100 km	0	0	0

Appendix 5: Diversity and status of rocky shore species recorded at the three sites.

	Duynefontein		Bantamsklip	Thuyspunt
	Exposed Site	Sheltered Site	Exposed Site	Exposed Site
Total spp number	11	16	32	20
Number of west coast endemics	0	0	na	na
Number of south coast endemics	na	na	0	0
Number of SA endemics	1	1	9	3
Number of alien spp	2	2	0	1
Number of spp restricted to < 100 km	0	0	0	0

Company name	
Specialist signature	
Date	