## 15.3 Marine Ecology

### 15.3.1 General Description

The Koeberg site falls within the relatively uniform Namaqua marine biogeographic region, which extends from Cape Agulhas to Luderitz. It is dominated by the cold Benguela current system and is noted for its high biological productivity but low species richness. There are no marine sites of special conservation value within the immediate vicinity of the plant and no particularly rare or endangered species occur on the site (***Reference 2***).

Scientific research has been conducted over a period of 24 years to assess the marine environmental impacts associated with the Koeberg 900 PWR Units 1 and 2. Preliminary studies were conducted in the late 1970's. Further studies have focussed on three distinct time phases: preoperational (1981 to 1984), transitional (1985) and operational (1987 to 2005) (***Reference 2***).

### 15.3.2 Impacts of the Koeberg 900 PWR Units 1 and 2 on the Marine Environment

#### 15.3.2.1 Intertidal Beach Macrofauna

Before the construction of the Koeberg 900 MW PWR units 1 and 2, B Currie and PA Cook of the University of Cape Town (***Reference 3***) described the gross ecological characteristics of the intertidal and shallow sub-tidal marine environment in the vicinity of Duynefontein, with specific reference to the distribution of fauna according to the character of the coastline.

Further experimental work by PA Cook on the possible effects of the thermal plume from Duynefontein, with particular reference to rock lobster, was undertaken on behalf of Eskom and a report published in 1978 (***Reference 4***).

During the construction phase of the Koeberg 900 MW PWR units 1 and 2, PA Cook continued to do further research in order to establish a more detailed base line and also to determine seasonal variations in population characteristics. He also studied possible differences in susceptibilities to temperature fluctuations during various stages in the life cycles of the dominant species.

The Baseline Ecological Report compiled by PA Cook in 1984 (***Reference 5***) contains a vast quantity of environmental and ecological data as well as some preliminary findings, which can be listed as follows:

- A decrease in specie diversity (i.e. likely reflection of natural variation in species abundance and is unlikely to indicate any positive or negative effect by Koeberg 900 MW PWR units 1 and 2);
- The white mussel, *Donax serra*, was identified as an indicator specie;

- It was suggested that the thermal pollution from the Koeberg 900 MW PWR units 1 and 2 might result in a disruption of the breeding cycle of *Donax serra*;
- The effects of entrainment on the suspended planktonic organisms, where the water is both heated and chlorinated as it passes through the Koeberg 900 MW PWR units 1 and 2, was not too serious as long as no 'shock' chlorinating took place;
- At that stage there was no evidence of colonisation of opportunistic 'warm water' species; and
- Generally metal concentrations of the metals cadmium, copper, lead, zinc, chromium, iron, manganese and nickel in both black and white mussels collected close to the Koeberg site had remained fairly constant.

Throughout the period 1981 to 1988, monthly beach samples were taken at Ou Skip (OS) and Out Fall (OF), and standardised intertidal transects were conducted at Ou Skip in July on an annual basis.Sampling was down sized from 1989 to include bi-annual (twice a year) transects at the Ou Skip Site, in January and July (***Reference 2 and Figure F-15.1***).

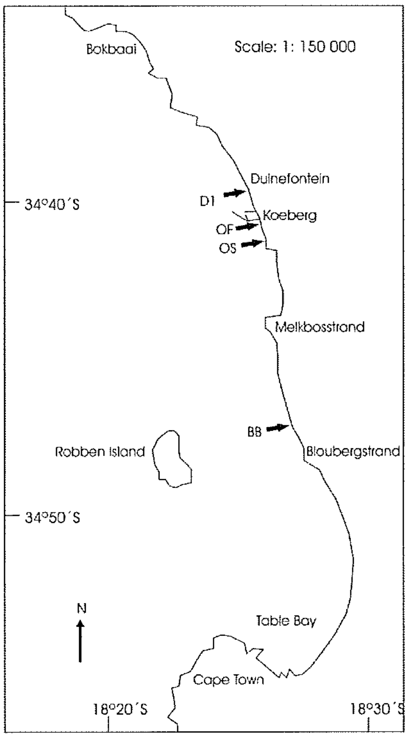



**Figure F-15.1**
**Sample Sites Ou Skip and Out Fall**

Intertidal sandy-shore habitats are known to demonstrate considerable inter-annual variation in species composition and density, and are to be expected to be apparent in bi-annual surveys. An analysis of the data obtained demonstrates the following (***Reference 2***):

**(i) Species Richness and Diversity Patterns**

There has been dramatic variation in the total number of species recorded in the beach surveys undertaken since 1990. The maximum numbers of species recorded in each year (i.e. the larger of winter and summer surveys) are listed in ***Table T-15.1*** and ***Figure F-15.2***.

**Table T-15.1**
**Numbers of Species Recorded in the Transect Survey per Year: 1990 to 2004**

| Year | Number of Species Found | Year | Number of Species Found |
|---|---|---|---|
| 1990 | 20 | 1997 | 15 |
| 1991 | 13 | 1998 | 19 |
| 1992 | 15 | 2000 | 19 |
| 1993 | 14 | 2001 | 28 |
| 1994 | 13 | 2002 | 26 |
| 1995 | 13 | 2003 | 23 |
| 1996 | 14 | 2004 | 10 |

The minimum number of species recorded in any survey was 9 in July 1995 and the maximum 28 in August 2001. There are many reasons for the variation, which could include weather condition, the height of low tide and the quality of the samples collected. However, there is no directional trend in the data to indicate a progressive decline or increase in species richness (***Reference 2***).

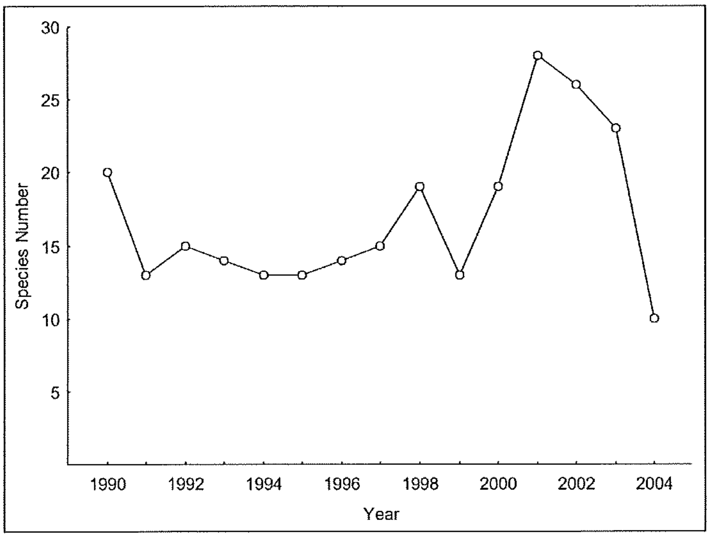



**Figure F-15.2**
**Graph Illustrating Numbers of Species Recorded in the Transect Survey per Year: 1990 to 2004**

Monthly data were also used by Cook to calculate diversity indices for each site. Both the Shannon-Weiner (indicated in a dashed line below) and Simpson (indicated in the solid line in below) diversity indices showed a gradual increase from the pre-operational period to 1988, by which time the Koeberg 900 MW PWR units 1 and 2 were operational (***Figure F-15.3***). The indices then decreased again between 1988 and 2004. The fluctuations are a likely reflection of natural variation in species abundance and are unlikely to indicate a positive or negative effect on beach the community (***Reference 2***).

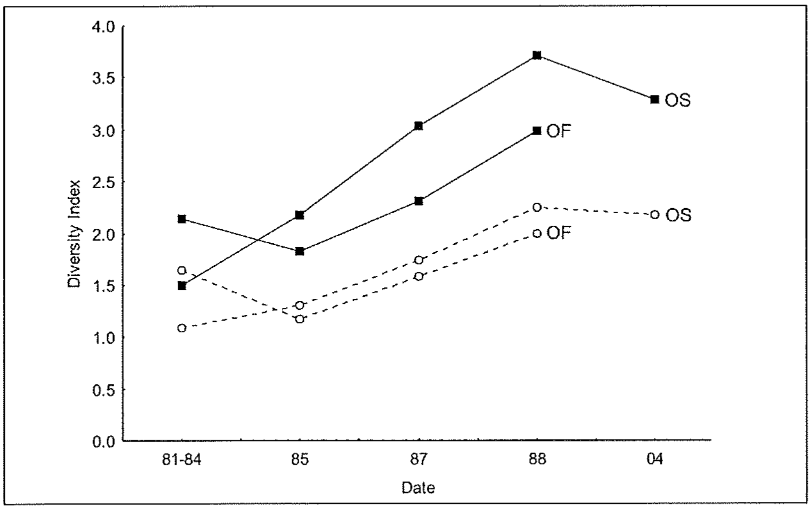


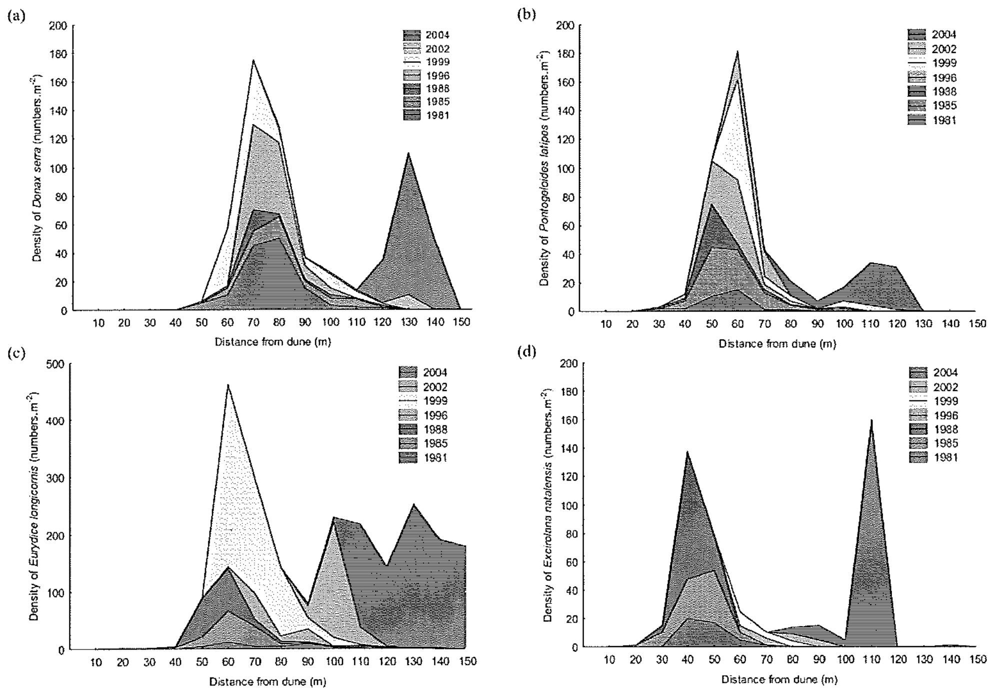

**Figure F-15.3**
**Shannon-Weiner and Simpson Diversity Indices**

### (ii) Presence or Absence of Individual Species

A small number of common beach dwelling species are consistently recorded at the transect site in every year. Many others are found in single surveys, or appear and disappear erratically from the sample site. No species recorded early in the sample species has disappeared from later samples, nor has any newly recorded species become abundant (**Reference 2**). Koeberg 900 MW PWR units 1 and 2 has therefore not had an impact on species diversity.

### (iii) Spatial Distribution of Species

The actual location of species along the transect is highly variable, as demonstrated by the annual, and later biannual transects at OS (**Figure F-15.2**). Interestingly, there has been a downward shift in the distribution of the white sand mussel *Donax serra* and the isopods *Eurydice longicornis, Pontogeloides latipes* and *Excirolana natalensis.* As the four most common intertidal species, these organisms are likely to reflect the general pattern of distribution of the sandy macrofaunal community as a whole. The observed shifts in distribution are illustrated in **Figure F-15.4** (**Reference 2**).




## Figure F-15.4

## Intertidal Distribution of Four Common Species (a) Donax Serra, (b) Pontogeloides Latipes, (c) Eurydice Longicornis and (d) Excirolana Natalensis

Variations shown in **Figure F-15.4** are reflections of natural inter-annual changes in beach slope that are common and may be cyclical over the long term, or related to seasonality and weather conditions. No changes in the growth rate of 1.14 mm per month have been recorded in *Donnax serra* (as an indicator species) in the transitional or operational phases. The reproductive cycle of *Donnax serra* demonstrated variability, even in the preoperational phase, with a peak spawning occurring from late winter to spring.

Despite unusual occurrences in the reproductive cycle of *Donnax serra,* observed during the first few years of operation of the Koeberg 900 MW PWR units 1 and 2 (attributed to unusually high variation in outfall temperature as a result of intermittent operation and testing), the overall population of white mussels appears unaffected, with the highest density of species being recorded at Ou Skip in 1996, 1999 and 2004 (***Reference 2***).

Since 1981, all samples examined for species that may indicate colonisation by opportunistic water organisms have indicated an isolated individual of the angular surf clam *Scissodesma spengleri*, which is normally found from False Bay to East London (***Reference 2***).

#### 15.3.2.2 Deep Water Macrofauna

In support of the studies carried out by PA Cook, Eskom undertook to study the extent and volume of the 'warm water plume' and the results are described in the 'Warm Water Plume Report' by Rattey and Potgieter (***Reference 7***). This report describes the dissipation, path and extent of the warm plume. Salient features that were deduced from the interpretation of the plume studies are:

- The dispersion of the plume is governed by the volume of warm water discharged into the sea (subject to the Koeberg 900 MW PWR units 1 and 2 status), the vertical mixing process of breaking waves, horizontal eddy diffusion and by the advection of ambient currents;
- Plume trajectory is in correspondence with the prevailing ambient currents, which are primarily wind induced;
- The downward penetration of the warm water plume is limited by its buoyancy, especially outside the surf zone where bottom measurements showed ambient temperatures;
- The main impact area of the warm discharge appears to be along the beach to the south side of the Koeberg 900 MW PWR units 1and 2, between the Outfall and the Ou Skip rocks;

- The relatively small extent of the plume is unlikely to have a dramatic effect on the local marine environment. The effected area is unlikely to extend more than a kilometre or so from the outfall channel, even in the worst conditions. It is important to note that downward penetration of the plume is limited by the buoyancy of the warmer water, such that (outside the surf zone) no elevation of temperature is evident on the sea floor; and
- No temperature increase in excess of two degrees above ambient was observed further than 1 km from the outfall.

A further study was conducted by Rattey and Potgieter to investigate the dynamic variances of the ocean physics (***Reference 8***). The study describes the degradation and propagation of beaches, which could physically affect the monitoring program undertaken by PA Cook, as well as to qualify the actual temperature increase at Ou Skip (the reference site for marine ecological impact studies) resulting from the warm plume created by the Koeberg 900 MW PWR units 1 and 2.

The dynamic beach processes and changes and temperature influences can be described as:

- The interrelationships of the sandy shore process. The extent and configuration being dependant upon wave height and period, currents, the range of tides, the degree of exposure to winds and sediment source;
- Although there are seasonal variations of the seabed slope, as confirmed by previous studies, the most significant changes occur at localised positions on the beach due to cell circulation systems in the near shore zone.;
- The wave induced cell circulation is most apparent with rip currents, which are strong narrow currents that flow seawards from the surf zone;
- The cell circulation system is dependent on complex wave incident and set-up conditions and can occur at any time of the year;
- The erosion/accretion cycle is of a short duration but is responsible for large amounts of sand being moved;
- It can be assumed that the beaches are in a constant state of dynamic equilibrium indicating little net loss or gain in the sediment budget;
- Cognizance must be taken of the fact that perturbations in faunal density and population could be affected by beach processes;

- The measurable influence of the warm pollution from the Koeberg 900 MW PWR units 1 and 2 on the sea temperature at Ou Skip rocks equals 0,62 °C. If the long term non-operational differential is applied to the seasonal regimes, the positive temperature influence is 0,66 °C during summer and 0,56 °C during winter; and
- The Koeberg 900 MW PWR units 1 and 2's influence is well within the standard deviation of the natural temperature variation over a long period.

### 15.3.3 Radioactivity Levels

In 2003 radioactivity levels were measured in abalone, black mussel, crayfish, fish, white sand mussel, marine sediment and sea water. The locations at which samples were collected and the radionuclides detected are given in ***Table T-15.2*** (***Reference 2***).

**Table T-15.2**
**Non-naturally Occurring Radionuclides (Bq/kg) Recorded in Biological, Sediment and Water Samples Collected In 2003**

| | Ag-110m | Co-58 | Co-60 | Cs-137 |
|---|---|---|---|---|
| **Abalone** *(Haliotis midae)* | | | | |
| Melkbosstrand | 0,22 to 0,31 | 0 | 0 | 0 |
| Springfontein | 0,15 | 0 | 0 | 0 |
| **Black mussel** *(Choromytilus meridionalis)* | | | | |
| Melkbosstrand | 0,14 | 0,32 | 0,12 | present |
| Springfontein | 0 | 0 | 0 | 0 |
| Intake Basin | 0,13 to 0,32 | 0 | 0,08 | 0 |
| Yzerfontein | 0 | 0 | 0 | 0 |
| **Crayfish** *(Jasus lalandii)* | | | | |
| Melkbosstrand | 0 | 0 | 0 | 0 |
| Springfontein | 0 | 0 | 0 | 0 |
| Dassen Island | 0 | 0 | 0 | 0 |
| **Fish** | | | | |
| Melkbosstrand | 0 | 0 | 0 | 0 |
| Springfontein | 0 | 0 | 0 | present |
| Dassen Island | 0 | 0 | 0 | present |

## Table T-15.2(Cont.) Non-naturally Occurring Radionuclides (Bq/kg) Recorded in Biological, Sediment and Water Samples Collected In 2003

| | Ag-110m | Co-58 | Co-60 | Cs-137 |
| --- | --- | --- | --- | --- |
| **White Mussel** *(Donax serra)* | | | | |
| South Outfall | 5,05 to 8,65 | 0,52 to 0,97 | 0,12 | 0,12 |
| Yzerfontein | 0 | 0 | 0 | 0 |
| **Sediment** | | | | |
| North Outfall | 0 | 0 | 0 | 0 |
| South Outfall | 0 | 0 | 0 | 0 |
| Intake Basin | 0 | 0 | 0 | 0 |
| **Sea Water** | | | | |
| North Outfall | 0 | 0 | 0 | 0 |
| South Outfall | 0 | 0 | 0 | 0 |
| Intake Basin | 0 | 0 | 0 | 0 |

While crayfish, sediment, and seawater samples were free of non-naturally occurring radionuclides, activation and fission products were detected in abalone, rock lobster, black mussel, fish and white sand mussel. These relatively small quantities are not considered indicative of any significant effect of the Koeberg 900 MW PWR units 1 and 2 on the surrounding marine environment (***Reference 2***). Radio-nuclides recorded as present in the table above, indicate levels below the reporting level in EKASACC8 Rev. 0 (13,7Bq/kg) and, and investigation levels prescribed in the SAR Rev. 3 (8,25Bq/kg). Species which are significant for recreational and economic reasons have also been listed in ***Table T-15.2***, even though no radio-nuclides may have been recorded.

### 15.3.4 Marine Organisms that may Impact on the Cooling Supply

Medusae of the phylum *Cnidaria* (jellyfish) and planktonic forms of the phylum *Ctenophora* (comb-jellies) are well known to cause blocking of Koeberg 900 MW PWR units 1 and 2 cooling systems when they reach high densities. Initial studies conducted, on plankton taken into the Koeberg 900 MW PWR units 1 and 2 cooling system in 1987, recorded medusae of the species *Obelia, Bougainvillia* and *Muggiaea.* In addition, a number of ctenophores were collected, with *Pleurobrachia pileus* the dominant species (***Reference 2***).

It was demonstrated that large individuals of both groups were effectively excluded from intake water by large screens in the pump house, but smaller individuals were able to enter.

Entrainment mortality of both medusae and ctenophores was found to be surprisingly low, with only a single dead medusa being recorded at the Koeberg 900 MW PWR units 1 and 2 cooling system outfall. This high degree of survival may be explained by a remarkable tolerance of these organisms to the chlorination and temperature changes associated with water entrainment at the Koeberg 900 MW PWR units 1 and 2. At the time of the experiment residual chlorine was 0,2 ppm. The extent of the effect of the thermal plume is limited to 1 km of the outlet. Such resistance to high temperatures has previously been recorded for some medusae species (***Reference 2***).

Considering the noticeable increase in jellyfish along the South African west coast since the 1970's, the chances of high densities of these organisms blocking the cooling water system at the Koeberg 900 MW PWR units 1 and 2 may be increasing. Although physical removal of these organisms may offer a management option when densities are moderate, higher densities may require chemical shock treatment. The impacts of such treatment on the surrounding environment would need to be determined (***Reference 2***).

### 15.3.5 Overall Impact of the Koeberg 900 PWR Unit 1 and 2 on the Marine Environment

In the final report by Dr Cook (***Reference 6***), which culminated the Marine Environmental Impact studies with the operational phase of the study, most of the earlier predictions (pre-December 1989) regarding the extent of the Koeberg plant pollution impact were proved incorrect. The main findings can be summarised as:

- No reduction in the specie diversity index was recorded. In fact the index rose during the operative period;
- Overall community structure of beach animals was very variable from year to year, but the dominance of a few key species was maintained throughout the experimental period;
- The predicted colonisation of the area by opportunistic warm water species did not occur;
- The breeding cycle of the main indicator specie, *Donax serra*, appeared to be significantly influenced by water temperature. Although the cycle was fairly variable before the Koeberg 900 MW PWR units 1 and 2 began operation, it appeared to be even more unpredictable during the operative phase. There was no evidence however, that this affected the overall number of mussels on the beach. In 2005 it was established that over the long term this mussel has maintained its dominance and the population appears unaffected (***Reference 2***);

- Phytoplankton biomass was reduced by an average of about 53% due to entrainment in the Koeberg 900 MW PWR units 1 and 2 cooling system whilst zooplankton mortality averaged 22,3%. Mortality of plankton during entrainment was not, however, considered to be detrimental to the marine environment because of the very localised area affected; and
- The overall conclusion is that Koeberg 900 MW PWR units 1 and 2 has had very little detrimental effect on the ecology of the local sandy beaches.

The most recent study conducted by Griffiths confirms most of the above (***Reference 2***), with the exception of determining that:

- Marine organisms most likely to impact on the Koeberg 900 MW PWR units 1 and 2 cooling water supply are medusae of the phyla *Cnidaria* and *Ctenophora*, which have been increasing in density along the west coast of South Africa since the 1970's. High densities may require chemical shock treatment, the impacts of which on the surrounding environment would need to be determined.

#### 15.3.6 Ongoing Programme

Since 1990 emphasis has been placed on *Donax serra* as being the indicator specie and most of the ongoing study has concentrated on this beach animal. In conjunction bi-annual total specie samples are being taken for identification and counting of the samples. The annual reports thus far indicate differences, which have little overall biological significance (***Reference 2*** and ***Reference 9***).

## 15.4 Terrestrial Ecology

### 15.4.1 Koeberg Nature Reserve

Eskom has committed itself to maintain the remaining land around the Koeberg 900 MW PWR units 1 and 2 as a nature reserve (2 820 ha). In 1991 the area was proclaimed as the Koeberg nature reserve. The main vegetation types of the area include: Strandveld and Acid Sand Plain Fynbos (***Drawing D-15.1***). These form part of the Cape Floristic Kingdom which is the smallest floristic kingdom in the world, but which has the greatest diversity of plant species. An environmental management plan has been drawn up by a consultant (***Reference 10***) and the nature reserve is managed on these principles.

There are a number of recorded and mapped archaeological sites on the reserve. These sites have been recorded by the SA Museum and are in the eastern region of the reserve. The largest excavated sites are Duynefontein and Duynefontein 2, which are Middle to Later Stone Age Layers of the Die Kelders Cave 1.

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