Australian Government
Director of National Parks

GREAT AUSTRALIAN BIGHT

MARINE PARK

(COMMONWEALTH & STATE WATERS) –

A DESCRIPTION OF VALUES AND USES

2005

© 2005 Commonwealth of Australia

Great Australian Bight Marine Park (Commonwealth Waters and State Waters) – A Description of Values and Uses
Director of National Parks (Australian Government Department of the Environment & Heritage)

ISBN 0-642-55079-4

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without prior written permission from the Director of National Parks.

Requests and inquiries concerning reproduction and rights should be addressed to:

The Assistant Secretary
Marine Conservation Branch
Department of the Environment and Heritage
GPO Box 787
CANBERRA ACT 2601

The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government or the Minister for the Environment and Heritage.

While reasonable efforts have been made to ensure that the contents of this publication are factually correct, the Commonwealth does not accept responsibility for the accuracy or completeness of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the contents of this publication.

Foreword

The area commonly referred to as the Great Australian Bight Marine Park is made up of adjoining South Australian and Commonwealth protected areas. The Australian and South Australian governments manage their respective components of the Great Australian Bight Marine Park cooperatively in accordance with management plans to protect conservation values while allowing ecologically sustainable uses.

The Australian Government released the second Management Plan for the Commonwealth waters of the Park in May 2005. The first Management Plan included a detailed description of the Park, but because resource information can date rapidly, the second Management Plan does not include a detailed description of the Park. Instead, this document has been produced to convey up-to-date information about the values and uses of the Park and surrounding environment. It will be updated regularly throughout the life of the Management Plan as information becomes available.

TABLE OF CONTENTS

FIGURES

1. Introduction

The Great Australian Bight Marine Park is part of Australia's National Representative System of Marine Protected Areas (NRSMPA). The Australian, State and Territory governments are developing the NRSMPA cooperatively within their respective marine jurisdictions. The aim of the system is to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels. Marine reserves provide important reference areas for scientific studies and long-term environmental monitoring. As part of this system, the Marine Park helps to conserve ecosystems that are characteristic of the Great Australian Bight region.

The temperate marine environments off Southern Australia are not well represented in the existing marine reserve system. These environments are in relatively pristine condition due to low levels of human use, which arises from their isolation and difficult coastal access.

1.1 Regional Setting

The Great Australian Bight extends from Cape Catastrophe, Eyre Peninsula in South Australia to Cape Pasley, east of Esperance in Western Australia (*Figure 1*). The Bight features a very wide continental shelf, in some parts extending to well over 200 nautical miles. It has the world's longest ice-free east-west extent of coastline, fronting the circum-polar waters of the Southern and Antarctic oceans.

Several unique factors combine to contribute to the high level of biodiversity and endemism in the region. These include a long period of geological isolation, a persistent high-energy environment, warm water intrusion via the Leeuwin current from Western Australia, and cold-water, nutrient-rich upwellings in the east. Taxonomic groups with particularly exceptional diversity include red algae (sea weed), ascidians (sea squirts), bryozoans (lace corals), molluscs (shellfish) and echinoderms (sea urchins and sea stars).

The Great Australian Bight region is an area of global conservation significance for species of rare and endangered marine mammals and seabirds. It provides important calving regions for the endangered southern right whale and colonies (including pupping areas) of Australia's only endemic pinniped, the Australian Sea-lion. Other protected species known to occur in the region include the great white shark, humpback whale and several species of albatross.

Adjoining the waters of the Great Australian Bight, the Nullarbor Plain is itself a relic of ocean floor, and its coastal cliffs and dunes are of great geomorphological interest and cultural significance. Predominantly at the eastern end of the Bight, there are many islands, rocky headlands, embayments and surf beaches. Limestone cliffs averaging 80 metres in height stretch for over 200 kilometres from the Head of Bight in South Australia to the Western Australian border. As a result of the limestone geology and generally low rainfall no rivers or streams flow into the Bight, and no true estuarine environments exist. The lack of sediment input means that relict calcareous Pleistocene sands are preserved on the sea floor.

Isolation and difficult coastal access combine to make Great Australian Bight environments relatively pristine, with areas of very high scenic value. Use of the region currently includes interests of the Anangu community of Yalata, Mirning and Wirungu Native Title interests, several economically valuable commercial fisheries, and petroleum and other mineral exploration activities. Tourism interests are focused on some of the best whale-watching opportunities in the world.

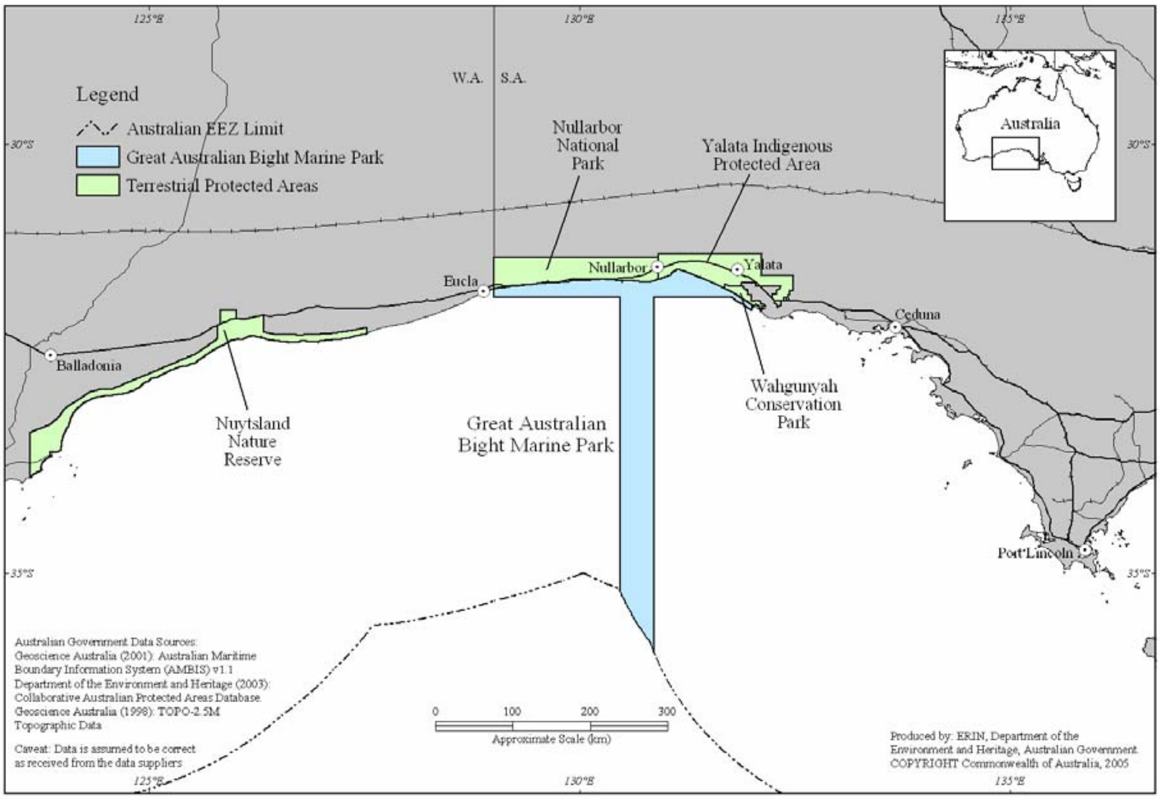


Figure 1: Great Australian Bight Region

1.2 Location and Zoning of the Park

The area commonly referred to as the Great Australian Bight Marine Park ('the Park') (*Figure 2*) is located in the Great Australian Bight stretching from 200 kilometres west of Ceduna in South Australia following the coast to the Western Australian border. The Park includes a 20 nautical wide strip extending out to 200 nautical miles offshore.

The Park is made up of adjoining South Australian and Commonwealth protected areas. The State Marine Park, in the State (coastal) waters of the Bight, combines a whale sanctuary established under the *Fisheries Act 1982* and marine national park established under the *National Parks and Wildlife Act 1972*. The adjoining Great Australian Bight Marine Park (Commonwealth Waters) is a Commonwealth reserve established under the *National Parks and Wildlife Conservation Act 1975*, which was replaced on 16 July 2000 by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Australian and South Australian Governments manage the Park cooperatively in accordance with management plans to protect conservation values while allowing ecologically sustainable uses that are consistent with protecting these values and that contribute to regional and national development. The plans regulate recreational, scientific and commercial uses of the Park using four distinct management areas or 'zones' as follows:

1. Sanctuary Zone 2. Conservation Zone	State waters
3. Marine Mammal Protection Zone 4. Benthic Protection Zone	Commonwealth waters

These zones are designed to protect the particular conservation values of the Park, which are:

- Habitat for the southern right whale (*Eubalaena australis*).
- Habitat for the Australian Sea-lion (*Neophoca cinerea*).
- Habitat for other species of conservation significance.
- A transect representative of the seabed on the continental shelf and slope of the Great Australian Bight.

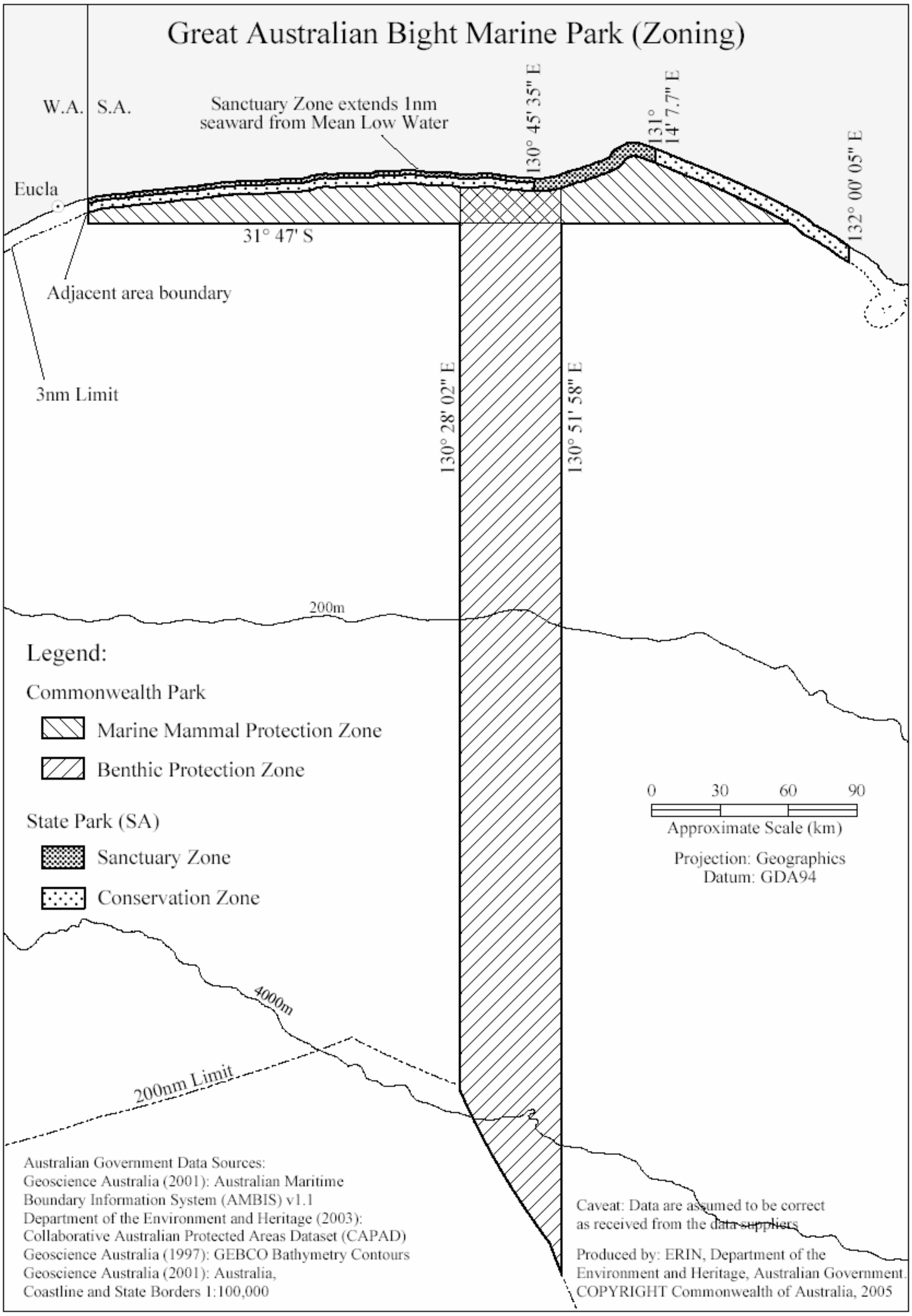


Figure 2: Location and Zoning of Great Australian Bight Marine Park

1.2.1 South Australian Waters ('the State Park')

The State Park covers an area of 1683 square kilometres (168 320 hectares) of South Australian waters out to the 3 nautical mile limit extending from the Western Australian border (129° 00'E) to just west of Cape Adieu (132° 00'E). It consists of a Whale Sanctuary and Marine National Park.

The South Australian Government proclaimed the Great Australian Bight Marine Park Whale Sanctuary on 22 June 1995. The Whale Sanctuary is located at the Head of Bight and has an area of 43 587 hectares. It lies between 130° 45.5'E and 131° 30'E, and extends three nautical miles out to sea from the Mean High Water Mark.

On 26 September 1996 the South Australian Government declared the Great Australian Bight Marine National Park. The Marine National Park has eastern and western components that lie to either side of the Whale Sanctuary and together cover an area of 124 732 hectares. The western component lies between the South Australia–Western Australia border at 129° 00'E and the western boundary of the Whale Sanctuary at 130° 45.5'E. The eastern component lies between the eastern boundary of the Whale Sanctuary at 131° 30'E and the meridian of longitude 132° 00'E. Both components extend three nautical miles out to sea from the Mean Low Water Mark.

The State Park adjoins the important terrestrial conservation areas of Nullarbor National Park and Wahgunyah Conservation Reserve, as well as the Yalata Indigenous Protected Area.

The State Park is made up of two zones, a Sanctuary Zone and a Conservation Zone. The Sanctuary Zone encompasses the Whale Sanctuary, plus the western portion of the Marine National Park, between the Mean Low Water Mark and one nautical mile offshore. The rest of the Marine National Park is the Park's Conservation Zone.

The Sanctuary Zone was declared to protect critical breeding and calving sites of the southern right whale and breeding colonies of Australian Sea-lions. It has been assigned to IUCN category[1] Ia, to be managed as a 'strict nature reserve'. The Conservation Zone of the Park is assigned to IUCN category VI, to be managed as a 'managed resource protected area'.

1.2.2 Commonwealth Waters ('the Commonwealth Park')

The Australian Government declared the Great Australian Bight Marine Park (Commonwealth Waters) on 17 April 1998. The Commonwealth Park is situated adjacent to the State Park and covers an area of 19 769 square kilometres (1 976 900 hectares). It encompasses the waters and seabed and the subsoil beneath the seabed to a depth of 1000 metres.

The Commonwealth Park is made up of two overlapping zones. Directly adjacent to the South Australian Marine Park is the Marine Mammal Protection Zone that extends from three nautical miles to approximately 31° 47'S. This area is primarily intended to provide for undisturbed calving for the southern right whale and protection of Australian Sea-lion colonies.

To the west of the Head of Bight is the Benthic Protection Zone, a 20 nautical mile-wide representative strip of the ocean floor, lying between 130° 28'E and 130° 51'E, and

[1] The 'IUCN Categories' are protected area management categories developed by the World Conservation Union (IUCN) to describe protected area management.

extending from the edge of the State Park (at three nautical miles) directly south to the edge of the Exclusive Economic Zone of Australia at 200 nautical miles. This area is intended to protect the unique and diverse plants and animals that live on, and are associated with, the ocean floor.

The management plan for the Commonwealth Park assigns the entire Park and each of these Zones to IUCN category VI, 'managed resource protected area'. Under the Australian Government's EPBC Act and the associated regulations, these areas must be managed to ensure long-term protection and maintenance of biological diversity whilst providing for ecologically sustainable use of marine resources.

2. Cultural values

2.1 Indigenous heritage

Aboriginal people have occupied the Nullarbor region for well over 20 000 years (Davey 1986). Archaeological evidence suggests Aboriginal people used Koonalda Cave for mining flint. The cave also contains finger markings and abraded grooves on walls deep underground, dated to about 20 000 years ago.

The ancestors of the Koonalda flint miners are known as the Mirning (Tindale 1974). The Mirning were traditionally a coastal people and their country extends from west of the Head of Bight to near Cape Pasley in Western Australia. There is no evidence to suggest they ventured much further inland than the coastal plain.

To the east of the Mirning are the Wirangu. Their country extends east from the Head of Bight, including Ooldea, to the Gawler Ranges and Streaky Bay (Tindale 1974). To the north of the coastal people the Kokata, Ngalea, Pindini and Antakarinja people inhabited the Great Victoria Desert (Cane & Gara 1989). These communities, known as the Western Desert Bloc Cultural Complex (Gara *et al* 1988), are considered the ancestors of today's Anangu people (Hinsliff & Wild 1996).

Aboriginal subsistence was dominated by seasonal weather patterns. The inhabitants of the region were described as living on the coast throughout the spring and summer, and travelling inland when the sea was rough and cold and the inland limestone rock holes were full (Cane & Gara 1989). These temporary supplies of water were connected by Aboriginal pathways or dreaming trails which formed major highways across the Nullarbor Plain. In the winter, kangaroo, emu and turkey were abundant (Bates 1938).

Much of the coastline was inaccessible because of the cliffs and occupation focused around fresh water soaks at the Head of Bight, Eucla and Merdayerrah Sandpatch. Coastal resources included seals, shellfish, fish, birds, wombats and other large game (Cane & Gara 1989).

In the early 20th century a number of factors including drought brought Aborigines from the Western Desert Bloc to Ooldea where the Lutherans established a mission. The British Atomic Tests at Maralinga and opening of the Woomera Rocket Testing Range displaced the Anangu from Ooldea in the 1940s and 50s. The Ooldea Mission was closed in 1952 and most people went to Yalata Station near Head of Bight. Today the Yalata Aboriginal Lands are managed by the Anangu and recognised as Anangu country under Aboriginal Law (Hinsliff & Wild 1996).

Today, the Mirning, Wirungu, Maralinga Tjaruta and Anangu hold indigenous cultural interests in the waters of the Bight. For the Anangu based at Yalata, interests focus mainly on the inshore reef areas within State waters (Jeremy LeBois, Yalata Community, personal communication).

2.2 Non-indigenous heritage

The first Europeans to see the Nullarbor Coastline were probably Dutch navigator Francis Thijssen and his crew. His ship, the Gulden Zeepaert (Golden Seahorse) was blown off-course en route to Java from the coast of Africa in 1627. No records survive of this trip. However, charts appearing after 1628 mapped this newly discovered stretch of Australian coastline, named Nuytsland, after Pieter Nuyts, an official on the Golden

Seahorse (Cane 1992, Gara & Cane 1988). Other explorers to visit the coastline were D'entrecastreaux in 1792, Flinders in 1801 and Baudin in 1802.

Edward John Eyre was the first overland explorer of the coast of the Nullarbor Plain. From 1840 to 1841 Eyre's party spent eight months walking from Streaky Bay to Albany. Eyre was followed by Warburton in 1860 and Delisser in 1865, who named the Nullarbor Plain after its lack of trees (Cane 1992). The latter half of the 19th century saw an increase in exploration as settlers set out looking for new grazing land.

Pioneers who attempted settlement of the area found limited opportunities. However, in the southern Nullarbor, pastoralists settled in areas where palatable bore water was located. Yalata Station near Fowlers Bay was established in 1858, Mundrabilla Station in 1871, Madura in 1876 and Balladonia in 1880. A relatively small area is now occupied by pastoral leases, none of which border the Marine Park (Edyvane 1998a).

The overland telegraph was commenced in 1874 and Eucla was declared a town site in 1885. For many years it was the only township in the Nullarbor region. The track associated with the telegraph line was upgraded in 1941 and became the Eyre highway (Edyvane 1998a).

According to the National Shipwreck Database an unidentified shipwreck may be located within the Marine Park on the coast near the Head of Bight. It is possible that other, as yet undiscovered, historic shipwrecks may occur in the Park.

Commercial fishing in Bight waters has contributed to settlement and development of the region. The first commercial fishing activity to be established in South Australia was the whaling and sealing industry in the 1800s, and early whalers helped chart parts of the west coast of South Australia (Commonwealth of Australia 2000). The earliest reports of southern right whaling in Australia were in 1805. It is estimated that more than 15 000 whales were taken from Australian waters in the period from 1826 to 1899. Commercial whaling peaked in southern Australia from 1820 to 1830. Southern right whales were protected under international agreement in 1935 (Edyvane 1998a). Researchers have discovered evidence of working structures and whale bones at Fowlers Bay that probably are relics of an early whaling venture that would have been the most westerly whaling operation in South Australia (Kemper & Samson 1999).

The Southern Rock Lobster Fishery was started soon after Europeans arrived in South Australia. The Fishery expanded rapidly in the 1940s with the development of an export market to the United States and the development of the School Shark Fishery. Fishing has had a long history in the region, and remains part of the economic and social culture of the west coast of South Australia today.

3. Physical Features

3.1 Climate

(From Edyvane 1998a)

The coastal area of the Nullarbor has a winter rainfall and a semi-arid climate. Occasional heavy rainfalls occur in mid to late summer from the remnants of tropical cyclones, but these events are exceptions. While a seasonal pattern of rainfall can be discerned along the Nullarbor coast, rainfall overall is variable.

The climate of the Eyre Peninsula coast to the east of the Great Australian Bight is typically semi-arid or Mediterranean and is characterised by hot, dry summers and cool, moist winters. It is largely influenced by mid-latitude anticyclones or high-pressure systems which pass from west to east across the continent. Winter generally brings southerly to south-easterly winds and low pressure systems which travel across the Southern Ocean between 40º and 50º bringing frontal activity and rain. Summer brings northerly to north-westerly winds. Along the Bight and west coast of the Eyre Peninsula, strong westerly, onshore winds have reworked the coast, resulting in extensive dune development.

Rainfall varies considerably with latitude, from approximately 500 mm in the south to less than 300 mm in the north. The townships of Eucla and Ceduna receive an annual average rainfall of 257 mm and 315 mm respectively, with the greatest proportion falling during winter. Mean monthly maximum temperatures on the coast range from 28º C in January to 17º C in July.

3.2 Geology and Geomorphology

3.2.1 Geological History

The Great Australian Bight is part of a divergent, passive continental margin that was formed during the protracted period of extension and rifting during the Cretaceous Period (140 to 65 million years ago) leading to the separation of Australia from Antarctica and Australia's subsequent northward drift (Willcox & Stagg 1990; James *et al.* 2001; Norvack & Smith 2000). Limestone cliffs up to 70 metres high dominate the western coastline from Cape Pasley to the Head of Bight. The eastern coastline is more complex, and is characterised by cliffs, scattered islands, headlands and large embayments (James *et al.* 2001).

The margins of the Great Australian Bight consist of extremely ancient basement rock of the Gawler Craton in the east and the Yilgarn Block in the west. Underlying the waters of the region is the submerged continental crust of the ancient Gondwana supercontinent. In the centre of the Bight, the crust extends oceanwards for up to 500 kilometres. This crust was in existence long before Australia's southern coastal margin, and incorporates some very old and poorly-defined sedimentary basins (older than 500 million years) (Willcox 1998).

The northward drift of Australia with respect to Antarctica continues to the present day. Sediments in the coastal region demonstrate that the area was initially a shallow embayment with large rivers flowing into it, and that by around 35 million years ago a full seaway had formed between the continents. This is evident in the replacement of terrestrial and estuarine sediments by marine carbonates of Middle to Late Eocene age (about 40 million years old), known as Wilson Bluff Limestone. This forms the characteristic chalky lower strata of the dramatic Nullarbor cliffs fronting the Great Australian Bight.

Associated with the rifting event, large sedimentary basins were formed in the Bight region, which now have both onshore and offshore extents (Li *et al*. 2003)(*Figure 3*). The Eucla Basin is a large onshore-offshore basin extending some 350 kilometres inland from the modern day coastline and extends seaward approximately 500 kilometres to the approximate foot-of-slope. The Eucla Basin contains the Wilson Bluff limestone and the more recent (Miocene – 24 to 5 million years ago) hard crystalline limestone making up the surface of the Nullarbor Plain and upper part of the cliffs.

The Bight Basin underlies part of the Eucla Basin and includes the Eyre, Recherche and Ceduna Sub-basins at depths from 200 to 4000 metres. It is in these relatively deep-water areas, and possibly along the shelf-break itself, that petroleum exploration activity has been focussed. To the east, and extending under the Eyre Peninsula, is the Polda Basin, and to the south-east is the Duntroon Basin. To the west the Bremer Basin is south of the Yilgarn Block.

This ancient ocean floor has essentially existed unchanged for 20 million years, and is one of the most extensive of such surfaces in the world. Due to its low rate of sediment accumulation, the seafloor is also notable for its preservation of relict calcareous Pleistocene (1 million years ago) material from a period when sea levels were lower, including evidence of lagoon environments (Li *et al*. 1996) and bryozoan reef mounds (Holbourn *et al*. 2002).

The coastal geology of the Bight also shows evidence of more recent (Pleistocene) development, in part because of sea level changes associated with climate changes, notably glaciations.

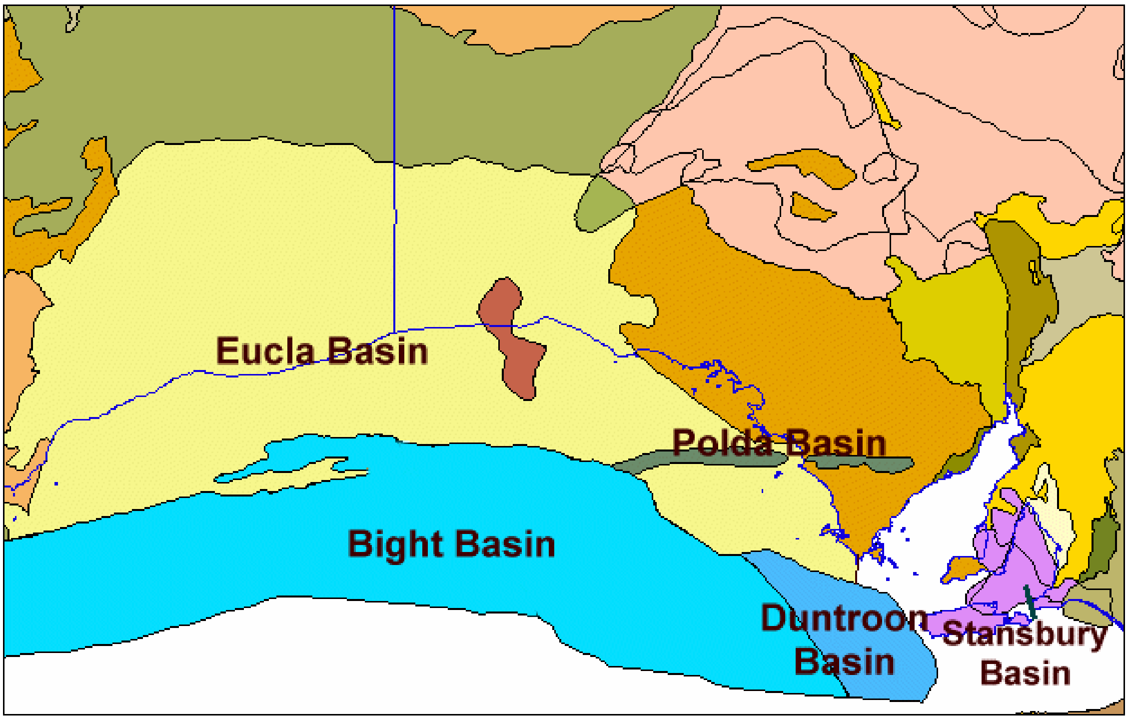


Figure 3: **Sedimentary Basins**
(Source: Geoscience Australia 2002)

3.2.2 Bathymetry

The extensive shallow continental shelf is a key bathymetric feature of the Great Australian Bight (Edyvane 1998b)(*Figure 4*). The shelf is an immense, relatively flat, arcuate in shape, submarine plain 80 kilometres wide at either end, expanding to 260 kilometres wide at the Head of Bight (Harris *et al* 2003; Willcox *et al.* 1988). The continental shelf can be divided into three shelf regions (James *et al*. 2001). The inner shelf (<50 metres water depth) includes all of the waters of the State Marine Park, the middle shelf (50 to 120 metres), and the 10 to 30 kilometre wide outer shelf (125 to 170 metres) extends out to the shelf break.

Beyond the shelf, the Bight region contains a broad continental slope that includes several terraces (Willcox *et al.* 1988)(*Figure 5*). The largest of these, the 700 kilometres long by 200 kilometres wide Ceduna Terrace, occurs in water depths of between 200 and 3000 metres in the central and eastern regions (Hill *et al* 2001; James *et al* 2001). The Eyre Terrace, located on the western margin, is 200 kilometres wide and occurs in water depths of between 200 and 2000 metres (Hill *et al* 2001; James *et al* 1994).

The margin of the shelf within the Commonwealth Park slopes gently down to 2500 metres and is relatively featureless except for two pinnacles less than 100 metres high and 700 metres across, near the 1750 metre isobath. From 2500 to 5000 metres, the margin is steeper, faulted and traversed by canyons, some of which include giant holes up to five kilometres wide and 500 metres deep (Hill *et al*. 2001). The south-eastern apex of the Benthic Protection Zone extends to the edge of the South Australian Abyssal Plain.

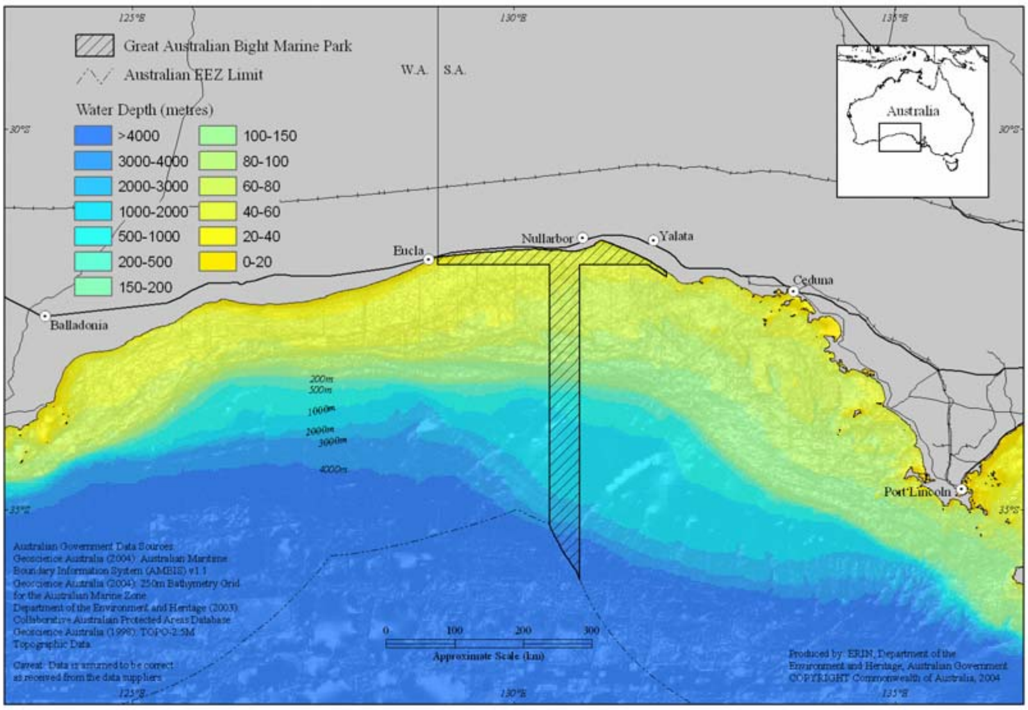


Figure 4: Bathymetry

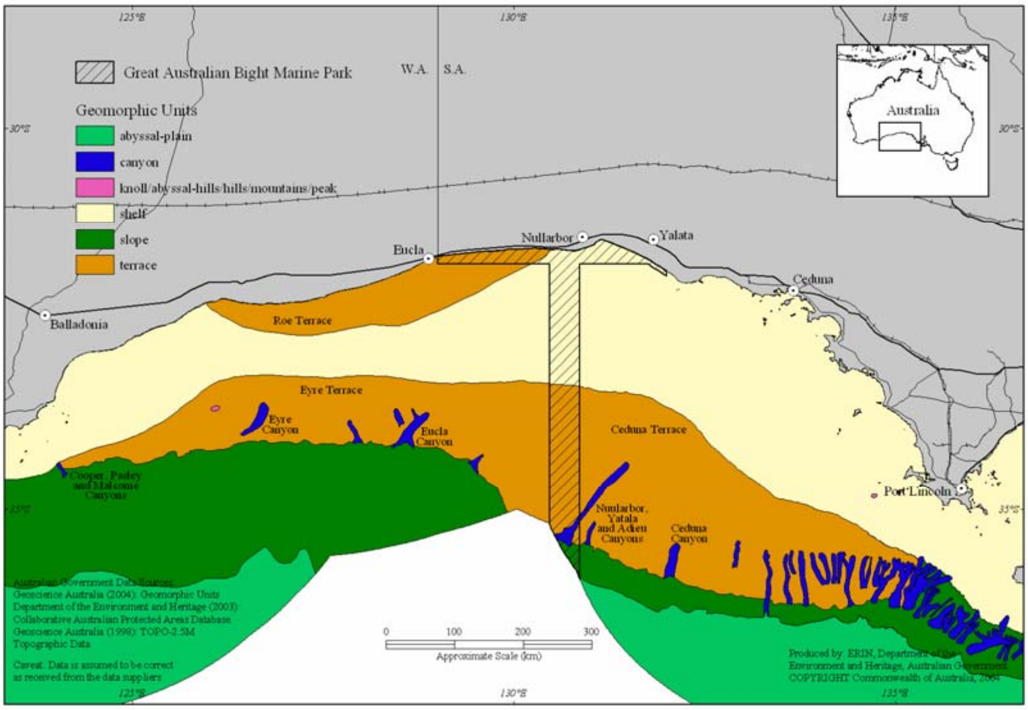


Figure 5: Geomorphic Units

3.2.3 Sedimentology

(Adapted from McLeay *et al* 2003 and Edyvane 1998a)

The wide, swell-dominated, open shelf waters of southern Australia, including the Great Australian Bight, have allowed the development of the world's largest cool-water carbonate province (James *et al.* 1992; Gostin *et al.* 1988; James and von der Borch 1991; Wass *et al.* 1970). This is in contrast to eastern Australia where sediments are mostly siliceous. Due to the lack of rivers, most of the shelf receives minimal inputs of terrigenous sediments. This effect, combined with the upwelling of cold ocean waters, has resulted in the preservation of relict calcareous Pleistocene sands and the growth of carbonate-producing bryozoans, coralline algae, sponges, molluscs, asteroids and foraminiferans (Wass *et al.* 1970; James *et al.* 1992). These organisms form the basis for the accumulation of Holocene sediments, which generally contain a high proportion of bryozoans. In open coastal areas, like the Great Australian Bight, winds and persistent south-west swells, erode and rework these contemporary sediments and older calcrete encrusted Pleistocene aeolianites (Gostin *et al*. 1988).

Studies have shown that the sediments of the western Bight are dominated by coralline algae and large foraminiferans but are rare in bryozoans, whereas shelf sediments in the eastern Bight are dominated by bryozoans (James *et al* 1994). This is largely due to the warmer waters of the Leeuwin current and downwelling off the Eucla shelf to the west, and cooler waters and upwelling to the east.

The upper slope area, (>130 metres), is predominantly inhabited by low-growing bryozoans, a few sponges and other biota. This area, being below storm-wave base, accumulates sediment at a measurable rate. Overall, the calcareous bryozoans are the major contributors to sediment deposition in the diverse areas of the Bight, whereas the sponges only contribute a minute amount of siliceous spicules to the overall sediment load, regardless of their density.

James *et al*. (2001) divides the sediments of the shelf and upper slope out to 500 metres deep into nine facies (*Figure 6*). The inner shelf is typified by modern biofragments, rodolith gravel and quartzose sands, the middle shelf (50 to 100 metres deep) by intraclasts, mollusc shells and bryozoan skeletons, and the outer shelf and upper slope by bryozoan sediments. The continental slope below 300 metres is comprised of a tenth facie dominated by spiculitic mud.

Inner shelf

Facies Q *(Quartzose Skeletal Sand and Gravel)*. Heterogenous fine to coarse sand and gravel with intraclasts, equal proportions of bryozoans and bivalves and 10 - 30% terrigenous particles (quartz, crystalline rock fragments, feldspar and granite fragments).

Facies MI *(Mollusc Intraclast Sand)*. Composed of 25 - 50% intraclasts and mollusc fragments over bryozoans in fine to medium well-sorted sand or poorly sorted fine sandy gravel.

Middle shelf

Facies I *(Intraclast Sand)*. Consists of brown coarse to very coarse, well-sorted, round, particulate sand composed of 80 - 90% intraclasts.

Facies IM *(Intraclast Mollusc Sand and Gravel)*. Well-sorted medium to course sand and gravel composed of 50-75% intraclasts and numerous large molluscs. A sand composed of 40% foraminiferans is present in some regions.

Facies IB *(Intraclast-Bryozoan Sand)*. A mixture of Facies I and B, it is composed of 50 - 75% sand-sized intraclasts with bryozoan sands and gravels of Holocene origin.

Outer shelf and Slope

Facies B *(Bryozoan Sand and Gravel)*. Cream to green coloured sediment with <25% intraclasts. Sediment is poorly to well-sorted with very fine sand to cobble sized particles. Sand is moderately sorted and rich in medium-sized sand to gravel-size bryozoan fragments.

Facies BI (Bryozoan Intraclast Sand). 25-50% intraclasts and abundant bryozoans. It is essentially the same as Facies B but mixed with a higher proportion of intraclasts, bivalves, coralline algae and abraded particles.

Facies BB *(Branching Bryozoan Sand and Gravel)*. This is a mixture of numerous delicate branching bryozoans and mud, grading to greater similarity with Facies B in shallower waters.

Facies SB (Spiculitic Branching Bryozoan Mud). Mixture of more than 50% fine biofragments and the branching/vagrant bryozoan assemblage common to Facies BB. Relict rhodoliths and coralline rods characterise shallow sites.

Additionally, Facies M *(Spiculitic Mud)* predominates wherever depths are greater than 300 metres. This is a mixture of approximately 66% fine biofragments and 33% fine pelagic components. It is rich in *Dentalium*, pteropods, gastropods, echinoid plates, spherical and vagrant bryozoans, benthic foraminiferans, ostracods, micromolluscs and angular clasts.

Facies Q, I, IB, and BB are represented in the Benthic Protection Zone, and Facies MI and Q are represented in the Marine Mammal Protection Zone and State Park. The other Facies are not or are only marginally represented in the Benthic Protection Zone.

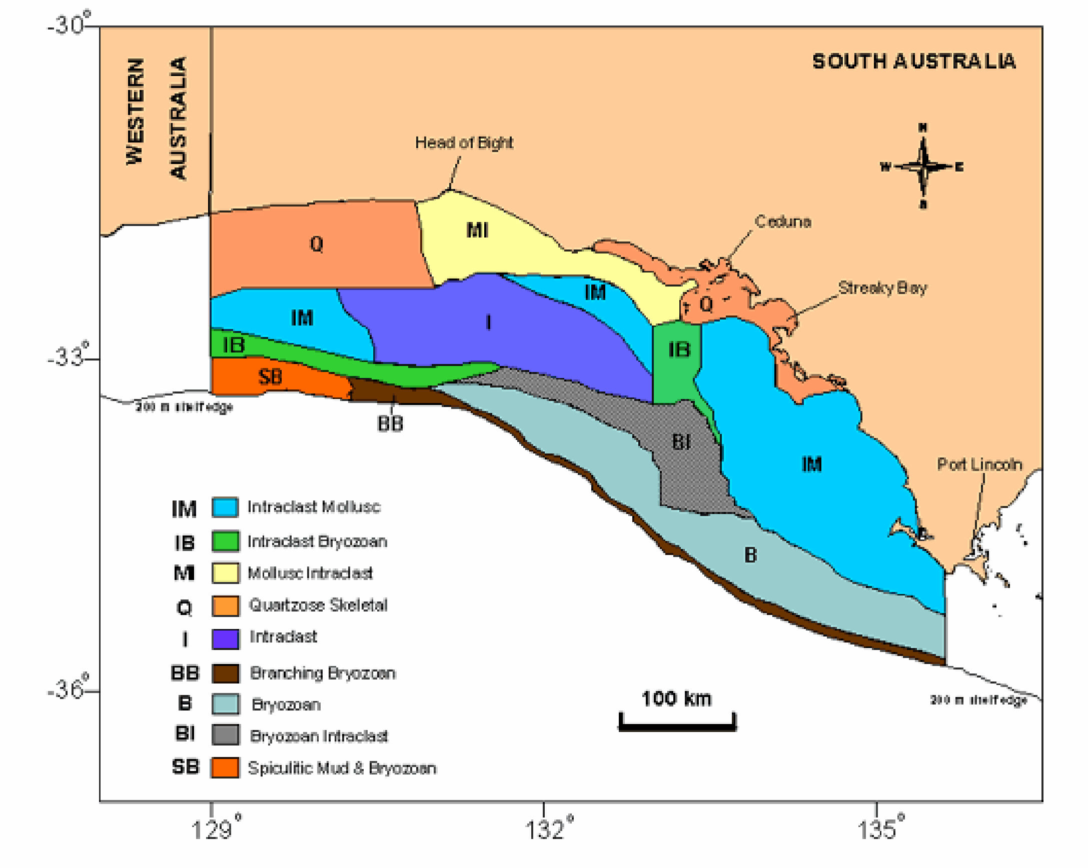


Figure 6: Sediment types on the shelf and upper slope of the eastern Bight
(Source: McLeay *et al* 2003)

3.2.4 Coastal geomorphology

(From Fotheringham 1994)

The major open coastal landforms of the Great Australian Bight can be divided into rocky and sandy sections. The rocky sections consist of Tertiary limestone cliffs (with the largest section comprising the Nullarbor or Bunda Cliffs), Precambrian bedrock (usually capped by dune calcarenite) and Pleistocene dune calcarenite which is exposed in cliffs up to 150 metres high, usually fronted by well-developed shore platforms and reefs (Parker *et al.* 1985, Short *et al*. 1986, Curry 1987). The sandy sections include numerous beaches with backing foredunes and transgressive dunes. To the east, some bays are composed of finer sediments and are usually vegetated with mangroves and lagoonal deposits.

Many offshore islands and reefs occur in the Great Australian Bight, including the Recherche Archipelago (WA) and Nuyts Archipelago (SA) and the Investigator Group of

Islands (SA) which includes the granite inselbergs of the Pearson Islands. No offshore islands occur within the Marine Park area.

The area within the State component of the Marine Park comprises two coastal geomorphological provinces: Western Barriers (Province 7) and Nullarbor Cliffs (Province 8) (Short *et al.* 1986)(*Figure 7*).

The Western Barriers Province consists of 122 kilometres of southwest facing coast stretching from Cape Adieu to the Head of Bight. It is comprised of extensive Holocene dune barriers interspersed with Pleistocene calcarenite. Further west, the Tertiary limestone cliffs of the Nullarbor Plain and Holocene and Pleistocene marine deposits at the Merdayerrah Sandpatch form the 209 kilometre Nullarbor Cliffs Province.

Along the Western Barriers Province Pleistocene calcarenite has strongly modified the distribution and form of Holocene sedimentation. Calcarenite cliffs have impeded inland sand drift. Calcarenite headlands have blocked or restricted longshore sand movement. Outlying calcarenite reefs have in places greatly reduced nearshore wave energy resulting in variable beach and dune environments. High energy nearshore wave conditions prevail along most of the province producing dissipative beaches backed by 4 to 7 kilometre wide transgressive sand drifts and stable vegetated parabolic dunes.

Where reef protection occurs moderate energy intermediate and low energy reflective beach types occur. These have narrower beach faces and steeper beach gradients than dissipative beaches with significantly reduced potential for inland sand transport. In consequence the backing dunes are considerably smaller. Clifftop dunes with fronting beaches indicate that beaches have either been transgressed by rising sea levels or eroded due to sand loss.

At the Head of Bight the Yalata dunes form the most extensive active dune transgression. Historic records indicate that the dunes are transgressing inland at a rate of eleven metres per year. Sediment analysis of beach and dune sands at the Head of Bight show they are fine to medium carbonate rich sands with silica content slightly higher in the dunes.

The high, continuous cliffs of the Nullarbor Cliffs Province have been little affected by the Holocene period apart from re-activation of Pleistocene cliff faces. Shore platforms are absent due to weakly consolidated lower cliff materials. Sediment produced from cliff erosion is too fine to produce beach sand.

At Merdayerrah Sandpatch, Pleistocene calcarenite and Holocene marine sediments front the Nullarbor Cliffs to form a narrow coastal plain which stretches 30 kilometres to the Western Australian border. Longshore transport of sand from the nearby Roe Plain is the most likely source of beach and dune materials. High silica content (40 - 70%) indicates that reworked pre-Quaternary bedrock may form an important component of the sediment. Due to calcarenite reefs, nearshore wave energy is low and beaches mainly reflective. The backing dunes are unvegetated and highly active. In several places cliff face sand ramps have formed and the Nullarbor Cliffs have been overtopped by dune sands. Pleistocene calcarenite dune ramps are also evident.

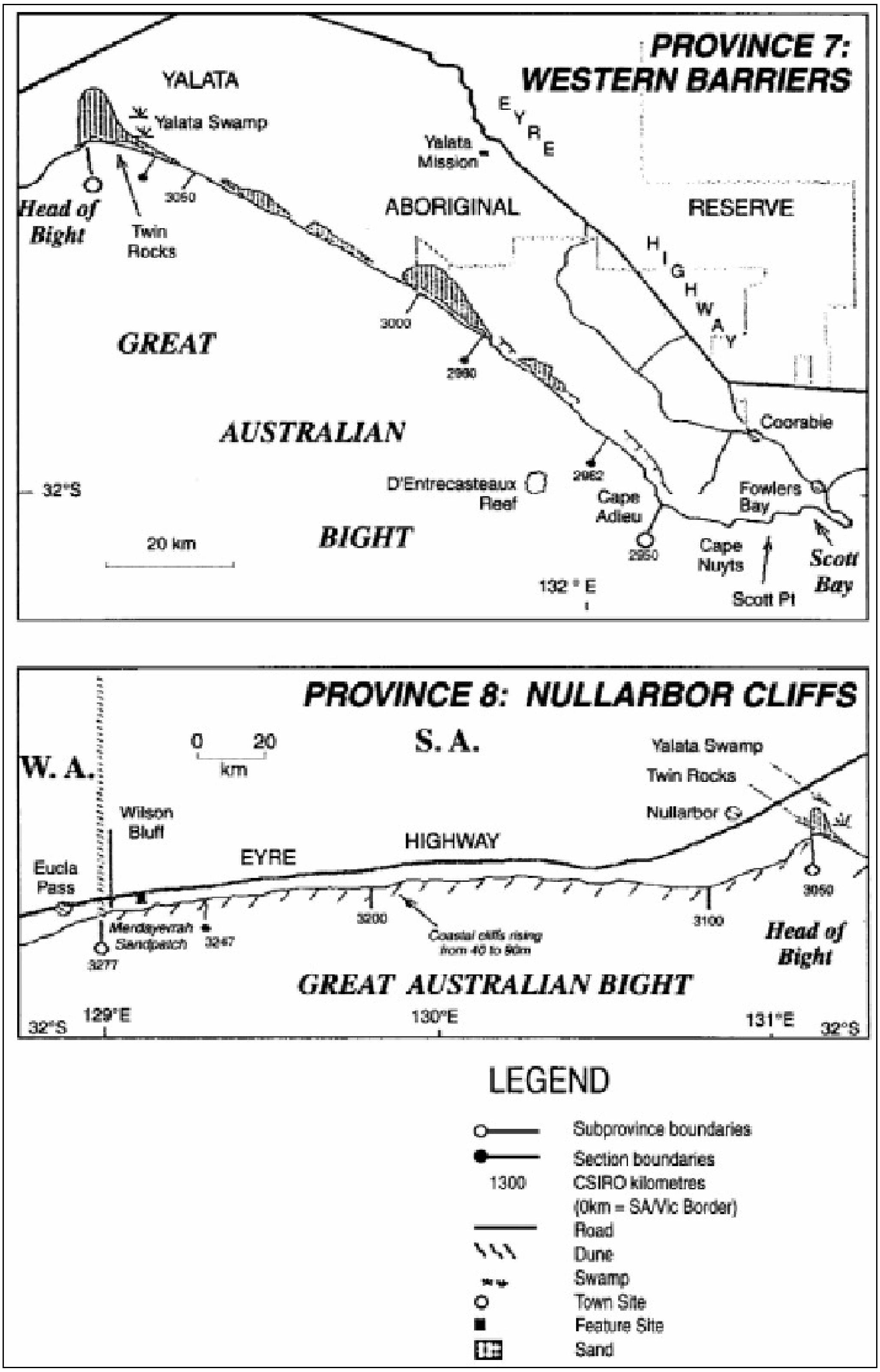


Figure 7: **Coastal Geomorphic Provinces**
(Source: Short *et al* 1986)

3.3 Oceanography

(From Edyvane 1998a)

3.3.1 Tides, Waves and Swells

Oceanographic processes in the Great Australian Bight are strongly influenced by frequent gales and heavy seas and a moderate to high deepwater wave energy coastline. Tides in the Bight (western Eyre Peninsula) are microtidal in range and are semi-diurnal, with a mean tidal range of between 0.8 and 1.2 metres.

The Great Australian Bight is located within the 'west coast swell environment', being under the influence of westerly moving low pressure cyclones south of the mainland that generate a consistently high south-west swell. This swell typically ranges from less than two metres for 50% of the year, two to four metres for 30 - 45% of the year and exceeding four metres approximately 10% of the year. Strong winds provide an additional source of wave energy, with seas averaging 0.5 to 1.25 metres and sometimes exceeding two metres.

Breaker wave energy varies considerably along the coast. Land-locked bays and sheltered areas in the eastern Bight (e.g. Venus Bay) experience low wave energy with the wind influencing energy regimes. The open coast is characterised by a high deepwater wave climate and a highly variable breaker wave climate due to differences in nearshore-offshore gradients.

3.3.2 Water Temperature, Salinity and Nutrients

Sea surface temperatures of open coastal areas of the Great Australian Bight vary from 18 - 23°C in summer (January to March) and 13 - 16°C in winter (July to September) (Hobday 2001)(*Figure 8*). Water temperatures (and salinities) vary markedly within the shallower coastal embayments and other sheltered areas of the Bight region.

During late summer the warm waters of the south-west coast of Eyre Peninsula (from Baird Bay to western Kangaroo Island) are subject to localised, seasonal, cold coastal upwellings, which may decrease the sea surface temperature to 11 - 12º C.

Generally, high salinity is a feature of the Bight, with levels of 35.7 % being recorded at 100 metre depths (Rochford 1980).

Like most Australian surface waters, the waters of the Great Australian Bight are generally deficient in nutrients. This is due, in part, to the isolation from the rich sub-Antarctic waters to the south and the lack of riverine input. By contrast, and of great significance for food chains in the region, the cold water upwellings are nutrient-rich, and support elevated levels of primary productivity (Gill 2002). High densities of zooplankton to the north-west of the upwellings indicate that prevailing south-easterly winds transport the products of this enhanced biological activity into the central Bight (McLeay *et al*. 2003).

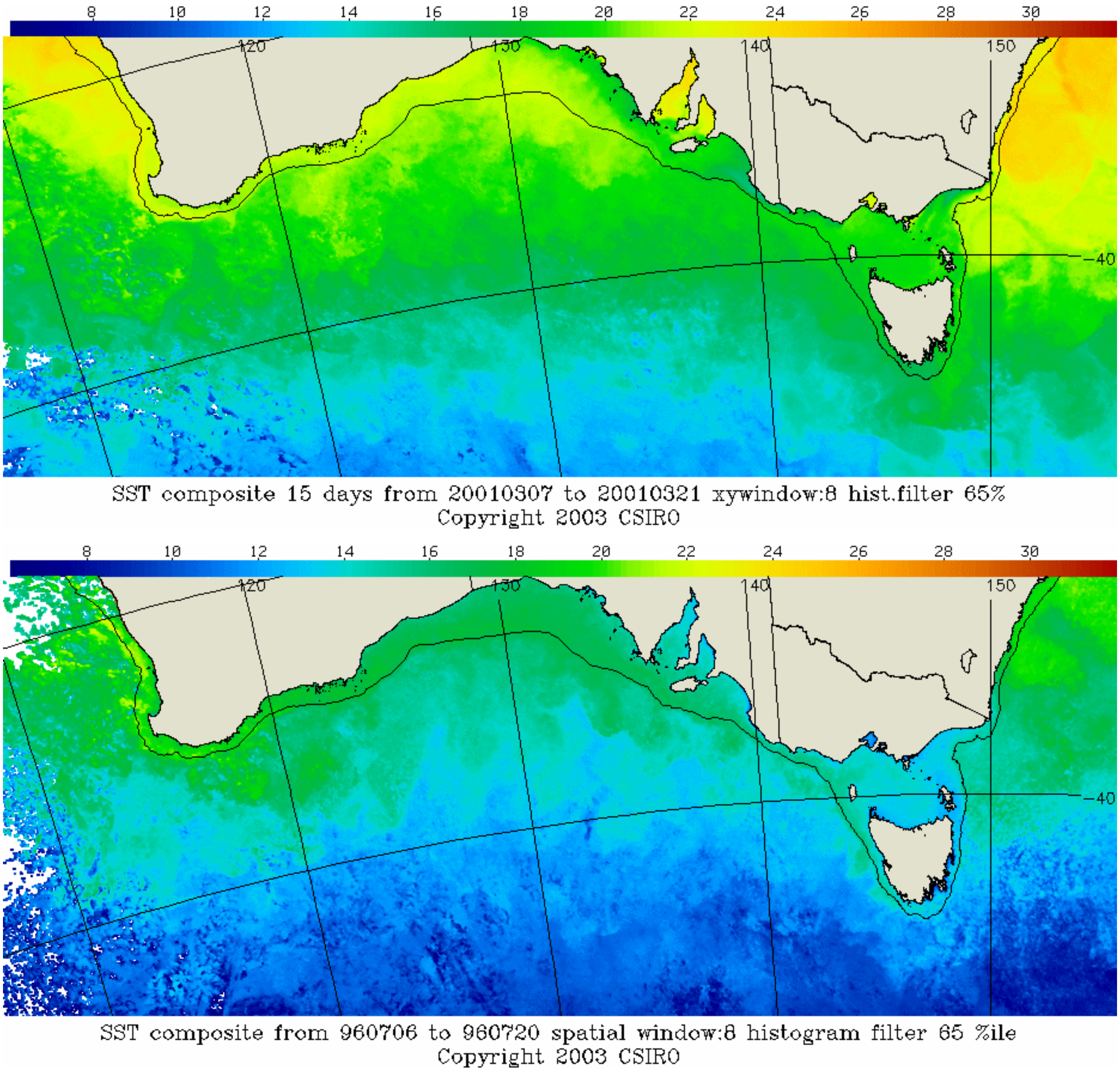


Figure 8: Sea Surface Temperature charts for southern Australia for summer (top) and winter (bottom)
(Source: CSIRO 2003)

3.3.3 Currents

Two important currents influence the Great Australian Bight region, and contribute to the great complexity of its oceanography (*Figure 9*).

The Leeuwin Current. This current originates from the tropical waters of the Indian Ocean and reaches along the continental shelf break as far as 130º E, with only minor eddies into the Bight. It has a low salinity and warm temperatures (17 - 19º C). It passes from west to east in a narrow band predominantly (though not exclusively) during winter months (Rochford 1986), when its velocity is at a maximum. It affects the sea-floor as well as the surface due to its vertical homogeneity.

The Flinders Current. This surface-flowing current runs westward along the continental slope throughout the year and is the world's only northern boundary current (Middleton and Cirano 2002). It has a relatively low mean salinity and a mean temperature of only 14º C. This current originates from the gyre south of South Australia (Bye 1972).

In addition to these currents a water mass exists over a broad region of the Great Australian Bight shelf east of 130º E. This water mass is produced in the western Bight around October each year. It intensifies throughout the summer and autumn whilst spreading in an easterly direction over the shelf and slope region as a plume, to a maximum easterly extent greater than 136º E (Petrusevics 1991, Herzfeld 2000). It is highly saline water with warm surface temperatures (17 - 21º C), which may be 2 - 3º C higher than the surrounding water. The origin of the warmest water in the plume is observed to be in a shallow (<30 metres deep) strip of coastal water in the north-western Bight between 124º and 129º E (Herzfeld 2000). This water mass, combined with the Leeuwin Current, provides a continuous band of warm water stretching across the Bight in winter.

Another water mass, the west wind drift cold water mass is also recognised. It has low salinities and temperatures (9 - 14º C), and is found throughout the year off the slope region of southern Australia. It periodically intrudes into the shelf break, especially when the Leeuwin Current is weakly developed (Rochford 1986). During summer and autumn surface waters over the shelf can become stratified with a well-defined near mid-depth temperature and salinity discontinuity. Westerly winds during winter favour downwelling of shelf waters which means that stratification is eroded and the water column is near homogeneous in terms of temperature and salinity.

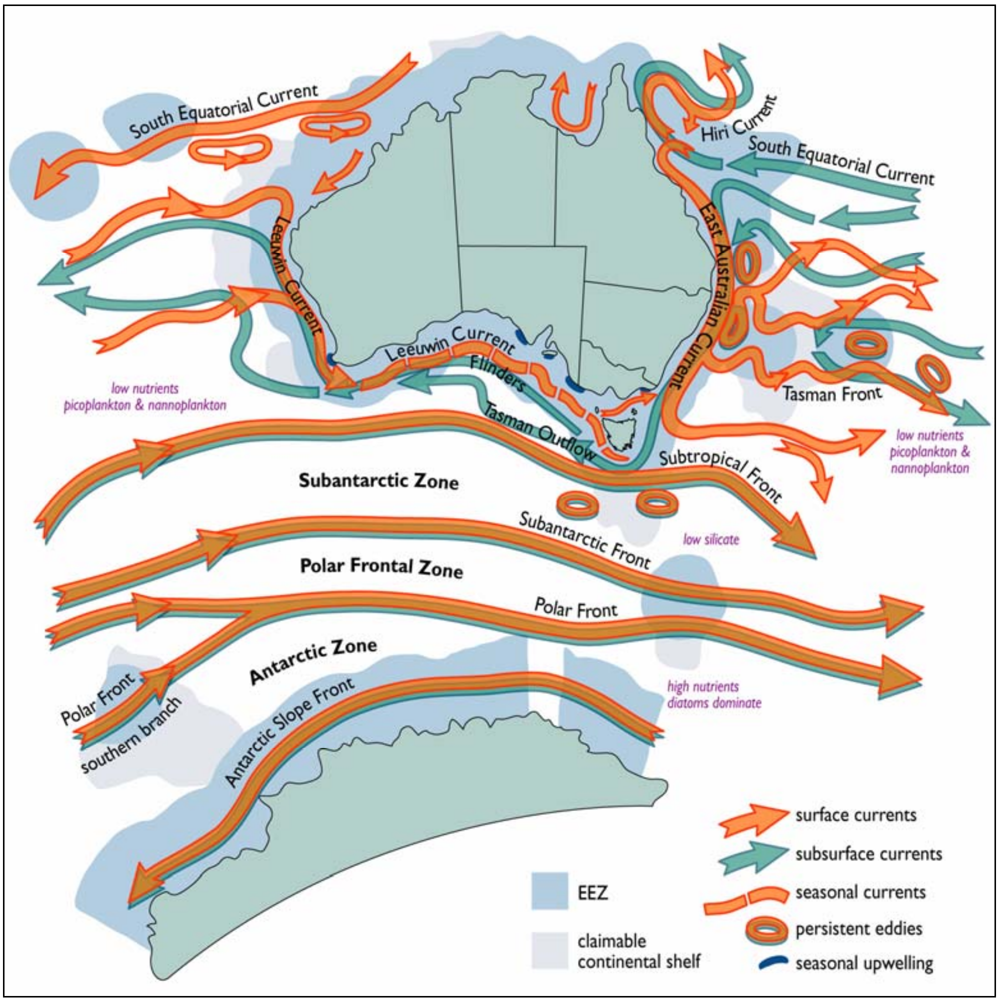


Figure 9: **Ocean Currents of Australia**
(Source: CSIRO Marine Research)

3.3.4 Oceanographic Sectors

The open waters within the continental shelf of the Great Australian Bight are divided into distinct oceanographic sectors (*Figure 10*). These are:

Baxter This sector is the western-most part of the Bight (James *et al* 2001). In near-shore waters the sea surface temperature reaches a warm 22º C in spring and summer. This warm, saline water extends offshore forming a strong thermocline that characterises the shelf throughout autumn. Throughout winter the warm Leeuwin current occupies the entire outer shelf whilst inshore waters cool significantly. Although the Baxter sector is affected by strong winter storms, the shelf is semi-protected from south-westerly swells.

Eyre This sector encompasses the middle of the Bight. Inshore waters of this sector stratify in summer, when sea surface temperatures warm to over 23º C, and salinity increases due to evaporation. There are year round south-westerly swells, and in winter the sector is fully exposed to storms. At this time inshore waters cool and the warm Leeuwin current enters from the west to join with the Great Australian Bight plume over the outer shelf and upper slope (James *et al* 2001).

Ceduna This sector lies to the east and is characterised by the cool, nutrient rich up-welled waters that intrude onto the shelf during summer, forming a strong thermocline across the shelf and reaching the surface in some coastal areas. Stratification of shelf waters weakens during late autumn and disappears during winter, as saline, oligotrophic water from the central Bight moves eastward. The sector is directly exposed to year-round south-westerly swells.

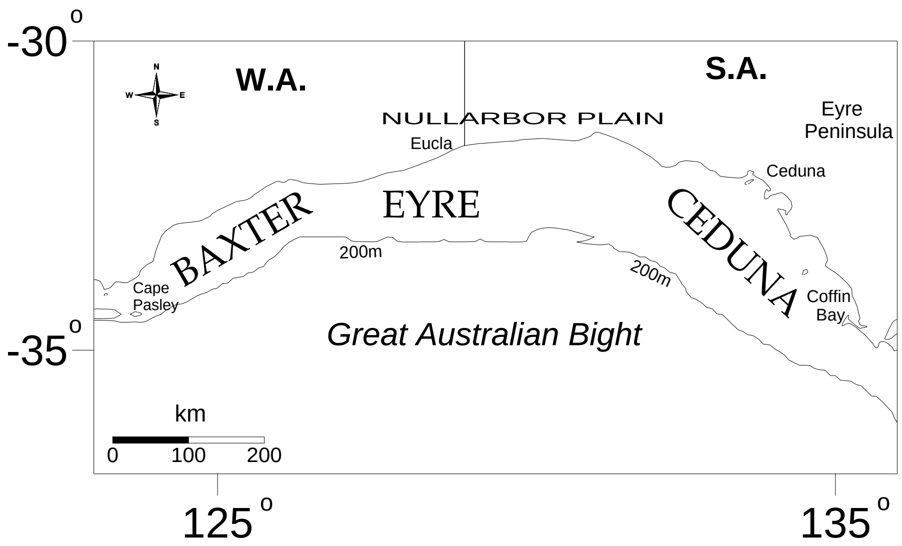


Figure 10: **Oceanographic Sectors**
(Source: Hill *et al* 2001)

4. Biological Features

4.1 Biogeography

The Interim Marine and Coastal Regionalisation for Australia (IMCRA) is a biogeographic ecosystem-based classification system developed to assist in marine planning. It divides the marine and coastal environment into regions, provinces and biotones out to the shelf break (200 metre isobath) based on physical and biological characteristics. Beyond the shelf break, sea floor topography and physical oceanography of the 0-50 metre water column is used (IMCRA Committee 1998).

The inshore waters of the Great Australian Bight can be divided into one pelagic province (Southern Pelagic Province), three demersal provinces and biotones (South Western Province, Great Australian Bight Biotone and Gulfs Province) and four meso-scale regions (McLeay *et al*. 2003). Beyond the shelf break, the sea floor topography of the Bight is described as slope/steep slope and abyssal plain/abyssal rise.

4.1.1 Meso-scale Regions

The inshore waters of the Marine Park lie within the Eucla Bioregion (*Figure 11*). This bioregion encompasses the western half of the Great Australian Bight. The swell-dominated inshore habitats of the Eucla Bioregion are characterised by the dominance of sand habitat, which cover approximately 88.5% of the total inshore habitats mapped. In contrast, reef habitats comprise only 11.5%, and with a lack of estuaries, no significant seagrass meadows have been recorded.

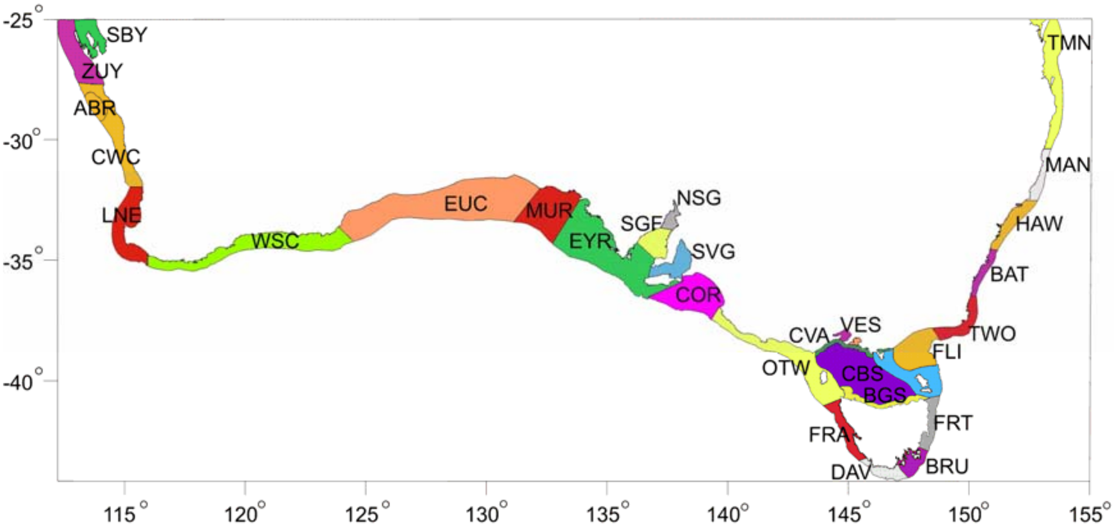
The Eucla Bioregion is an area of relatively low productivity and benthic biodiversity, but is influenced by the warm waters of the Leeuwin Current and coastal heating, so that warm temperate affinities can be found in the marine biota. Brown algae of *Cystaphora* species dominate the intertidal and sublittoral fringe. *Ecklonia radiata* and *Scytothalia dorycarpa* dominate the high-energy reefs. This bioregion forms important habitat for Australian Sea-lions and breeding southern right whales.

The Murat Bioregion covers about half of the eastern half of the Bight. It features a generally rocky coast with numerous sheltered embayments for seagrasses (and one species of mangrove), which cover 61.3% of the total inshore habitats mapped, while sand habitats and reef habitats occupy 21.5% and 17.2% respectively. It includes numerous offshore reefs and islands. Its fauna and flora also reflects the influence of the Leeuwin Current, and species diversity is moderate to low.

The exposed rocky coast of the Eyre Bioregion covers the eastern Bight, extending to Kangaroo Island. It comprises mostly sand (56.2%) and reef habitats (24.6%), with seagrass habitats (19.2%) principally confined to the sheltered embayments of Port Douglas, Venus Bay and Baird Bay. It is characterised by high energy, cool temperate waters and the influence of the localised nutrient-rich upwellings. Very high levels of benthic biodiversity (particularly in the macroalgae, especially red algae) and productivity have resulted in this region being a key area of krill and pilchard abundance and one of the most important sites for seabirds and marine mammals in temperate Australia (Edyvane 1998a).

The eastern limits of the Western Australia South Coast Bioregion extend into the western Bight. This bioregion is a high-energy wave environment characterised by prominent headlands, limestone cliffs and beaches backed by dune fields (McLeay *et al*.

2003). The marine flora and fauna has strong affinities with the southern Australian region but with a significant endemic element.



Key to meso-scale regions

ABR	Abrolhos	**HAW**	Hawkesbury Shelf
BAT	Batemans Shelf	**LNE**	Leeuwin-Naturaliste
BGS	Boags	**MUR**	Murat
CBS	Central Bass Strait	**NSG**	Northern Spencer Gulf
COR	Coorong	**OTW**	Otway
CVA	Central Victoria	**SBY**	Shark Bay
CWC	Central West Coast	**SGF**	Spencer Gulf
DAV	Davenport	**SVG**	St Vincent Gulf
EUC	Eucla	**TMN**	Tweed-Moreton
EYR	Eyre	**TWO**	Twofold Shelf
FLI	Flinders	**VES**	Victorian Embayments
FRT	Freycinet	**WSC**	WA South Coast
FRA	Franklin	**ZUY**	Zuytdorp

Figure 11: **Meso-scale Regions of southern Australia**
(Source: Interim Marine and Coastal Regionalisation for Australia Technical Group 1998)

4.2 Marine Mammals

4.2.1 Southern Right Whale

The southern right whale (*Eubalaena australis*) is an 'icon' species, which provided a primary motivation for the proclamation of the Great Australian Bight Marine Park.

Southern right whales have a southern hemisphere circumpolar distribution. The population using the southern Australian coast has summer feeding grounds within the Antarctic and sub-Antarctic regions, and a winter migration to Australian coastal waters from May to October to calve and mate. Warm water from the Leeuwin Current may be important for calving in the Bight, since cetaceans are born with little insulation.

The routes of migration are not precisely known (Kemper *et al*. 1994), but probably comprise a broad front rather than a narrowly defined path. Burnell's (2001) observations suggested that southern right whales may take an almost circular anti-clockwise migration along the south coast of the Australian continent.

A lack of suitable prey (i.e. pelagic larval crustaceans and copepods), whaling data and recent observations all suggest that no feeding occurs in continental Australian waters. This implies that calving females fast for at least four months (Bannister *et al*. 1996).

Historical whaling records indicate that calving areas were once common in protected bays and estuaries of the southern Australian coast, with occasional animals reported north of 25º S. Currently, breeding and calving aggregations are primarily in western South Australia, and Western Australia along the shores of the Great Australian Bight to Cape Leeuwin (Bannister 2001). In this region there appears to be some preference by calving females for shallow north-east trending bays over sandy bottoms, with animals occurring in a narrow band, generally no more than one kilometre from the shoreline (Bannister *et al*. 1996).

There is a high degree of fidelity to nursery sites, with some 92% of females returning between years (Burnell 2001). Similar conditions are favoured in South African waters, where Elwen and Best (2004) also concluded that the social structure within the nursery grounds was of great importance for reproductive success.

The tall cliffs at the Head of Bight provide an excellent viewing platform for the general public and scientists to observe and study southern right whales, and much of the present knowledge of the movements and behaviour of this species in Australian waters stems from studies undertaken there.

The nursery area at the Head of Bight is one of the most important breeding areas in the world, with about one third of the observed number of calves born in Australian waters born there. Between 1991 and 1997 over 350 individuals were identified in the Head of Bight region (Burnell 2001), with the highest recorded number on a single day being 103 in 1998 (Burnell 2002).

Inshore movements of breeding females have been reasonably well documented. Some individuals remain resident in preferred calving sites for the entire winter season while others are mobile over large areas of coastline (Bannister *et al*. 1996, Burnell 2001). Movements of animals other than calving females (i.e. males, non-breeding females, juveniles and sub-adults) are understood less, but appear to be far more transient (Bannister 1993, Burnell and Bryden 1997, Burnell 2001). Southern right whales in southern Australian waters are thought to belong to a single population (Burnell 2001).

The southern right whale is presently considered both 'endangered' (under the Commonwealth EPBC Act) and 'vulnerable to extinction' (by the World Conservation Union and the IUCN). Population levels are classed as severely reduced, increasing but not yet secure. The rate of increase is naturally slow because of the three-year calving cycle. Estimates currently put the world population of southern right whales at around 7500 (Anon. 1998), with an Australian population of about 1500 (Bannister 2004). While the species is recovering, there are concerns that the low population base following being hunted to near-extinction has resulted in a low genetic diversity.

A National Cetacean Action Plan (Bannister *et al*. 1996), Guidelines for Cetacean Observation (Environment Australia 2000) and a Southern Right Whale Recovery Plan have been developed. The Southern Right Whale Recovery Plan can be viewed at www.deh.gov.au/biodiversity/threatened/publications/recovery/e-australis/index.html.

The Great Australian Bight Marine Park represents a major contribution to the world-wide recovery of the species.

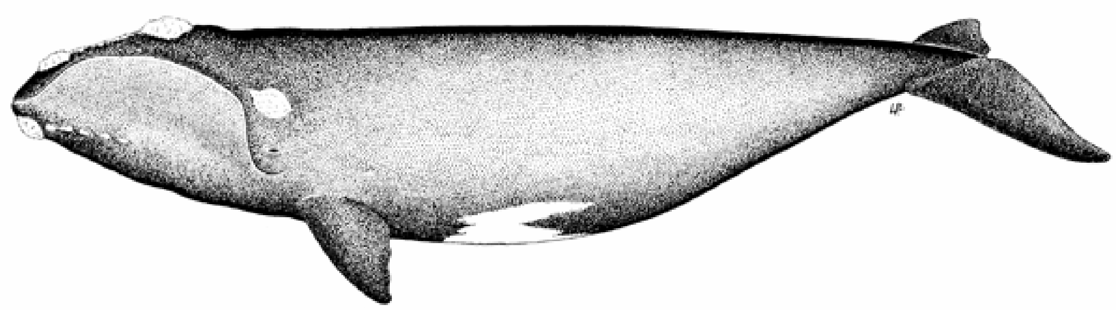


Figure 12: Southern right whale
(Source: Food and Agriculture Organization of the United Nations)

4.2.2 Australian Sea-lion

The Great Australian Bight Marine Park also protects the Australian Sea-lion (*Neophoca cinerea*). This species occurs mainly on offshore islands from the Houtman Abrolhos, off Western Australia to Kangaroo Island, South Australia (Shaughnessy 1999).

Colonies of the Australian Sea-lion occur under the Bunda Cliffs adjacent to the State Park and the largest of these occurs at the base of cliffs midway between Wilson Bluff and the Head of Bight. Further surveys along the Bight coastline have revealed a total of ten breeding sites and 14 haul-out sites (Dennis and Shaughnessy 1996). Haul-out platforms are formed by collapsed sections of the cliff at various levels above the sea.

Recent studies of the population genetic structure of Australian Sea-lions suggest that the South Australian and Western Australian populations are genetically distinct (Campbell 2003). Estimates of genetic distance suggest that these populations have been isolated for 170 000 years. Studies suggest there is a pattern of almost exclusive female natal site fidelity (Campbell 2002). This means that females return to their birth site to breed and, subsequently, there is a very low chance of recolonisation of locally extinct colonies, as is the case in Bass Strait where seal harvesters exterminated all breeding colonies in the late 1700s and early 1800s.

The Australian Sea-lion is unusual in that it breeds every 17 to 18 months , rather than the usual 12 months for most pinnipeds (seals and sea-lions) (Gales 1990). The rate of increase in populations is also limited by delayed sexual maturity (Gales *et al*. 1994). The species also has an asynchronous breeding cycle, meaning that various colonies could be breeding at different times (Gales *et al*. 1994). Females invest much time and energy nursing their pups, usually for 15 - 18 months until the next pup is born. If an Australian Sea-lion does not pup consecutively each breeding season, she may continue to nurse her current young for up to 40 months (Higgins and Gass 1993).

Australian Sea-lions are relatively sedentary and do not undertake definite migrations or seasonal movements (Shaughnessy 1999). Females with dependent young may move between haul-out areas to nurse during lactation.

Foraging behaviours vary over geographic range, but data available indicate that Australian Sea-lions are benthic foragers in waters near their breeding sites, making short trips of 20 – 30 kilometres and feeding in depths of the order of 60 – 80 metres (Costa and Gales 2003). Adult males forage in depths to 300 metres (Gales and Costa

1997). Little is known of the precise diet but data suggest a broad diet including cephalopods (squid or cuttlefish), fish and benthic species (Shaughnessy 1999). Female and juvenile sea-lions may also feed on southern rock lobsters (Richard Campbell personal communication). Sea-lions work hard to exploit the food in the benthic areas around their breeding sites. They are generally deeper feeders than the fur seals that occupy the same regions and their thick blubber is a functional adaptation for this (Costa and Gales 2003).

The Australian Sea-lion is the only pinniped that is endemic to Australia. It is listed as 'rare' under South Australian legislation and has 'special protected species' status in Western Australia. Nationally, it is listed as a threatened species (vulnerable) under the EPBC Act. Internationally, it is listed as 'rare' in the 1994 IUCN Red List of Threatened Animals. A recovery plan for the Australian Sea-lion is currently in preparation. The estimated population of Australian Sea-lions is between 9900 and 12 400, with an estimated 6% of the population occupying the Bight (Dennis and Shaughnessy 1996). The Great Australian Bight Marine Park has a critical role in protecting this species.

4.2.3 Other marine mammals

The New Zealand fur seal (*Arctocephalus forsteri*) is a common species with a distribution across the southern coast of Australia and southern Tasmania as well as in New Zealand, where it is much more numerous. The South Australian population of the fur seal is estimated at 27 500 (Shaughnessy *et al*. 1994), and this is increasing (Shaughnessy and McKeown 2002).

In the Great Australian Bight the most westerly South Australian colonies are located on Nuyts Reef and the most easterly sites in Western Australia are on the Recherche Archipelago. Between these two locations, a number of haul-out sites have been recorded, where only small numbers of fur seals are found (Dennis and Shaughnessy 1996).

The New Zealand fur seal does not presently fall into any of the IUCN 'threatened ' categories (i.e. critically endangered, endangered or vulnerable), but is currently recognised as 'conservation dependent' in the lower risk IUCN category (Dennis and Shaughnessy 1996). The species is afforded some protection as a listed marine species under the EPBC Act. The Australian fur seal is also found off the coast of South Australia.

Dolphins are probably the most frequently sighted toothed cetaceans in the Bight, especially inshore. These are the common bottlenose dolphin (*Tursiops truncatus*), the Indo-Pacific bottlenose dolphin (*T. aduncus*) and common dolphin (*Delphinus delphis*).

Sightings and strandings suggest that 31 species of cetacean occur in South Australian waters, and of these 20 are known from the Great Australian Bight between the Western Australian border and tip of Eyre Peninsula (2003 SA Museum list, C. Kemper, personal communication). Five of these are baleen whales (i.e. filter-feeding, including the southern right whale), and 15 toothed whales. Many toothed cetaceans prey upon the cephalopods (squids, octopus and cuttlefish) which are thought to be diverse and abundant in the Ceduna Canyons and on the edge of the continental shelf (Kemper 1998).

Some species such as the blue whale (*Balaenoptera musculus*) (listed as 'endangered' under the EPBC Act), sperm whale (*Physeter macrocephalus*) and humpback whale (*Megaptera novaeangliae*) (listed as 'vulnerable' under the EPBC Act) are migratory and have been sighted along the Bight by tuna spotters in aircraft.

The warm Leeuwin Current has been suggested as a mechanism for bringing individuals of tropical species such as Bryde's whale (*Balaenoptera edeni*) into southern waters (Kemper and Ling 1991). Possible resident cetaceans include the killer whale (*Orcinus orca*), beaked whales and several dolphin species. Little information is available on their distribution, abundance and ecological requirements, although in the case of killer whales their presence is probably related to the abundance of pinnipeds in the region upon which they feed (Kemper and Ling 1991).

4.3 Fish

The fish fauna of the southern temperate region as a whole is diverse, and most species occur nowhere else in the world. This is in strong contrast to the fauna of northern Australian waters where endemism is relatively low. According to Edyvane (1998a), the fish fauna of the Great Australian Bight is poorly known, particularly for non-commercial species.

The species composition of the Bight appears to be typical of southern temperate Australian coastal waters (Glover and Olsen 1985), with many species in common with southern and south-western Western Australian waters, and to a lesser extent, with western Victoria and north-west Tasmania. For example, Hutchins and Thompson (1983) reported that of the 344 species they listed for south-western Western Australia, 61% extended eastwards to, at least, off South Australia.

Species restricted to South Australia that occur in the Bight region include the coastal stingaree (*Urolophus orarius*) and the crested threefin (*Norfolkia cristata*) (Edyvane 1998a). Overall there are some 300 species of known marine fish recorded off the Great Australian Bight down to the base of the continental slope, which represents approximately 67% of the species recorded from all South Australian marine waters (Glover 1982).

Most of the species in the Bight tend to be inshore with fairly permanent resident populations. However, there are also some regular migratory visitors such as the Australian salmon (*Arripis truttaceus*) and occasional oceanic vagrants such as oceanic sunfish (*Mola* sp.), basking shark (*Cetorhinus maximus*), black marlin (*Makaira indica*), and the lizardfish (*Saurida undosquamis*). Their presence in these waters can be attributed to the easterly flowing Leeuwin Current (Glover and Olsen 1985).

A survey of offshore fish in the Bight, at depths of 400-1200 metres (Newton and Klaer 1991), has recorded 166 species of deep-sea fishes, recording new species and extending species distributions (Glover and Newton 1991).

The warm Leeuwin Current is also responsible for the dispersal of pelagic marine organisms into the Bight region. Life history characteristics, such as spawning, migration, recruitment and feeding patterns of many species along the western and southern seaboard of Australia have evolved under the influence of this current (Maxwell and Cresswell 1981, Wilson and Allen 1987, Lenanton *et al*. 1991). Therefore, tropical pelagic species, such as the southern bluefin tuna (*Thunnus maccoyii*) move with the Leeuwin Current in their migration from the spawning grounds in the Java Sea.

Southern bluefin tuna migrates through the southern oceans between 30° S and 50° S, tending to move in an easterly direction around the south of the Australian continent as they age. Individuals of about one to four years old are found seasonally in the surface waters off southern Australia, and the Bight appears to be an important feeding and nursery ground during the summer (Cowling *et al*. 1996). Older juveniles move into deeper waters, and by maturity, most lead an oceanic, pelagic existence and have an almost circumpolar distribution. Fish mature at about eight years of age and may live as long as 40 years.

Other commercial pelagic fish whose distribution and abundance is affected by the Leeuwin Current include blue mackerel (*Scomber australasicus*), horse mackerel (*Trachurus declivis*), Australian salmon and Australian herring (*Arripis georgianus*). The distribution and abundance of these species is influenced by the seasonality, strength and timing of the Current.

Australian salmon comprise a single stock with one known spawning location near the south-western coast of Western Australia, but with migrations of young fish as far as the Coorong (Cappo 1987).

Mulloway (*Argyrosomus hololepidotus*) is another important recreational and commercial fish species in South Australia that undergoes a migratory journey. Observations from fishers in the Great Australian Bight indicate a westward movement of fish from the Head of Bight in the spring to summer period and a reverse movement in the autumn to winter period (Hall 1986). Several management measures have historically been put in place with the special aim of conserving the mulloway stock in the area (Jones 1991).

Summer spawning pilchards or sardines (*Sardinops sagax*) are commercially significant as baitfish (especially for caged tuna) and are also one of the major prey species of a range of fish, bird and mammalian predators, including the little penguin (*Eudyptula minor*), the southern bluefin tuna and Australian salmon (Fletcher 1990). In 1995 there were mass mortalities of pilchards across the southern coast of Australia, emanating from populations off the Eyre Peninsula (Griffin *et al*. 1997). A similar event occurred in 1998. These events demonstrated the extremely rapid spread of disease in this species, and offered evidence that anchovies (*Engraulis australis*) may have expanded their range and abundance as a consequence of the rapid declines in pilchard populations (Ward *et al*. 2001).

A range of shark species is found in the Bight, some of which are targeted as the basis for a well-established shark fishery. Many shark species are long-lived, take many years to reach maturity and produce only a few offspring at a time, thus making them vulnerable to population declines. Sharks may also be migratory and travel long distances to reach breeding grounds.

Of particular note is the great white shark (*Carcharodon carcharias*). Although naturally uncommon, this species is relatively abundant due to the large number of prey species, such as pinnipeds (Bruce 1992). It is listed as 'vulnerable' under the EPBC Act, and a Recovery Plan has been produced (Commonwealth of Australia 2002). Females do not reproduce until in excess of 4.5 – 5.0 metres in length (age 18 – 23 years), produce few pups (2 – 10) and reproduce every two to three years (Malcolm *et al.* 2001).

4.4 Birds

Very little is known about the ecology of seabirds in the Great Australian Bight. Of the 110 species found in Australian waters, 72 are known to visit the coastal and oceanic waters off South Australia. Of these, only ten breed in significant numbers in South Australia (Copley 1995). Approximately 75% of the total number of breeding seabirds in South Australia are found in the eastern Bight, and this mainly comprises short-tailed shearwaters or muttonbirds (*Puffinus tenuirostris*) and white-faced storm petrels (*Pelagodroma marina*) which migrate to islands of the region (e.g. Nuyts Archipelago and Franklin Islands) to breed. Caspian terns (*Sterna caspia*), fairy terns (*Sterna nerius*) and pacific gulls (*Larus pacificus*) occur in a small number of colonies in the Bight.

Breeding colonies of little penguins are known to occur at the base of the Nullarbor Cliffs (Reilly 1974). In personal communications to Slater (1998), P. Dann highlighted the importance of this area as one of the few remaining mainland breeding sites, with a population of perhaps 600 birds.

Less than 50 pairs of osprey (*Pandion haliaetus*) occur in South Australia with more than half of these in the Bight region (Dennis 2004). The South Australian population of the white-bellied sea-eagle (*Haliaeetus leucogaster*) has declined by about 40% in historical times. 32% of the current population occur in the Bight region (Dennis and Lashmar 1996).

Large breeding grounds for the Cape Barren goose (*Cereopsis novaehollandieae*) occur on islands off the west and south coasts of Eyre Peninsula (Robinson *et al*. 1982), and eastern reef egrets, rock parrots and pelicans are also known to breed at such sites (Eckert *et al*. 1985).

During a survey of the Bight during 2000/2001, Burton *et al*. (2001) recorded over 5000 seabirds belonging to 17 species, mostly petrels (especially the great winged petrel, *Pterodroma macroptera*), shearwaters and albatrosses. Other species commonly observed in the Bight include the Australasian gannet (*Morus serrator*), black-faced cormorant (*Phalocrocorax fuscescens*), crested tern (*Sterna bergii*) and fleshy-footed shearwater (*Puffinus carneipes*) (Simpson and Day 1999).

Although they do not breed in the region, migratory seabirds, such as albatrosses, petrels and prions are known to frequent the pelagic shelf regions of the Bight where waters are cooler, presumably for feeding (Copley 1995, Surman and Wooller 2000). These include species listed in the EPBC Act such as the southern giant petrel (*Macronectes giganteus*), shy albatross (*Thalassarche cauta*), wandering albatross (*Diomedea exulans*), southern royal albatross (*D. epomophora*) and sooty albatross (*Phoebetria fusca*), species that are becoming alarmingly endangered or vulnerable to extinction (Baker *et al*. 2002). A number of species listed on the JAMBA and CAMBA agreements also frequent the Bight region. These include the wandering albatross, sooty shearwater (*Puffinus griseus*), fleshy-footed shearwater and short-tailed shearwater.

4.5 Flora

4.5.1 Seagrasses

South Australia has one of the world's largest seagrass ecosystems (Larkum *et al*. 1989), with about 10% of these meadows occurring in the Great Australian Bight (Edyvane 1999). Here, seagrass distribution is patchy and mostly limited to sheltered bays or in the lee of reefs and islands in the eastern Bight with *Posidonia* species dominating. Species with warm water affinities tend to decrease in number from west to east as water temperatures decline. No seagrass communities occur in the Marine Park (Edyvane 1998a).

4.5.2 Macroalgae (Seaweeds)

Seaweed diversity and endemism in Australian temperate waters is recognised as being among the highest in the world, with the number of species found in southern Australia being 50 - 80% greater than elsewhere (Phillips 2001). South Australian waters contain over 1200 species (Womersley 1981). It is probable that such diversity is associated with the high clarity of the Bight waters, that enables photosynthesising organisms to live at depths of up to 70 metres (Shepherd 1979). As for other marine biota in the region, a long period of geological isolation is likely to be a major factor (Phillips 2001).

Brown algae (Phaeophyta) and red algae (Rhodophyta) are especially diverse. In the rocky reefs of the State Marine Park, subtidal macroalgal communities are dominated by the kelp *Ecklonia radiata* and the fucoid *Scytothalia dorycarpa* (Edyvane 1998a). Of particular interest is the presence of an undescribed species of *Sargassum*. The Leeuwin Current is thought to have introduced this and other tropical elements to the region.

4.6 Benthic Invertebrates

Little is known of the composition of the benthic fauna of the Great Australian Bight. However, sampling effort has increased in recent years (e.g. CSIRO Southern Surveyor Cruise 2000, Ward *et al*. 2003a), and many species new to science have been recovered.

Taxonomic research is slow by nature, and it is understood that of the more than 6500 invertebrate species found in South Australian waters, only about a third have been adequately collected and described (EPCSA 1998). Similarly, difficulty of access makes an understanding of the role of benthic organisms in the Great Australian Bight ecosystem extremely difficult to ascertain, especially at great depths.

The few studies that have been conducted indicate a high level of marine biodiversity and endemicity among the invertebrate fauna. McLeay *et al*. (2003) briefly reviewed the benthic fauna of the Bight region, referring in part to the numerous recent accounts of species provided in the Zoological Catalogues of Australian marine invertebrates series, and other taxonomic texts. The South Australian Research and Development Institute (SARDI) conducted a large benthic sampling survey within the Bight, including the Benthic Protection Zone in 2002 (Ward *et al*. 2003a). This study confirmed that the Bight region is one of the world's most diverse benthic ecosystems (O'Hara and Poore 2000).

The SARDI survey collected a total of 811 species, of which sessile, colonial poriferans, ascidians and bryozoans dominated, comprising 72.5% of the species, and 96.5% of the biomass. The abundance of these groups was also reflected in the high proportion of suspension-feeders (86% of species), relative to deposit-feeders and scavengers/carnivores. Poriferans (sponges), ascidians (sea squirts) and/or bryozoans (lace corals) were found to be the dominant species at the sites surveyed and the most abundant free-living organisms were echinoderms and molluscs. The prevalence of suspension feeders in the Bight compared with soft-bottomed habitats elsewhere was likely related to the coarse sediments of the region (and lack of riverine input), and relatively high plankton concentrations (Ward *et al*. 2003a).

The survey concluded that the Benthic Protection Zone is reasonably well placed to represent the biodiversity of the Bight, as 53% of the species collected were obtained there.

The following, taken from McLeay *et al*. (2003), summarises the current state of knowledge on benthic invertebrates in southern Australian waters.

4.6.1 Sponges (Phylum Porifera)

Approximately 1000 species of sponges belonging to 200 genera have been described from southern Australia. However, most descriptions were made in the 1800s and, as yet, it is difficult to compare their significance to elsewhere in the world (Bergquist and Skinner 1982).

4.6.2 Corals (Phylum Cnidaria, Class Anthozoa)

Corals are popularly known from tropical waters, but some occur in the Bight, including three reef-building species in shallow waters, and more than 50 non-reef-building species in waters up to 900 metres deep (Shepherd and Veron 1982). The distribution of corals in the Bight is largely unknown. Records of soft corals are rare from Albany to the Bight and there are no records of shallow-water soft corals from the western and central Bight (Alderslade 2003).

4.6.3 Hydroids (Phylum Cnidaria, Class Hydrozoa, Order Hydroida)

Hydroids, which are related to corals, are small, sessile organisms that are abundant in southern Australian waters, with around 200 species from eleven families recorded (Watson 1982). This represents about half of the families' known and reflects the lack of knowledge of species composition and distribution in Australia (Watson 1982).

4.6.4 Polychaetes (Phylum Annelida, Class Polychaeta)

Most polychaete worm families (67 out of 81) are represented in Australia, with the highest degree of endemism occurring in southern Australia. Hutchings (1982) described 100 polychaetes from southern Australia; however, this listing is incomplete and reflects a paucity of knowledge of the taxa in Australia.

4.6.5 Sea squirts (Phylum Chordata, Class Ascidiacea)

The waters of southern Australia contain some of the richest assemblages of ascidians (sea squirts) in the world, with over 200 described species (Greenwood and Gum 1986), many of them endemic to the northern Bight (Kott 1975). Many of these species have been recorded near the offshore islands of the Bight region and among the extensive limestone cave systems of western Eyre Peninsula.

4.6.6 Lace corals (Phylum Bryozoa)

According to Bock (1982) there are over 500 species of bryozoans (lace corals) in southern Australia. These animals contribute up to 80% of the total sediment production on the shelf of South Australia (Wass *et al*. 1970, Edyvane 1999). However, the number and distribution of species in the Bight is poorly understood.

4.6.7 Sea stars, sea cucumbers, urchins, feather stars (Phylum Echinodermata)

Over 300 species of echinoderms have been recorded from shallow water (0-100 metres) marine habitats in southern Australia (O'Hara and Poore 2000). However, little is known of their distribution and abundance in the Bight. Of the temperate echinoderm species found in southern Australia, 90% are endemic. O'Hara and Poore (2000) attributed much of the speciation to that within a few large cosmopolitan genera.

Many of the species recorded from South Australia originate from the Indo-Pacific region, and arrived via the Leeuwin Current (Maxwell and Cresswell 1981). Echinoderms of Indo-Pacific origin include the basket star (*Euryale aspera*) and the holothurians (sea cucumbers) *Pentacta anceps* and *P. quadrangularis* (Maxwell and Cresswell 1981).

4.6.8 Shells, sea slugs, octopus, squid and cuttlefish (Phylum Mollusca)

Approximately 95% of molluscs found in southern Australia are endemic (Wilson and Allen 1987, Poore 1995). Nudibranchs, the generally small and colourful sea slugs, are very well represented in South Australian waters, with over 500 species recorded (Greenwood and Gum 1986). Volutes, cones and cowries (Class Gastropoda) represent a relict tropical element, with interesting species such as the giant baler shell (*Melo miltonis*) and black cowrie (*Cypraea friendii*) being found in the Bight (Edyvane 1999). The distribution and abundance of most molluscs in the Bight is unknown; however, the biology of commercially important species such as abalone (*Haliotis* spp.) and southern calamari (*Sepioteuthis australis*) is relatively well known.

4.6.9 Crabs, shrimps, lobsters (Phylum Arthropoda, Subphylum Crustacea)

Little is known of most crustaceans in southern Australia except for the well known, commercially important species such as the southern rock lobster (*Jasus edwardsii*), western king prawn (*Melicertus latisulcatus*) and giant crab (*Pseudocarcinus gigas*), a species endemic to southern Australia. There is a paucity of decapod crustacean (e.g. crabs, lobsters, shrimps) collections from east of Esperance, particularly from deep waters (Morgan and Jones 1991). Of interest is the shrimp *Rhynchocinetes enigma* that is only known from the Bight (Okuno 1997). A total of 204 Cirripedia (barnacle) species have been recorded in Australia with eleven found in the Bight.

5. Economic and Social Values

5.1 Fisheries

The Great Australian Bight supports six Commonwealth fisheries managed by the Australian Fisheries Management Authority (AFMA), and six major (and several minor) State fisheries managed by Primary Industry and Resources South Australia (PIRSA).

5.1.1 Commonwealth Fisheries

The marine fauna of the Commonwealth waters (between three nautical miles and the limit of the Australian Fishing Zone at 200 nautical miles offshore) from the Western Australian border to just west of Cape Adieu support several commercially significant fisheries. Each of these operates across Australia's southern coastline, including the waters of the Marine Park.

These fisheries are managed by AFMA under the *Fisheries Management Act 1991* and in accordance with the EPBC Act. Two of the most important in economic terms are the Southern Bluefin Tuna Fishery and the Gillnet Sector of the Southern and Eastern Scalefish and Shark Fishery (SESSF), while the Great Australian Bight Trawl Sector of the SESSF, in its present form, is relatively new, targeting demersal species in more southerly waters of the Bight.

5.1.1.1 Southern and Eastern Scalefish and Shark Fishery (SESSF)

In 2003, the South East Trawl, Great Australian Bight Trawl and Gillnet Hook and Trap (formerly the Southern Shark and South East Non-trawl fisheries) Fisheries were combined under a single set of management arrangements to become sectors of the SESSF. The Great Australian Bight Trawl (GABT) and Gillnet Hook and Trap (GHAT) sectors operate within parts of the Bight.

Great Australian Bight Trawl Sector

The GABT sector extends from Cape Leeuwin, Western Australia, to Cape Jervis near Kangaroo Island, South Australia. It excludes State (South Australia and Western Australia) fishery shelf waters to the extreme east and west which have traditionally been fished by State based fishers.

The GABT sector is primarily a demersal (bottom) and developmental mid-water trawl fishery based around regular catches of inshore species and trawling for the deeper dwelling species.

It has two basic components; the continental shelf fishery, at depths of less than 200 metres, and the deeper slope fishery, in depths between 200 and 1000 metres. Species caught vary according to depth and the area being trawled.

Shelf species are targeted year round and include deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*), while those taken on the slope are fished seasonally, mainly orange roughy (*Hoplostethus atlanticus*) and various species of oreo and dory (Bureau of Rural Sciences 1998).

Total catch in 2003-2004 was valued at $14 million, comprising mostly deepwater flathead (2466 tonnes), Bight redfish (945 tonnes) and orange roughy (210 tonnes) (ABARE 2005).

At least 30 other commercial species are regularly trawled. The most commonly caught species in the fishery after these three target species are Chinaman leatherjacket

(*Nelusetta ayraudi*), angel shark (Squatinidae), western gemfish (*Rexea solandri*), arrow squid (*Nototodarus gouldi*) and blue grenadier (*Macruronus novaezelandiae*)

For the GABT sector, the status of all species, including target species, is regarded as uncertain.

Onboard observers noted some 40% of the trawl catch was discarded, including fish with potential commercial value, such as latchet (*Pterygotrigla polyommata*), which the industry is attempting to find a market for (AFMA 2002). Whilst most trawls are carried out on substrates with minimal sessile epifauna, some exploratory shots contain significant amounts of benthos including sponges, the precise composition of which has not been assessed (Caton 2002).

The GABT sector was the first fishery to be managed under a statutory management plan made under the Fisheries Management Act 1991. It is managed through input controls including limited entry of vessels (only 10 vessels are allowed to operate), limited cod-end mesh size and area restrictions for boats in excess of 40 metres in length and spatial measures being developed for target species such as orange roughy. Output controls include catch trigger limits for the major target species (in lieu of quota management arrangements expected to be in place in 2006) and catch trigger limits for the main byproduct species.

Demersal trawling is prohibited in all zones of the Marine Park except the Conservation Zone of the State Park. Mid-water trawling is prohibited in the Sanctuary Zone, but allowed in the remainder of the Marine Park under strict management arrangements. All types of fishing are not permitted in the Marine Mammal Protection Zone and Conservation Zone from 1 May to 31 October.

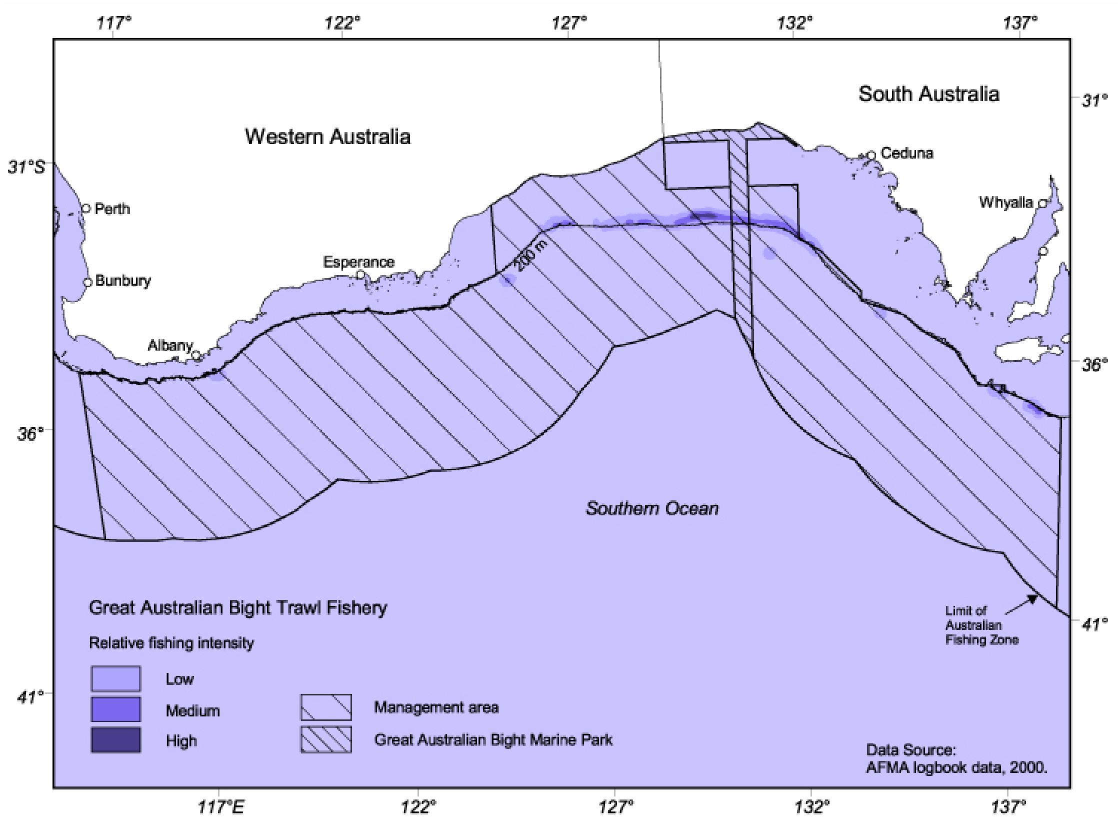


Figure 13: **Great Australian Bight Trawl Sector** (Source: AFMA)

Gillnet or Shark Hook Sectors

The Gillnet or Shark Hook Sectors of the SESSF are collectively known as the GHAT Fishery. This is not a formal sector under the SESSF Management Plan but the term is used to describe the previously separately managed South East Non-trawl and Southern Shark Fisheries into a single fishery sector of the SESSF.

The former South East Non-trawl Fishery (now known as the Scalefish Hook Sector of the SESSF) can be traced back to the early 1900s. Methods traditionally used in the fishery are demersal longlines, droplines, gillnets or traps to target species such as blue eye trevalla (*Hyperoglyphe antarctica*), pink ling (*Genypterus blacodes*) and warehous (*Seriolella* species).

The former Southern Shark Fishery (now known as the Gillnet or Shark Hook Sectors of the SESSF) was established in the late 1920s. Vessels operating in the shark fishery use gillnets and demersal longlines to target primarily gummy shark (*Mustellus antarcticus*), with major byproduct of school shark (*Galeorhinus galeus*) and saw shark (*Pristiophorus* spp.), which together make up the major proportion of the shark fishing catch. Total catch of gummy shark, school shark and saw shark in the Gillnet Sector for 2003-2004 was 3066 tonnes, valued at around $14.3 million (ABARE 2005).

School shark populations are known to have decreased dramatically, as the species has been severely overfished (Caton 2003). Gummy shark is considered fully fished, and the status of the other targeted shark species is uncertain. There is anecdotal information from fishers that trawling on previously good shark grounds has had a detrimental effect on catch rates by modifying bottom habitat (Stevens 1998). Deep-water dogfish are one of many other shark species that have declined markedly in Australian fisheries, and the southern dogfish is IUCN listed as Vulnerable to extinction. It is currently unclear if the 20 mile wide Benthic Protection Zone secured against trawling in the Bight is large enough to offer protection to dogfish species (Stevens 1998). However, protected waters in the northern Bight may aid both school and gummy sharks, as it is possible pregnant females concentrate there. These shark species are mobile animals therefore the current Marine Park may be unlikely to have an overall benefit (Stevens 1998). A fishery closure at the head of the Bight from Eyre Bluff to the Western Australian border has been established to protect breeding grounds of school shark populations.

Most shark fishing operations take place on the continental shelf and slope out to 500 metre depths, and as far west as the South Australia/Western Australia border.

Today the Gillnet and Scalefish Hook Sectors primarily targets Commonwealth-managed species of demersal scalefish, such as pink ling and blue eye trevalla, and shark species. The fishery is managed through an individual transferable quota system and operators use a variety of fishing methods including demersal gillnets, droplines, demersal longlines and traps.

There is concern that demersal gillnets incidentally catch protected species including seals, sea-lions, dolphins and great white sharks. Despite a lack of data, it is reasonable to assume that great white sharks have suffered a long-term decline in abundance in Australian waters, and the species is IUCN listed as Vulnerable (Commonwealth of Australia 2002, Pogonowski *et al*. 2002). There is no current way to estimate either the magnitude or the implications of this suspected decline. Commercial bycatch, including by the Gillnet Sector of the SESSF, is suspected to be the largest cause of mortality for great white sharks in Australia. (Commonwealth of Australia 2002). Shark fisheries have been identified as a threat to Australian Sea-lions (Shaughnessy 1999), particularly those using monofilament gillnets in the vicinity of sea-lion colonies. The fishery closure at the Head of the Bight to protect the breeding grounds of school shark populations may also provide indirect benefit to sea-lions and great-white sharks as it's a known area of concentration for these species.

The Gillnet Sector of the SESSF is permitted in all zones of the Marine Park except the Sanctuary Zone of the State Park.

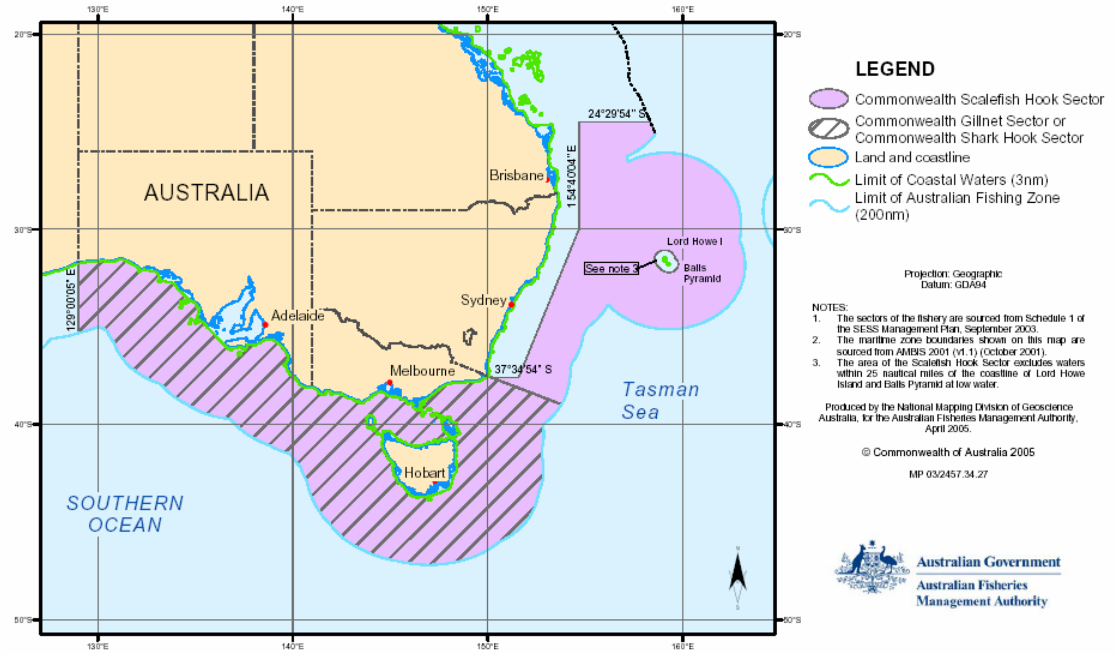


Figure 14: Gillnet and Scalefish Hook Sectors
(Source: AFMA)

5.1.1.2 Southern Bluefin Tuna Fishery (SBTF)

The Australian Southern Bluefin Tuna Fishery in the GAB is part of an international fishery, and is formally managed by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). The CCSBT has existed since 1994 although the 3 founding member nations (Japan, Australia and New Zealand) have set quotas and management measures in place since 1985. The Australian Fisheries Management Authority (AFMA) manages the domestic fishery under the SBTF Management Plan 1995 (including 2004 amendments) (see AFMA 2005a web link) established under the *Fisheries Management Act 1991*. CCSBT has set an annual national catch allocation for Australia of 5265 tonnes, which limits the domestic fishery's catch. The SBTF Management Plan prohibits the taking of other species (Caton 2003).

About 98% of Australia's southern bluefin tuna (*Thunnus maccoyii*) (SBT) is taken by 5-10 purse seine vessels in the Great Australian Bight (AFMA 2005a). Schooling juveniles supply the tuna mariculture industry in Port Lincoln. These are towed alive to static grow-out cages and fattened up for six months before harvest and export primarily to Japan. Pelagic long-liners operating under the Western Tuna and Billfish Fishery Management Plan 2005 (once operational) are able to operate in the eastern Bight where SBT comprise a valuable but largely incidental catch of about 100 tonnes/year. These longliners are required to cover any catch of SBT with quota under the SBTF Management Plan. In the recent past there has been a reduction in effort in the eastern Bight by longliners.

In 2002-2003 5391 tonnes of tuna was caught by the Australian Fishery, at a total value of $256 million (this includes value-adding by fattening in fish farm cages) (Bureau of Rural Sciences 2004).

Southern bluefin tuna has been overfished globally for many years, including take by vessels operating outside international conventions. The CCSBT continues to work actively to bring all catches of SBT under its management regime and is developing processes to allow for rebuilding of stocks. However, catches outside CCSBT control persist, and total removals continue to prevent parental stock rebuilding raising concerns about the sustainability of the Fishery (Caton 2002 & 2003). The CCSBT is working to have all countries taking SBT join the CCSBT.

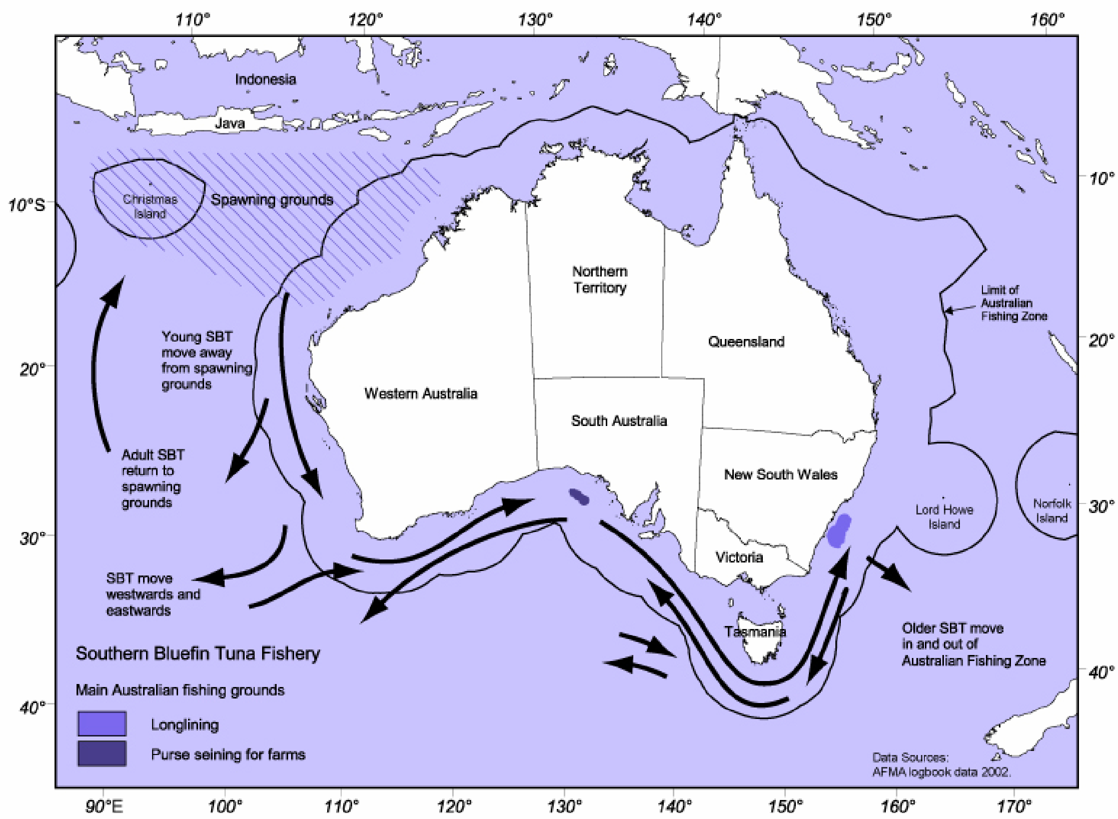


Figure 15: Southern Bluefin Tuna Fishery
(Source: AFMA)

5.1.1.3 Western Tuna and Billfish Fishery (WTBF)

Previously known as the Southern and Western Tuna and Billfish Fishery the Western Tuna and Billfish Fishery covers an area from Cape York Peninsula in Queensland to the southwest corner of Western Australia and extends eastward from this point, across the Bight to the South Australian/Victorian border (AFMA 2005b). The WTBF is part of an international fishery, managed under the Indian Ocean Tuna Commission (IOTC). The domestic fishery is managed by AFMA under the WTBF Management Plan (once determined) established under the *Fisheries Management Act 1991*.

The fishery developed in the mid 1980s and expanded in the late 1990s after Japanese longliners were excluded from fishing in the Australian Fishing Zone (AFMA 2003a, Caton 2002). Formal management arrangements were introduced in 1994 and the fishery has experienced rapid development since 1997.

The fishery is a multi-species and multi-method fishery and targets tuna and tuna-like species. The species targeted are broadbill swordfish (*Xiphias gladius*), bigeye tuna (*Thunnus obsesus*) and yellowfin tuna (*T. albacares*). The fishery also takes several shark and fish species. Albacore tuna (*T. alalunga*) and skipjack tuna (*Katsuwonus* *pelamis*) are also taken as part of the fishery but are minor components. Skipjack tuna is managed as a separate fishery (see below).

The estimated catch of the three target species in 2002-2003 was 1580 tonnes valued at $14.4 million (Bureau of Rural Sciences 2004). The catch for the entire Fishery in 2003-2004 was 1262 tonnes valued at $8.2 million (ABARE 2005). Current status of the fish stocks as reported by the Bureau of Rural Sciences and the IOTC indicates that bigeye tuna is overfished and catches at current levels are considered unsustainable. Broadbill swordfish is fully fished in the Western Indian Ocean and further increases in catch would probably be unsustainable. Yellowfin tuna is fully fished in the Indian Ocean, but only moderately fished adjacent to the SWTBF, and catches at current levels are considered unsustainable. Albacore is under fished (Bureau of Rural Sciences 2004). Few operations target tuna within the Marine Park.

In response to bycatch issues, AFMA has formulated a Bycatch Action Plan for the Commonwealth tuna fisheries. Bycatch recorded from longline catches has included sharks, seabirds, and (rarely) sea turtles and marine mammals. Seabirds, such as albatrosses and shearwaters, are attracted to longline baits when vessels are setting gear, and sometimes become hooked and drown (Bureau of Rural Sciences 2004). A Threat Abatement Plan (TAP) to reduce the incidental catch of seabirds by longliners was approved in 1998. The objective of the Plan is to reduce seabird by-catch in all fishing areas, seasons or fisheries to below 0.05 seabirds per thousand hooks, based on current fishing levels (Environment Australia 1998). The WTBF has met this standard (Amanda Parr, AFMA, personal communication).

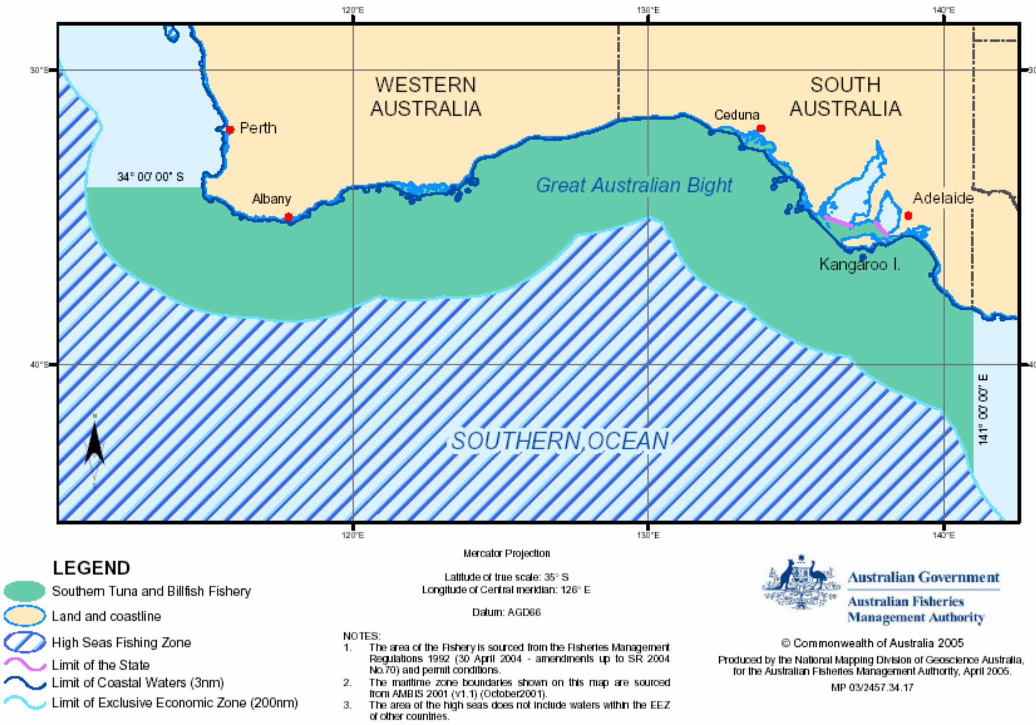


Figure 16: **Western Tuna and Billfish Fishery (Southern Sector)** (Source: AFMA)

5.1.1.4 Skipjack Tuna Fishery (SJTF)

The Skipjack Tuna Fishery is comprised of the Eastern SJTF (ESTF) and the Western SJTF (WSTF). The area encompassed incorporates the entire AFZ but is mainly confined to two areas in southern Australian waters (AFMA 2004). These are in the Bight (WSTF) and off south-east New South Wales (ESTF). The area of the fishery also includes adjacent high seas which includes waters under the mandate of the IOTC and the WCPFC. The domestic fishery is managed by AFMA under a management regime established under the *Fisheries Management Act 1991.*

Skipjack tuna (*Katsuwonus pelamis*) were first caught as late season bycatch in the southern bluefin tuna fishery in the 1950s. The SJTF was part of the ETBF (Eastern Tuna and Billfish Fishery) and WTBF (previously known as the Southern and Western Tuna and Billfish Fishery) until 2003 when AFMA decided to manage it as a separate fishery. The separate fishery was a result of the contrasting catch methods used in each fishery (AFMA 2004) and meets a recommendation of the SJT Consultative Committee established by AFMA. Skipjack tuna is the only target species in the fishery. The majority of the fishery uses the purse seine fishing method with > 95% of the catch being taken by this method.

The value of the fishery is low and catch rates variable. The estimated catch of the fishery in 2003-2004 was 779 tonnes valued at $1.3 million (ABARE 2005). Current stock assessments indicate that the fishery is not overfished globally and there may be room for expansion in some portions of the fishery (AFMA 2005c).

5.1.1.5 Southern Squid Jig Fishery (SSJF)

The Southern Squid Jig Fishery targets arrow or Gould's squid (*Nototodarus gouldi*) in night-time operations. Most squid are caught with automatic jigging machines. The fishery is mainly concentrated off Victoria, however the species is also taken as byproduct in the Bight by operators in the GABT sector of the SESSF. The SSJF is considered to have minimal negative environmental effects.

Overall catch in the SSJF in 2002-2003 was 1239 tonnes valued at $1.2 million and 1587 tonnes in 2003-2004. The GABT sector of the SESSF landed 165 tonnes of squid in 2002/2003 (AFMA 2005d, Bureau of Rural Sciences 2004).

There has been very little research undertaken on squid stocks. However, arrow squid are known to reach a maximum age of 12 months with environmental changes thought to have an impact on recruitment levels (AFMA 2005d). According to Caton (2003) arrow squid are underfished outside of Bass Strait.

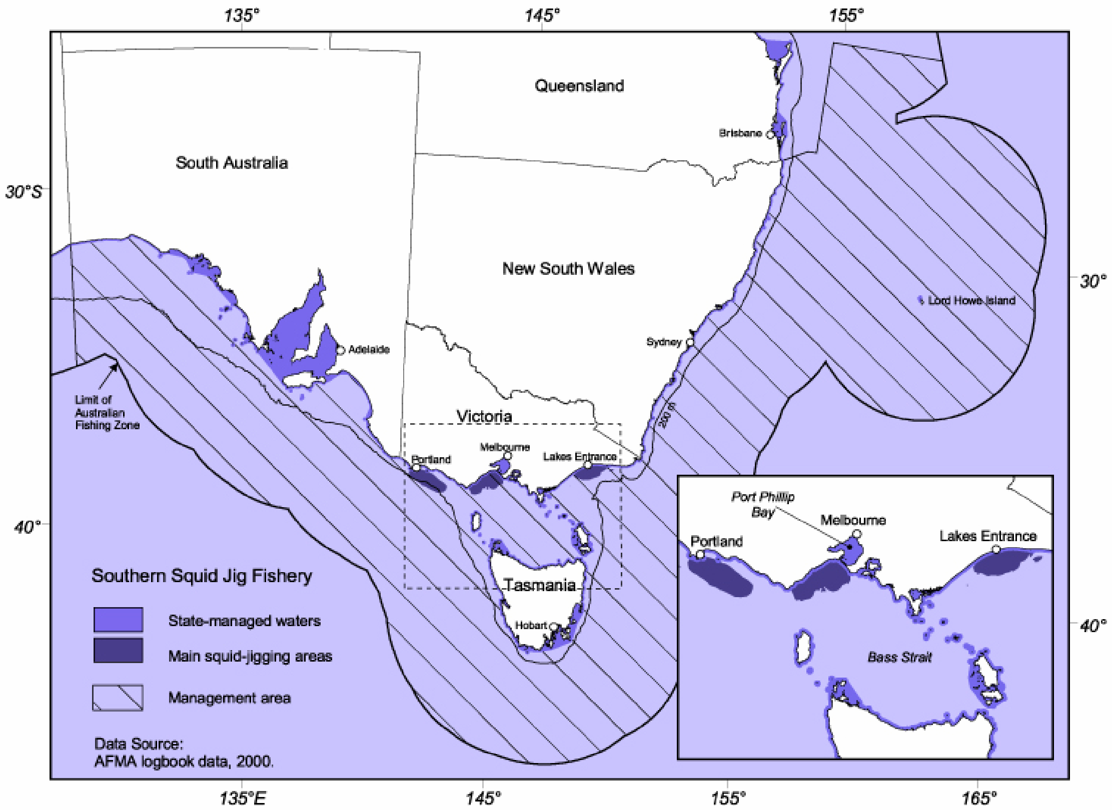


Figure 17: Southern Squid Jig Fishery
(Source: AFMA)

5.1.1.6 Small Pelagic Fishery (SPF)

The SPF extends from the Queensland/New South Wales border around southern Australia to just north of Perth, Western Australia. The fishery is divided into four zones (A to D) (AFMA 2003b). The majority of operations occur in Zone A, off southern Tasmania. The Bight is within Zone B.

The fishery is a purse-seine and mid-water trawl fishery that targets small schooling fishes, including jack mackerel (*Trachurus declivis*), Peruvian jack mackerel (*T. symmetricus*), yellowtail scad (*T. novaezelandieae*), blue mackerel (*Scomber australasicus*) and redbait (*Emmelichthys nitidus*).

The catch is mostly used for fishmeal and bait. The estimated catch in 2002/2003 was 5703 tonnes (AFMA 2005e). The status of the target species is uncertain, but it is probably underfished in the Bight. Development of the fishery will require caution because of the role of small pelagic fish species in the food-chain and the potential for their localised depletion or overexploitation (Caton 2003).

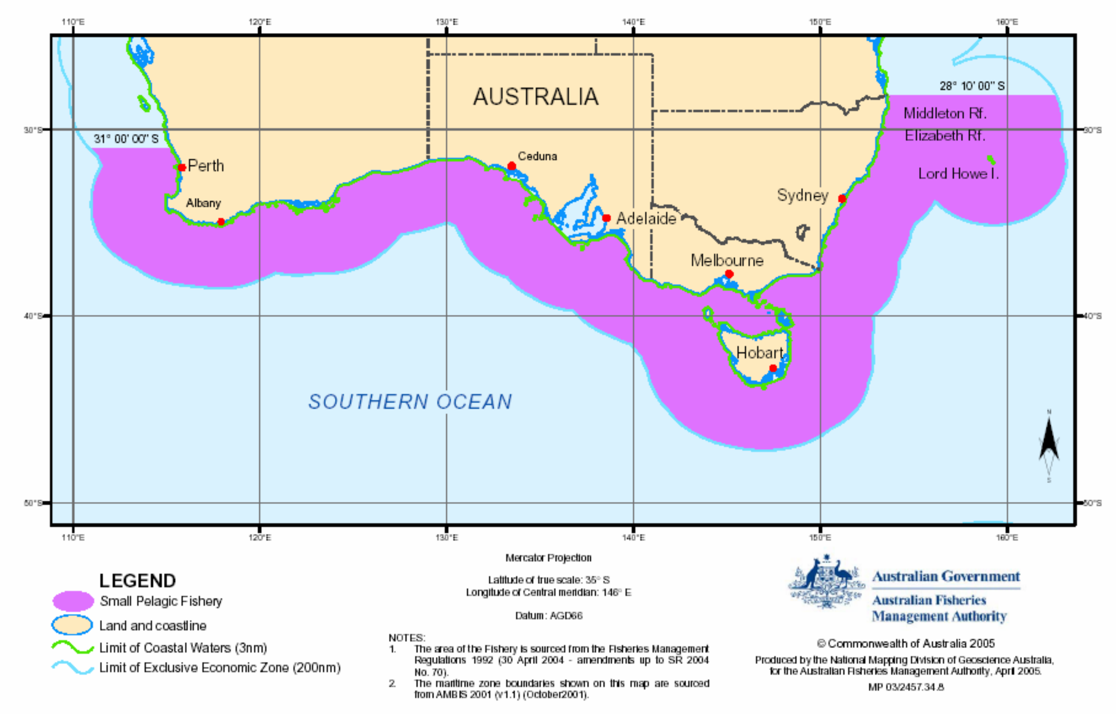


Figure 18: **Small Pelagic Fishery**
(Source: AFMA)

5.1.2 State Fisheries

South Australia's fisheries are managed under the *Fisheries Act 1982*, which is administered by PIRSA Fisheries.

5.1.2.3 South Australian Rock Lobster Fishery – Northern Zone

The Northern Zone of the South Australian Rock Lobster Fishery (SARLF) is mostly restricted to the eastern Bight, where islands and reefs provide suitable habitat for the southern rock lobster (*Jasus edwardsii*). The rock lobster season runs from October to May and the catch is regulated by a licence and quota system.

About 95 % of the SARLF annual catch of 2620 tonnes is sold live to Asian markets, which brings more than $100 million into the State.

The mean annual catch is relatively low in the Marine Park, where it is mostly confined to the reefs east of Twin Rocks near the Head of Bight (Edyvane 1998a). Abundant stocks and sustainable fishing make South Australia's rock lobster fishery among the best managed in the world. However, stocks of southern rock lobster in the Northern Zone Rock Lobster Fishery have recently been recognised to be declining (Commonwealth of Australia 2003).

The main species taken as bycatch by the rock lobster fishery are leatherjacket species, Octopus species, blue-throat wrasse (*Notolabrus tetricus*) and velvet crab (*Portunus puber*), along with small quantities of snapper (*Pagrus auratus*) and Bight redfish. Most of this bycatch is used as bait. Australian Sea-lions are known to rob lobster pots, and although no quantitative studies have yet been conducted, some sea-lions are suspected to drown in lobster pots.

5.1.2.4 Giant Crab Fishery (GCF)

Giant crabs (*Pseudocarcinus gigas*) have been taken as byproduct of the Northern Zone of the SARLF for many decades. More recently, although only a small number of fishers take giant crabs, significant quantities have been exported. The GCF was established as a fishery in its own right in the 1990s. As with the SARLF, the GCF is managed with separate northern and southern zones of the fishery, with the larger northern zone covering the area of the Bight.

In 1998/99 the total return was around $1 million. Most fishing is limited to south-western Kangaroo Island and southern Eyre Peninsula, and to date little has been conducted in the central Bight. In a more recent assessment of the fishery (Commonwealth of Australia 2004), it was noted that the 2001 harvest for the entire GCF was below the quota, being worth only $447 000.

5.1.2.5 Abalone Fishery – Western Zone

The South Australian Abalone Fishery is managed under 3 separate geographic zones. The largest of these management zones, in terms of area, licences and catch, is the western zone that covers coastal waters from the Western Australian border to the eastern Eyre Peninsula, and focuses on greenlip (*Haliotis laevigata*) and blacklip (*H. rubra*) abalone. It operates under a licence and quota system, and in 2001/02 had a commercial value of some $35 million (Knight *et al*. 2003). Most of the fishery is based in the eastern Bight, with only a minor amount of activity known in the Marine Park.

5.1.2.6 West Coast Prawn Fishery (WCPF)

The West Coast Prawn Fishery is a season-based trawl fishery for three licence holders that operate in three main regions off the west coast of the Eyre Peninsula. It targets the western king prawn (*Penaeus latisulcatus*), and in 2001/02 had a commercial value of about $1.6 million. Licence holders are permitted to retain slipper lobster (*Ibacus* spp.), *Octopus* spp., scallops, southern calamari and arrow squid as bycatch. Currently, the fishery does not extend into the Marine Park.

5.1.2.7 Marine Scale-fish Fishery (MSF)

The Marine Scale-fish Fishery is the oldest commercial fishing industry in South Australia, with over 400 licence holders, and a total catch in 2001/02 of 4500 tonnes valued at $18.5 million. The fishery is diverse, with permission to take finfish, crustaceans, molluscs, annelids, sharks and rays. In inshore waters of the eastern and central Bight the main focus is on snapper, King George whiting (*Sillaginodes punctata*) and Australian salmon, whilst in deeper waters the focus is on ocean jacket. A variety of restrictions apply, including seasonal closures, with specific arrangements for the main species.

Commercial snapper catches comprise less than 5% of the total fishery harvest, with most landed using handlines and setlines. Less than 10% of this catch is taken in the Marine Park. King George whiting is fished around islands, reefs and in shallow bays of the eastern Bight, using handline, gill-net and haul-net methods. For the 2001/02 season the commercial catch was conservatively worth $1.6 million.

Commercial salmon is mostly caught by purse-seine nets in the eastern Bight and used for bait by the Rock Lobster Fishery. Only small quantities are sold for human consumption on local markets.

Ocean jacket is caught using purpose-built traps in eastern Bight waters.

5.1.2.8 Pilchard Fishery (PF)

The Pilchard Fishery is Australia's largest fishery by weight, with a total allowable commercial catch (TACC) in 2003 of 36 000 tonnes and actual catch in 2003 of 26 161 tonnes. Since 1991, sardines (or pilchards) (*Sardinops sagax*) have been purse-seine netted to supply fodder for the tuna mariculture industry in Port Lincoln. The fishery operates under a licence and quota system.

At present most of the catch is taken in southern Spencer Gulf, and there is no operation in or near the Marine Park. However, with the growth of the fishery (tonnage doubled from 2002 to 2003), there is significant potential for the fishery to move westward.

5.1.3 Recreational Fishing

Recreational fishing in the eastern Bight includes charter fishing operations out of Eyre Peninsula ports, and beach fishing by individuals, members of fishing clubs, organised fishing safaris and 4WD enthusiasts. Indigenous anglers use the beaches of the Yalata Indigenous Protected Area.

Charter vessels visit shallow bays, offshore islands and deeper waters in the pursuit of such species as King George whiting, bluefin tuna, snapper, yellowtail kingfish, trevally (*Pseudocaranx dentex*) and sweep (*Scorpis aequipinnis*) (Ward *et al*. 2003b). Snapper and whiting are highly prized species, although it is unknown what quantity is taken in the Bight.

Boat-based fishing is limited in the Marine Park region by a lack of local launching facilities. The shore fishery focuses on mulloway and Australian salmon, and major fishing areas occur east of the Head of Bight, including along surf beaches from Almonta Beach (Coffin Bay) to the State Marine Park Conservation Zone (Edyvane 1998a).

An important recreational rock lobster fishery exists in the eastern Bight, although no fishing has been recorded in the Marine Park. An estimated 118 tonnes of recreational catch was taken from the entire SARLF commercial fishery in 2001/2002 (Venema *et al*. 2003). The recreational fishery operates during the same season as the commercial fishery. Recreational lobster fishers have access to all harvesting methods including diving, drop nets, hoop nets and pots. All lobster pots must be registered with PIRSA Fisheries (McLeay *et al*. 2003).

Abalone are taken by snorkelling or diving, and bag limits apply. It is not known what quantity is taken in the Bight.

It is difficult to assess the amount of catch taken by recreational fishers, and there are no quantitative data on catches in and near the Marine Park. However, the importance of this activity for local and regional tourism on the far west coast is well accepted (Ward *et al*. 2003b).

Among others, Pogonowski *et al*. (2002) have pointed to the evidence that recreational and charter boat fishing activities can cause at least localised depletions of fish populations. For example, there are concerns about declining King George whiting stocks (McGarvey *et al*. 2003). The disappearance of favoured species could also have pronounced economic impacts on coastal towns of the Eyre Peninsula region, as fishers contribute significantly to tourism revenue (Ward *et al*. 2003b).

5.2 Mining Operations

The hydrocarbon and mineral potential within the Great Australian Bight Marine Park is still largely unexplored, although it is considered that the offshore Bight and Duntroon Basins offer one of the most prospective frontier petroleum areas currently available to the industry (Hill 1999).

The greatest sediment thicknesses (and hence the most prospective areas) in the Bight region occur in water depths >500 metres and have not been tested for hydrocarbons. However, with advancing deep water drilling technology, areas such as the Ceduna Sub-basin are now a viable target for exploration. Preliminary research shows that there are some gas or oil deposits in the eastern Bight region, especially in the Duntroon Basin (Lisk *et al*. 2001).

Mining operations within the Benthic Protection Zone of the Marine Park are subject to a rigorous approvals process on a case by case basis, in which explorers must comply with the requirements of the Petroleum (Submerged Lands, Management of Environment) Regulations 1999 of the *Petroleum (Submerged Lands) Act 1967*, the EPBC Act and the prescriptions set out in the Management Plan for the Marine Park. All mining operations are prohibited in the Marine Mammal Protection Zone of the Commonwealth Park and Sanctuary Zone of the State Park.

In 2000, five Exploration Petroleum Permits (EPP) were granted in the Bight. EPPs 28, 29, 30 and 31 were granted to Woodside Energy and its consortium partners, and EPP 32 was granted to Santos (McLeay *et al*. 2003). Two of the Permits (EPP 28 and 29) pass through parts of the Benthic Protection Zone of the Commonwealth Marine Park.

Several exploration wells have been drilled in the Bight. Two of these wells, Potoroo 1 and Apollo 1, drilled and capped before the park was proclaimed, are located within the Benthic Protection Zone. In 2003 Woodside Energy drilled an exploratory well about 50 kilometres east of the Benthic Protection Zone in waters over 1300 metres deep. Further exploration is expected in the future.

Exploratory cruises, including that of the CSIRO Southern Surveyor (2000) and RV Franklin (2001) have also been undertaken, in part to investigate the presence of other mineral resources. These cruises collected numerous samples for analysis, using a variety of techniques including benthic sleds and coring. Woodside Energy is planning to undertake 3D seismic surveys within their Permit Areas (including parts of the Benthic Protection Zone) in 2006. There are no other mineral exploration or mineral extraction activities being undertaken in the Bight, or known to be proposed for future development (M. Bissell, Minerals Council of Australia, personal communication to Pidcock *et al*. 2003).

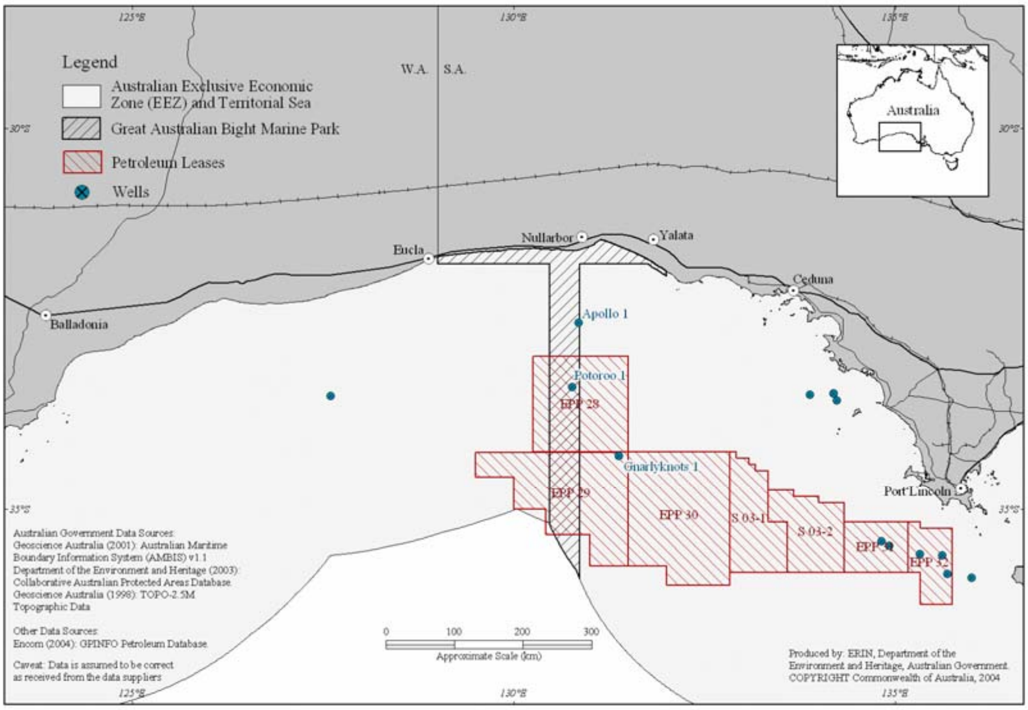


Figure 19: Petroleum Activity in the Bight

5.3 Bio-prospecting

Many animals and plants produce chemicals with antimicrobial, antiviral and anti-tumour properties (Lowenstein 1989). There is increasing interest in the biota of the world's oceans to provide pharmaceutical compounds with these properties. Considering the wealth of biodiversity in the waters of the Bight, this region is of great interest to Australian researchers. Dr Robert Capon and his team from the University of Melbourne have isolated several chemicals from sponges found in the Bight (McLeay *et al*. 2003). These include; new stesterterpenes from *Spongia hispida* (Davies and Capon 1993); antimicrobial sesquiterpenes; quinones from a *Spongia* species (Capon *et al.* 1993); antimicrobial acetylenic acids from *Phakellia carduus* (Barrow and Capon 1994) and a new antimicrobial alkaloid from a *Clathria* species. A previously undescribed functional group of novel metabolites 'aplidites' has been isolated from a tunicate (*Aplidium* species) found in the Bight (Murray *et al.* 1995).

5.4 Tourism

5.4.1 Whale Watching

The Head of Bight region is a major site for land-based whale watching, especially from the boardwalk infrastructure at Callosity Point. An air charter tour also operates from the nearby Nullarbor Roadhouse. The area affords spectacular close views of southern right whales calving, nursing and mating, often within 100 metres of shore. The unspoiled coastline, including the Yalata dunes and Nullarbor Cliffs, enhances these views. Visitors are required to obtain a permit, as the area is managed by the Yalata Community Inc.

According to an International Fund for Animal Welfare report (IFAW 2004) whale watching activities centred on the Head of Bight attract over 14 000 visitors annually, directly generating over $260 000 and indirectly over $1.6 million for the region. They described this as “a massive tourist attraction for such an isolated location”, and noted its importance for the Indigenous Yalata Community. Apart from the awe that whales inspire, whale watching activities and interpretation can also serve to educate visitors about the marine environment in general.

5.4.2 Other Visitor Activity

The Bight region attracts large numbers of visitors seeking a diversity of recreation experiences apart from whale watching. A major attraction is the intrinsic beauty of the rugged wilderness landscape and high-energy seascape.

5.4.3 Interpretive Material

A new Interpretative Centre has opened at the Head of Bight. Operated by the Yalata Community, it contains information on the social and natural history of the area. Boardwalks lead from the centre to the Head of Bight where the whales can be observed. Material is also available from National Parks and Wildlife SA offices at Ceduna and Port Lincoln, and various tourist offices, tourism operators and retailers. The Yalata Community has a web address at www.yalata.org that outlines whale watching activities as well as various aspects of Aboriginal culture and natural history of the Nullarbor region.

6. Pressures and Threats to the Marine Park

6.1 Southern Right Whale

A Recovery Plan for southern right whales in Australian waters has been developed and can be viewed at www.deh.gov.au/biodiversity/threatened/publications/recovery/e-australis/index.html. Gales *et al*. (2003) provides further information about the southern right whale.

6.1.1 Bycatch and Marine Debris

Entanglement and incidental bycatch that captures and kills cetaceans in fishing gear and long-lines is a local, regional and international threat of increasing concern. "Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris" is a 'key threatening process' under the EPBC Act, and a national threat abatement plan is being developed. Further information can be found at www.deh.gov.au/cgi-bin/sprat/public/publicshowkeythreat.pl?id=14.

Even widely dispersed pelagic whales and dolphins are at risk, principally associated with the use of monofilament drift-nets by hundreds of vessels year-round in international waters. The bycatch of cetaceans is poorly documented, but Burnell (personal communication) noted four known instances of southern right whales becoming entangled off the Australian coast, and Kemper *et al*. (in press) have summarised the data for South Australian waters.

Mead (1986) reported entanglements of northern right whales (*Eubalaena glaciali*s) in fishing gear in United States waters. Significantly, the lengths of the whales recorded in the study ranged from 7.5 metres (calves) to 12 metres (sub-adults), highlighting the vulnerability of younger animals to entanglement.

Marine litter, including discarded nets, also has the potential to cause mortality to mammals in the Great Australian Bight. The longest running annual survey of beach litter in Australia has been conducted at Anxious Bay, on the remote far west coast of South Australia (Edyvane *et al*. 2004). It indicates that most of the litter originates from commercial fishing activities within the Bight.

Aquaculture operations are also becoming increasingly prevalent in the Bight and will potentially affect more whales and other cetaceans (Kemper *et al*. 2003).

6.1.2 Acoustic Disturbance

Pidcock *et al*. (2003) reviewed the abundant recent literature relating to acoustic disturbance to cetaceans, including reports that noise from seismic surveys and operating facilities was considered to pose the greatest potential for direct and indirect impacts. Migrating and feeding bowhead whales (*Balaena mysticetus*), closely related to the right whales, have been documented avoiding seismic activity in the Northern Hemisphere.

Pidcock *et al*.'s (2003) key points were:

- Humpback whales (*Megaptera novaeangliae*), another baleen species of whale like the southern right whale, are more susceptible to noise while resting or breeding compared to during migration
- For continuous noise, whales begin to avoid sounds at exposure levels of 110 dB and more than 80% of species observed show avoidance to sounds of 130 dB

- For seismic noise, most whales show avoidance behaviour at 180 dB
- Mother-calf pairs of humpback and southern right whales have been seen to be displaced from major nursery grounds by noise disturbance from vessel activity associated with the whale watching industry.

However, it cannot be conclusively stated that an identified decibel level will always produce the same response in cetaceans. Geographic conditions may dampen the effect of noise propagation, and it is apparent that disturbance effects vary according to such factors as underwater acoustics, marine mammal physiological and behavioural differences and temporal variation.

Cetaceans may be especially vulnerable to noise because of their reliance upon sound for communication, prey detection and orientation (Reeves 1992). Human induced sounds such as shipping or seismic noise have most energy between a frequency range of 5 – 1000 Hz, which encompasses the believed best 'hearing range' of baleen whales (10 – 1000 Hz).

The types of effects underwater noise may produce range from no effect to severe (McCauley 1994). Lethal effects are suspected to be related to a stranding event in 2000 in the Bahamas that was coincident with the use of mid-frequency US Navy sonar in the area (Balcomb and Claridge 2001).

Under the 'Guidelines on the application of the EPBC Act to interactions between offshore seismic operations and larger cetaceans' (Environment Australia 2001), sounds heard by whales of over approximately 140 dB in feeding, breeding or resting areas may be considered likely to significantly disturb whales that are present. Sounds heard by whales of over 150 dB in other areas, such as migratory paths, may significantly disturb whales that are in the area. These Guidelines are currently under review.

Noise from low-flying aircraft may induce behavioural changes in whales. For example, Ling and Needham (1988) observed deep diving by southern right whales as a response to the noise and downdrafts produced by helicopters. The EPBC regulations specify a minimum altitude of 300 metres for whale observation from aircraft, a distance of 1000 metres for helicopters and a minimum distance of 100 metres from whales for water-based vessels (Environment Australia 2000).

Underwater seismic pulses and offshore drilling are other potential sources of disturbance, although their effects on southern right whales are not fully understood. Responses to industrial and drilling noises several kilometres away have been observed in the bowhead whale (Richardson *et al* 1995).

Other studies have linked cetacean strandings with low frequency seismic and industrial noise (Frantzis 1988, Simmonds and Mayer 1997). The low frequency noise produced by large ships is within the bandwidth of maximum acoustic sensitivity for baleen whales (Gordon and Moscrop 1996). An important aspect identified by Gordon *et al*. (1998) is the expansion of seismic surveys with advancing deep-water mining technology, and the concomitant impacts likely on deep diving marine mammals, the toothed whales such as the sperm whale (*Physeter catodon*) and beaked whale.

If observations of work done on northern right whales can be used as a guide, southern right whales could be expected to respond at anything from 10 – 30 kilometres and may avoid seismic operations from 3 – 20 kilometres, depending on the acoustic characteristics of the Bight environment. Females with newly born calves, calves, and pregnant females within this area may have different responses. The impact of high noise levels on unborn calves is not known.

Proposals for seismic testing near or within the Park undergo a rigorous assessment process under the EPBC Act and occur well away from the Marine Mammal Protection Zone in periods outside the whale migration and calving season.

6.1.3 Vessel Strikes

Pidcock *et al*. (2003) reviewed the literature pertaining to whale strikes by vessels. A recent study has compiled information on the frequency of the occurrence of motorised ship strikes on large whales and their contributing factors (Laist *et al*., 2001). The study concluded that the species most frequently hit by ships were fin whales (*Balaenoptera physalus*), with right whales, including southern right whales, humpback whales, sperm whales, and grey whales (*Eschrichtius robustus*) being commonly hit. In some areas, one-third of all fin whale and right whale strandings appear to involve ship strikes.

The most lethal or severe injuries were caused by larger, faster moving vessels. Compared with adults, a higher proportion of right and humpback whale calves and juveniles have been struck. The right whale is relatively susceptible to the dangers posed by ships and equipment because of its habits of resting on and near the surface (Terhune and Verboom 1999), as well as surface courtship and feeding.

Off the east coast of the USA, vessel strikes accounted for 7% of injuries and 28% of all known northern right whale deaths between 1970 and 1994 (Corn, 1995). Vessel collisions could increase due to increased shipping activity in the future, and habituation of animals to the vessels.

There are anecdotal reports of southern right whales being struck and superficially wounded by small craft in Australian waters, and a report of a southern right whale strike and death off Cape Jervis by the Kangaroo Island Ferry.

Most commercial ships pass to the south of the Bight in a line from the corner of south-western Australia to Melbourne, with less traffic between Perth and Adelaide that enters the southern limits of the Benthic Protection Zone. This implies that there could be collisions with whales migrating into the Bight, but very little potential interference within the waters of the Park.

6.1.4 Pollution

The Great Australian Bight Marine Park is in a relatively remote area with low population, in a region with no rivers or streams. It should therefore receive very little input of potentially toxic chemicals and sewage.

Furthermore, because southern right whales feed well away from the coast in the sub-Antarctic waters, and are filter-feeders, they are relatively unlikely to be vulnerable to the possible effects of bio-accumulated toxins, especially when compared with toothed whales.

Oil spills from marine vessels or petroleum mining would appear to be the greatest threat for southern right whales, although such spills are not considered to be as significant a risk to whales and dolphins as for other animals. Reproductive success for southern right whales may be reduced by exposure to a spill in the breeding site at the Head of Bight, since pregnant females are considered most at risk to the effects of oil spills. However, oil spills are unlikely to occur in the Park, as there is very little shipping activity and currently no petroleum extraction undertaken in the area.

The inshore sites presently favoured for calving, including those in the Bight, are most vulnerable to marine pollution from the south and south-west, due to prevailing winds and currents. Dolphins and porpoises are considered to have the ability to detect and avoid petroleum hydrocarbons (Overton *et al*. 1994), and there is no concrete evidence that oil contamination has been directly responsible for the death of a cetacean (Pidcock *et al*. 2003).

Direct surface fouling of whales is not considered a serious risk to the thermoregulatory capabilities of these animals, due to their extraordinarily thick epidermal layer. Also, even the heaviest of petroleum compounds may only temporarily reduce a baleen whale's feeding efficiency through adherence to the baleen plates (NOAA 1992). However, inhalation of the toxic volatile fractions of oil may produce a variety of problems for these air-breathing mammals, including permanent damage to respiratory surfaces (Overton *et al*. 1994).

6.2 Australian Sea-lion

A range of factors may impact on Australian Sea-lions. Breeding populations are highly susceptible to disturbance by humans, especially during the pupping season, when cows are attending their pups and bulls are competing for territory. This can lead to an increase in pup mortality and can be dangerous to the humans who enter such an area (Gales 1990). This is not an issue in the Bight due to the inaccessibility of breeding sites at the base of the cliffs. Pidcock *et al*. (2003) concluded that ship strike is not considered to be a risk for Australian Sea-lions.

6.2.1 Bycatch and marine debris

Much of the discussion that applies to whales also applies for Australian Sea-lions. It is not currently possible to assess the level of interaction between sea-lions and fishers, although interaction can be expected to increase (Kemper *et al*. 2003) as fisheries activities expand.

Sea-lions are known to rob baits from lobster pots, as well as nets set for school shark. Commercial and recreational fishers often regard Australian Sea-lions as competitors and pests (Shaughnessy 1999), and there are some reports of animals being illegally shot. Gales (1990) reported instances of conflict with fisheries operations in the form of net and bait-band entanglements and drownings in cray-pots.

Recent studies on the interaction between the western rock lobster fishery (on the west coast of Western Australia) and sea-lions have shown a low incidence of drowning in cray-pots (Gales et al. 1994, DoF 2004). However, anecdotal reports support that incidental mortality occurs in pot-based fisheries along the south coast of Australia (Shaughnessy et al. 2003, R. Gould, Commercial Fisheries Manager DoF personal communication). There are also reports of Australian Sea-lions drowning in demersal set gillnets (Shaughnessy et al. 2003).

Shaughnessy (1999) reviewed the evidence relating to instances of seals that have been shot around fish farms, nets or ashore, and Mawson and Coughran (1999) found that for the pinnipeds known to have died in Western Australia from 1980 – 1996, sea-lions were the most frequently killed, most commonly by gunshot wounds. Of the pinniped carcasses retrieved in the Port Lincoln area since the caged tuna industry began, most have been sea-lions (Kemper *et al*. 2003).

A recent study on Australian seal entanglements found that an estimated 146 Australian Sea-lions become entangled in marine debris every year, with at least 64 dying as a result of the entanglement (Page et al 2004). The Australian Sea-lion entanglement rate (1.3% in 2002) is the third highest for any seal species in the world.

While this rate may appear low, the effect on a rare species can be significant. For example, studies on the closely related Hooker's Sea-lion in New Zealand, indicate that increases in mortality of only 1% is sufficient to cause the population to decrease (Woodley and Lavigne 1993). These apparently low rates should also be regarded as a fraction of the true rate, because it is likely that most entangled animals die undetected at sea (Shaughnessy 1999).

This problem may be amplified by the fact that these animals are specialist benthic feeders, exposing them to the entire water column during foraging. As such, they may interact with a range of different fishing activities (Costa and Gales 2003). Low dispersal and high site fidelity also make it unlikely that colonies will be replenished if depleted.

Future research funded by DEH will determine what level of interaction sea-lions have with commercial fishing vessels with a view to minimising adverse interactions.

6.2.2 Acoustic Disturbance

Noise related disturbance at sea-lion colonies includes visits by commercial tourism ventures, private boat visits, and over-flights by aircraft, particularly low-level rotary wing aircraft. Rather than noise *per se* being a problem, this activity can lead to pup abandonment during breeding seasons, as a typical response to such visitations is for the animals to take to the water (Shaughnessy 1999).

The decrease in sea-lion pup production at major colonies in South Australia, including the Great Australian Bight, is a possible outcome of such interactions (Gales 1990). However, in their review of the literature pertaining to marine mammal disturbance, Pidcock *et al*. (2003) concluded that the noise created during mining industry seismic surveys is generally considered to be outside of the hearing range of Australian Sea-lions, and is therefore not considered to be a source of great disturbance.

6.2.3 Pollution

According to Pidcock *et al*. (2003), the greatest potential for direct and indirect impacts on Australian Sea-lions comes from oil spills. The few breeding sites and very high birth site fidelity for breeding females are factors that would make contamination of these sites a serious threat to the population.

Impacts from oil spill include inhibition of maternal recognition of young covered with oil, endocrine or stress impacts leading to premature delivery or spontaneous abortion of pups, and disturbance of sea-lions through clean-up activities associated with coastal oil spills. Contact with oil can also cause surface lesions in the skin, especially around the eyes, which may become damaged.

Ingestion of petroleum hydrocarbons can occur either through direct ingestion while foraging or through grooming, and has been implicated in numerous sea-lion deaths.

As mentioned above, as there is very little shipping activity and currently no petroleum extraction within the Park there is little chance of oil spills affecting sea-lions within the Park.

6.2.4 Decline of Predator and Prey Species

Impacts of seismic activities on populations of some of the main prey species (shellfish and squid) of sea-lions are possible (Pidcock *et al*. 2003). Cephalopod molluscs and fish are not likely to accumulate petroleum hydrocarbons in their tissues, unlike filter-feeding benthic bivalves that may be eaten.

Sea-lions are believed to be able to metabolise some petroleum fractions, while others may be stored in fat deposits. However, to date, no evidence of deleterious effects related to bioaccumulation of petroleum hydrocarbons have been documented (NOAA 1992).

A further potential threat is a reduction in food supply through, for example, enhanced development of the pelagic squid fishery, as occurred in the New Zealand sub-Antarctic (Shaughnessy 1994). Furthermore, as the numbers and range of the New Zealand fur seal (*Arctocephalus forsteri*) increase (Shaughnessy and McKeown 2002), there is potential for interspecies competition for prey resources, especially if prey fish species decline.

Overfishing of certain prey species has also been implicated as a factor in the decline of other higher order predators such as seabirds including albatrosses (Tasker *et al*. 2000, Baker *et al*. 2002). Highly productive upwelling regions require careful management, as they may be feeding grounds for predator species such as blue whales (Gill 2002).

6.3 Representative Benthic Communities

Recent work has begun to investigate the effects of various human related activities on the benthos of the Great Australian Bight and its biota, and a major study has been completed by Ward *et al*. (2003a). One of the aims for the study was to provide some baseline information about the Benthic Protection Zone for future management, as the park boundaries were established with very little understanding of the seafloor biota. Future studies will provide comparative data to compare changes in benthic composition over time.

6.3.1 Demersal Fishing inside and near reserve

Up to 14% of trawling by GABT sector vessels of the SESSF was conducted in the Benthic Protection Zone prior to its proclamation in 1998 (Ward *et al*. 2003b). Probably the bulk of this was demersal trawling targeting deep water flathead and Bight redfish on the Continental shelf and orange roughy on the Continental slope. Following the declaration of the Marine Park demersal trawling was banned. No trawling was recorded in this area in 2002 (Caton 2003).

The effects of trawling have yet to be assessed in the Bight, although James *et al*. (2001) observed tracks from demersal trawls across the sediments of the Bight, suggesting that the effects are quite long term.

According to Ward *et al*. (2003b) trawl nets vary between vessels in the trawl fishery, but most are cutaway wing trawls with headline lengths of 35 – 50 metres, and headline openings of 4.5 – 6 metres. Studies elsewhere suggest that the bottom trawling used in the trawl fishery is likely to affect the structure and species composition of the benthos. It can cause chronic and widespread disturbance to the seabed in shelf areas and consequent direct or indirect impacts to the biota, as dragging gear causes immediate mortality, displacement, changes to the sediment structure and geochemistry, and affects the abundance of predators or competitors (Schratzberger and Jennings 2002).

In areas subject to frequent disturbance, the biomass, diversity and production of fauna is reduced, with larger sessile species such as sponges showing greater sensitivity than smaller free-living species (Koslow *et al* 2001, Probert 2002). Ward *et al*. (2003a) advocated the need for continual monitoring of benthic communities inside and outside the Benthic Protection Zone boundary.

6.3.2 Mining inside and near reserve

No mining currently occurs in the Great Australian Bight region, although exploratory activity has been undertaken. Pidcock *et al*. (2003) prepared a comprehensive report related to the potential impacts of the petrochemical industry on the region. Threats to benthic flora and fauna from drilling fluids used in the petroleum industry have been relatively well studied in some regions.

Currently, the majority of offshore drilling operations in Australia use non-toxic water based fluids, not oil-based (Cobby and Craddock 1999). Where low toxicity synthetic and oil-based fluids are used, they are generally recovered during the drilling process and re-used (URS 2001). Water-based fluids are a mixture of water, clay, a weighting material (usually barite), and various chemicals.

During drilling the fluid and cuttings are generally discharged to sea, where they fall to the seabed and disperse. According to the Australian Petroleum Production and Exploration Association (APPEA), 90% of this material settles within 100 metres of the platform. In sensitive environments, cuttings may be removed for disposal elsewhere or re-injected where practical (URS 2001).

Environmental monitoring programs in Bass Strait conducted by BHP Petroleum Pty Ltd (BHP and Santos 1995) and Esso Australia Ltd (Terrens *et al*. 1998) recorded the effects of drilling activities on benthic flora and fauna over 12 months. Both assessments showed more localised effects (within 200 – 400 metres) that were generally short-lived, with most parameters measured recovering within four months. However, at Minerva 2A, community changes in the benthic biota were evident after 12 months within 200 metres of the well site (BHP & Santos 1995), and at Fortescue, increased levels of barium were detected up to 100 metres from the well site after eleven months (Terrens *et al*. 1998).

Abandoned wells are plugged with concrete and thus should not seep. In the event of production proceeding, infrastructure establishment would also have a direct but localised disturbance to the benthos.

6.3.3 Research inside and near reserve

Provided appropriate guidelines are followed, scientific research should have minimal impact on the Marine Park. For example, Ward *et al*. (2003a) described the sampling technique used for their benthic research. For each site they used a 1.81 metre wide sled that was towed over the substrate for five minutes at a speed of 3.5 knots. Given the size of the area this would be only a minimal form of disturbance.

Disturbance to Australian Sea-lions from researchers undertaking work within colonies is possible unless research activities are conducted appropriately.

6.3.4 Invasive Species

At present, the Bight region and particularly the Marine Park are relatively remote from possible sources of invasive species. These sources usually centre around harbours where ballast water is discharged, and aquaculture activities occur. For example, Hewitt *et al*. (2004) found that there are 160 alien species in Port Phillip Bay, representing over 13% of the species recorded there. The Adelaide region recently experienced a major outbreak of the invasive seaweed *Caulerpa taxifolia*. This seaweed forms a thick matt on the seabed smothering native seaweeds and seagrasses, and displacing other marine benthic organisms. The seaweed presents a serious threat to the environment and associated marine industries in nearby Gulf St. Vincent, the Coorong, and Spencer Gulf if it is not contained (SARDI 2001). However, it is unlikely to spread into the Bight.

Two other marine species have the potential to threaten the values of the Marine Park if they were introduced there. Wakame (Japanese) (*Undaria pinnatifida*) is a seaweed that has the ability to rapidly colonise disturbed or new surfaces in the intertidal to subtidal zones to a depth of 15 – 20 metres. Wakame has been introduced to areas of Bass Strait and around Tasmania (NIMPIS 2002a). The New Zealand screwshell (*Maoricolpis roseus*) forms dense mats on the seafloor in depths up to 130 metres. The screwshell has also been introduced to areas of Bass Strait and Tasmania (NIMPIS 2002b). These species have the potential to spread through the ballast water of ships, but would be unlikely to spread into the Bight due to the lack of nearby port facilities. Researchers working in the Marine Park have been asked to report any sightings of marine pests.

7. Bibliography

ABARE (2005). *Australian Fisheries Statistics 2004*. Australian Bureau of Agricultural and Resource Economics, Canberra.

Alderslade, P. (2003). A new genus and new species of soft coral (Octocorallia: Alcyonacea: Alcyoniidae). *Zootaxa*. **175**: 1-10.

AFMA (2002). *Strategic Assessment Report – Southern and Eastern Scalefish and Shark Fishery*. Draft for Public Comment. Australian Fisheries Management Authority.

AFMA (2003a). *Draft Assessment Report – Southern and Western Tuna and Billfish Fishery*. Australian Fisheries Management Authority. http://www.afma.gov.au/services/environment/stratassess/wtbfjuly03.pdf

AFMA (2003b). *Draft Assessment Report – Small Pelagic Fishery*. Australian Fisheries Management Authority.

AFMA (2004). *Draft Assessment Report – Skipjack Tuna Fishery*. Australian Fisheries Management Authority. http://www.afma.gov.au/fisheries/skipjack/plans/draft_assess_dec_04.pdf

AFMA (2005a). *Our Fisheries – Southern Bluefin Tuna Fishery*. Australian Fisheries Management Authority Website: http://www.afma.gov.au/fisheries/sbt/default.php

AFMA (2005b). *Our Fisheries – Southern and Western Tuna and Billfish Fishery*. Australian Fisheries Management Authority Website: http://www.afma.gov.au/fisheries/swtb/at_a_glance.php

AFMA (2005c). *Our Fisheries – Skipjack Tuna Fisheries*. Australian Fisheries Management Authority Website: http://www.afma.gov.au/fisheries/skipjack/at_a_glance.php

AFMA (2005d). *Our Fisheries – Southern Squid Jig Fishery*. Australian Fisheries Management Authority Website: http://www.afma.gov.au/fisheries/squid/at_a_glance.php

AFMA (2005e). *Our Fisheries – Small Pelagic Fishery*. Australian Fisheries Management Authority Website: http://www.afma.gov.au/fisheries/pelagic/default.php

Anon. (1998). *Report of the Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison*. Report to the Scientific Committee of the International Whaling Commission, SC/50/Rep4, Oman: 45 pp.

Baker G.B., Gales R., Hamilton S. and Wilkinson V. (2002). Albatrosses and petrels in Australia: A review of their conservation and management. *Emu* **102**, 71-97.

Balcomb K.C.I. and Claridge D.E. (2001). A mass stranding of cetaceans caused by naval sonar in the Bahamas. *Bahamas Journal of Science* **8**, 1-12.

Bannister J.L. (1993). *Report on aerial survey for southern right whales off southern Australia, 1992*. Report for the Australian Nature Conservation Agency (Unpublished).

Bannister J.L. (2001). Status of southern right whales (*Eubalaena australis*) off Australia. *Journal of Cetacean Research and Management (Special Issue)* **2**, 103-110.

Bannister J.L. (2004). *Southern Right Whale Aerial Survey and Photoidentification, Southern Australia, 2003*. Report to the Commonwealth of Australia and Western Australian Museum (Unpublished).

Bannister J.L., Kemper C.M. and Warneke R.M. (1996). *The Action Plan for Australian Cetaceans.* Australian Nature Conservation Agency, Canberra.

Bates D.M. (1938). *The Passing of Aborigines*. John Murray, London.

Barrow R.A. and Capon R.J. (1994). Carduusynes (-E): Acetylenic Acids from a Great Australian Bight marine sponge *Phakellia carduus. Australian Journal of Chemistry*. **47**(10): 1901-1918.

Bergquist P.R. and Skinner I.G. (1982). Sponges (Phylum Porifera). In: Shepherd SA Thomas IM (eds). *Marine Invertebrates of South Australia* pp 38-72. Government Printer, South Australia.

BHP Pty Ltd and Santos Pty Ltd (1995). *Minerva Gas Field Development: Technical Reports, Marine Environment - Environmental Impact Statement, Volume 2*.

Bock P.E. (1982). Bryozoans. In: Shepherd SA Thomas IM (eds). *Marine Invertebrates of South Australia* pp 319-394. Government Printer, South Australia

Bruce B. (1992). Preliminary observations on the biology of the White Shark, *Carchardon carcharias,* in South Australian waters. *Australian Journal of Marine and Freshwater Research* **43**, 1-11.

Bunce A., Norman F.I., Brothers N. and Gales R. (2002). Long-term trends in the Australasian gannet (*Morus serrator*) population in Australia: the effect of climate change and commercial fisheries. *Marine Biology* **141**, 263-269.

Bureau of Rural Sciences (1998). *Fishery Status Reports: Resources Assessments for Australian Commonwealth Fisheries*.

Bureau of Rural Sciences (2004). *Fishery Status Reports 2004*. Eds. A. Caton and K McLoughlin. Australian Government Department of Agriculture, Fisheries and Forestry.

Burnell S.R. (2001). Aspects of the reproductive biology, movements and site fidelity of right whales off Australia. *Journal of Cetacean Research and Management (Special Issue)* **2**, 89-102.

Burnell S. (2002). *Ecology and Behaviour of Southern Right Whales- Head of the Great Australian Bight*. Marine Species Protection Program Completed Projects (Phase One 1996-1997 to 2001-2002). www.nht.gov.au/nht1/programs/mspp/srwecology.html

Burnell S.R. and Bryden M.M. (1997). Coastal residence periods and reproductive timing in southern right whales, *Eubalaena australis. Journal of Zoology* **241**, 613-621.

Burton C.J., Coleman C., Serginson C. and Green C. (2001). *Dedicated Marine Fauna Monitoring Program during the Flinders Deepwater 2D Seismic Survey in the Great Australian Bight*: December 2000 - May 2001. Woodside Energy, Anadarko, and Pan Canadian Perth, Western Australia. Unpublished report.

Bye J.A.T. (1972). Oceanographic Circulation South of Australia. Antarctic Oceanography II. The Australian - New Zealand Sector. *Antarctic Research Series. American Geophysics Union* **19**, 95-100.

Campbell R. (2002). The population genetics of the Australian Sea-lion, *Neophoca cinerea*. *Marine Species Protection Program Completed Projects* (Phase One 1996-1997 to 2001-2002). www.nht.gov.au/nht1/programs/mspp/genetics.html

Campbell R.A. (2003). *Demography and genetic population structure of the Australian Sea-lion* (*Neophoca cinerea*). Department of Zoology, University of Western Australia.

Cane S. (1992). *Something for the future: community development at Oak Valley, South Australia*. Report to the Oak Valley community and ATSIC, SA.

Cane S. and Gara T. (1989). *Undiri. Aboriginal Association with the Nullarbor Plain*. Unpublished report to National Parks and Wildlife Service, South Australia. National Heritage Studies, ACT.

Capon R.J., Groves D.R., Urban S. and Watson R.G. (1993). Spongiaquinone revisited: structural and stereochemical studies on marine sesquiterpene/quinones from a southern Australian marine sponge, *Spongia* sp. *Australian Journal of Chemistry*. 46: 1245-1253.

Cappo M.C. (1987). The biology and exploitation of Australian salmon in South Australia. *Safish* **12**, 4-14.

Caton A. (2002). *Fishery Status Reports 2000-2001- Resource Assessments of Australian Commonwealth Fisheries*. Bureau of Resource Sciences - Agriculture, Fisheries and Forestry, Australia.

Caton A.E. (2003). *Fishery Status Reports 2002/2003: Assessments of the Status of Fish Stocks Managed by the Australian Government*. Bureau of Rural Sciences, Canberra. www.affa.gov.au/statusreports

Cobby G.L. and Craddock R.J. (1999). Western Australian Government decision-making criteria involved in the regulation of drilling fluids offshore. *APPEA Journal* **39**, 601-605.

Commonwealth of Australia (2000). *Great Australian Bight Marine Park (Commonwealth Waters) Plan of Management*. Environment Australia.

Commonwealth of Australia (2002). *White Shark (Carcharodon carcharias) Recovery Plan*. Environment Australia www.deh.gov.au/coasts/species/sharks/greatwhite/plan/index.html

Commonwealth of Australia (2003). *Assessment of the South Australian Rock Lobster Fishery*. Department of the Environment and Heritage www.deh.gov.au/coasts/fisheries/assessment/sa/rock-lobster

Commonwealth of Australia (2004). *Assessment of the South Australian Giant Crab Fishery*. Department of the Environment and Heritage. http://www.deh.gov.au/coasts/fisheries/assessment/sa/giant-crab/index.html

Copley P. (1995). *Status of South Australian Seabirds*. Unpublished report. Department of Environment and Natural Resources, South Australia.

Corn M.L. (1995). *The Northern Right Whale Congressional Research Service*, a branch of the Library of Congress providing non-partisan research reports to members of the House and Senate. 95-493 ENR

Costa D.P. and Gales N.J. (2003). Energetics of a benthic diver: Seasonal foraging ecology of the Australian Sea-lion, *Neophoca cinerea*. *Ecological Monographs* **73**, 27-43

Cowling A., Polacheck T. and Miller C. (1996). *Data analysis of the aerial survey (1991-1996) for juvenile southern bluefin tuna in the Great Australian Bight*. Commission for the Conservation of Southern Bluefin Tuna Scientific Committee Meeting CCSBT/SC/96/21.

Curry G. (1987). Geology and Geomorphology. In: McKenzie N.L. and Robinson A.C. (eds), *A Biological Survey of the Nullarbor Region South and Western Australia in 1984*. South Australian Department of Environment and Planning, Western Australian Department of Conservation and Land Management. Australian National Parks and Wildlife Service. pp. 17-24.

CSIRO Southern Surveyor (2000). *Cruise Report 01/00*. Commonwealth of Australia.

CSIRO (2003). Website: http://www.marine.csiro.au/~dunn/eez_data/atlas.html

Dennis T.E. and Shaughnessy P.D. (1996). Status of the Australian Sea-lion, *Neophoca cinere*a, in the Great Australian Bight. *Wildlife Research* **23**, 741-54

DoF (2004). *Western Rock Lobster Environmental Management Strategy July 2002 – June 2006*. Department of Fisheries, Western Australia.

Eckert H.J., Parker S.A. and Reid J.R.W. (1985). Birds. Chapter 12 In: Twidale CR Tyler MR Davies M (eds). *Natural History of Eyre Peninsula* pp 149-157. Royal Society of South Australia Inc.

Edyvane K.S. (1998a). *Great Australian Bight Marine Park Management Plan, Part B, Resource Information*. Department of Environment, Heritage and Aboriginal Affairs, South Australia. 62 pp.

Edyvane K.S. (1998b). Marine Biodiversity and Biogeography of the Inshore Habitats of the Great Australian Bight. In: Slater J (ed). Working Draft. *Workshop to identify research and monitoring priorities for the Great Australian Bight Marine Park*. Environment Australia. Technical Report No. 1.

Edyvane K.S. (1999). *Conserving Marine Biodiversity in South Australia, Part 1 – Background, status and review of approach to marine biodiversity in South Australia*. SARDI. South Australia.

Edyvane K.S., Dalgetty A., Hone P.W., Higham J.S. and Wace N.M. (2004). Long-term marine littering monitoring in the remote Great Australian Bight, South Australia. *Marine Pollution Bulletin*. 48: 1060-1075.

Elwen S.H. and Best P.B. (2004). Female southern right whales *Eubalaena australis*: Are there reproductive benefits associated with their coastal distribution off South Africa? *Marine Ecology Progress Series*. **269**: 289-295.

Environment Australia (1998). Threat Abatement Plan for the Incidental Catch (or by-catch) of Seabirds during Oceanic Longline Fishing Operations. http://www.deh.gov.au/biodiversity/threatened/publications/tap/longline/index.html

Environment Australia (2000). *Australian National Guidelines for Cetacean Observation and Areas of Special Interest for Cetacean Observation*. Environment Australia. http://www.deh.gov.au/coasts/species/cetaceans/observe.html

Environment Australia (2001). *Guidelines on the Application of the Environment Protection and Biodiversity Conservation Act to Interactions Between Offshore Seismic Operations and Larger Cetaceans*. Commonwealth of Australia. http://www.deh.gov.au/epbc/assessmentsapprovals/guidelines/seismic/index.html

EPCSA (Environmental Council of South Australia) (1998). *The state of the environment report for South Australia*. Department of Environment and Planning, Adelaide.

Fletcher W.J. (1990). A synopsis of the biology and the exploitation of the Australian pilchard, *Sardinops neopilchardus* (Steindachner). Part 1: Biology. *Fisheries research report no. 88*. Fisheries Department of Western Australia, Perth.

Fotheringham D.G. (1994). The Great Australian Bight and Coastal Management Issues. In: *Proceedings: Great Australian Bight Marine Park Workshop*, Ceduna, 1994. Edited by G.J. Andrews. SARDI, West Beach, South Australia.

Frantzis A. (1988). Does acoustic testing strand whales? *Nature* **392**, 29.

Gales N.J. (1990). *Abundance of Australian Sea-lions, Neophoca cinerea, along the Southern Australian Coast, and Related Research*. Unpublished report to the Western Australian Department of Conservation and Land Management, South Australian

National Parks and Wildlife Service and the South Australian Wildlife Conservation Fund.

Gales N.J., Shaughnessy P.D. and Dennis T.E. (1994). Distribution, abundance and breeding cycle of the Australian Sea-lion *Neophoca cinerea* (Mammalia: Pinnipedia). *Journal of Zoology* **234**, 353-370.

Gales N.J. and Costa D. (1997). The Australian Sea-lion: a review of an unusual life history. In '*Marine mammal research in the southern hemisphere. Volume 1: Status, ecology and medicine*'. Eds. M. Hindel and C. Kemper. Surrey Beatty & Sons, Chipping Norton.

Gales N.J., Hindell M. and Kirkwood R. (eds) (2003). *Marine mammals: fisheries, tourism and management issues*. CSIRO Publishing, Melbourne.

Gara T. and Cane S. (1988). *Environmental, Anthropological and Archaeological background to the Nullarbor Plains*. A resource document for Stage 1 of the Nullarbor Plains Project. Anutech, Canberra.

Gara T., Colley S., Brockwell S. and Cane S. (1988). *The Aboriginal Metropolis of Ooldea*. Anutech, Canberra.

Geoscience Australia (2002). Website:
http://www.ga.gov.au/oceans/projects/20011011_13.jsp

Gill P.C. (2002). A blue whale (*Balaenoptera musculus*) feeding ground in a southern Australian coastal upwelling zone. *Journal of Cetacean Research and Management* **4**, 179-184.

Glover C.J.M. (1982). A provisional checklist of marine fishes (Amphioxi, Petromyzones, Myxini, Elasmobranchii, Holocephali, Teleostomi) recorded in South Australian coastal waters. *South Australian Museum Information Leaflet* **70**, 1-25.

Glover C.J.M. and Newton G. (1991). Denizens of the deep: deep-sea fishes in the Great Australian Bight. *Australian Fisheries* **50**, 30-35.

Glover C.J.M. Olsen A.M. (1985). Fish and Major Fisheries. Chapter 14 In: Twidale CR Tyler MR Davies M (eds). *Natural History of Eyre Peninsula* pp 169-181. Royal Society of South Australia Inc.

Gordon J. Moscrop A. (1996). Underwater noise pollution and its significance for whales and dolphins. In: Simmonds M Hutchinson J (eds). *The Conservation of Whales and Dolphins: Science and Practice* pp 290-293. John Wiley and Sons Ltd, West Sussex.

Gordon J.C.D., Gillespie D., Potter J., Frantzis A., Simmonds M.P. and Swift R. (1998). *The effects of seismic surveys on marine mammals*. Workshop. London, UK.

Gostin V.A., Belperio A.P. and Cann J.H. (1988). The Holocene non-tropical coastal and shelf carbonate province of southern Australia. *Sedimentary Geology*. **60**: 51-70.

Greenwood G. and Gum E. (1986). *The State of Biological Resources in South Australia.* Department of Environment and Planning, Adelaide, South Australia.

Griffin D.A., Thompson P.A., Bax N.J., Bradford R.W. and Hallegraeff G.M. (1997). The 1995 mass mortality of pilchard: no role found for physical or biological oceanographic factors in Australia. *Marine and Freshwater Research* **48**, 27-42.

Hall D.A. (1986). *An assessment of the mulloway (Argyrosomus hololepidotus) fishery in South Australia with particular reference to the Coorong Lagoon*. South Australian Department of Fisheries Discussion Paper, 41 pp.

Harris P., Heap A., Passlow V., Sbaffi L., Fellows M., Porter-Smith R., Buchanan C. and Daniell J. (2003). *Geomorphic Features of the Continental Margin of Australia*. Report to the National Oceans Office on the production of a consistent, high-quality bathymetric data grid and definition and description of geomorphic units for Australia's EEZ.

Herzfeld M. (2000). *Water mass formation, circulation and productivity in the Great Australian Bight*. Seminar Abstract. www.marine.csiro.au/seminars/sem-abs00/herzfeld.html

Hewitt C.L., Campbell M.L., Thresher R.E., Martin R.B., Boyd S., Cohen B.F., Currie D.R., Gomon M.F., Keough M.J., Lewis J.A., Lockett M.M., Mays N., McArthur M.A., O'Hara T.D., Poore G.C.B., Ross D.J., Storey M.J., Watson J.E. and Wilson R.S. (2004). Introduced and cryptogenic species in Port Phillip Bay, Victoria, Australia. *Marine Biology* **144**, 183-202

Higgins L.V. and Gass L. (1993). Birth to weaning: parturition, duration of lactation, and attendance cycles of Australian Sea-lions (*Neophoca cinerea*). *Canadian Journal of Zoology* **71**, 2047-2055.

Hill P., Rollet N. and Symonds P. (2001). *Seafloor mapping of the south-east marine region and adjacent waters; AUSTREA final report*; Lord Howe Island, south-east Australian margin (includes Tasmania and South Tasman Rise) and central Great Australian Bight. AGSO Australian Geological Survey Organisation. Canberra, Australia. 83 pp.

Hill T. (1999). 1999 Offshore Bight and Duntroon Basins acreage release. *MESA Journal* **14**, 50-53.

Hinsliff M. and Wild C.N. (1996). *Yalata Aboriginal Lands Ecotourism Assessment Study*.

Hobday A.J. (2001). *Rapid Assessment of Australian Marine Protected Areas Using Satellite Remote Sensing*. Report to Environment Australia. Tropical and Pelagic Ecosystems CSIRO Marine Research, Hobart.

Holbourn A., Kuhnt W. and James N. (2002). Late Pleistocene bryozoan reef mounds of the Great Australian Bight: Isotope stratigraphy and benthic foraminiferal record. *Paleoceanography* **17**, 1401-1413.

Hutchings P. (1982). Bristleworms (Phylum Annelida). In: S.A Shephard and I.M. Thomas (Eds.). *Marine Invertebrates of Southern Australia Part I*. Pp. 228-298. Govt Printer, South Australia.

Hutchins B. and Thompson M. (1983). *The Marine and Estuarine Fishes of South-western Australia – A field guide for anglers and divers*. Western Australian Museum, Perth.

IMCRA Committee (1998). *Interim Marine and Coastal Regionalisation of Australia*. An Ecosystem Classification of the Marine and Coastal Environments of Australia. Version 3.3. Environment Australia, Commonwealth Department of the Environment. Canberra. 104 pp.

IFAW (2004). *From Whalers to Whale Watchers*. The growth of whale watching tourism in Australia. International Fund for Animal Welfare report. www.ifaw.org/ifaw/dimages/custom/whale_watching_au/pdf/Final%20report.pdf

James N.P. and von der Borch C.C. (1991). Carbonate shelf edge off southern Australia: a prograding open platform margin. *Geology*. **19**: 1005-1008.

James N.P., Bone Y., von der Borch C.C. and Gostin V.A. (1992). Modern carbonate and terrigenous clastic sediments on a cool-water, high-energy, mid-latitude shelf; Lacepede Shelf, southern Australia. *Sedimentology* **34**, 877-904.

James N.P., Boreen T.D., Bone Y. and Feary D.A. (1994). Holocene carbonate sedimentation on the west Eucla Shelf, Great Australian Bight: a shaved shelf. *Sedimentary Geology*. **90**: 161-178.

James N.L., Bone Y., Collins L.B. and Kyser T.K. (2001). Surficial sediments of the Great Australian Bight: Facies dynamics and oceanography on a vast cool-water carbonate shelf. *Journal of Sedimentary Research* **71**(4), 549-567.

Jones G.K. (1991). Fin fishery considerations in the management of the proposed Great Australian Bight Marine Park. *Safish* **15**, 11.

Kemper C. (1998). Cetaceans in the Great Australian Bight. In: Slater J (ed). *Working Draft. Workshop to identify research and monitoring priorities for the Great Australian Bight Marine Park*. Environment Australia. Technical Report No. 1.

Kemper C.M. and Ling J.K. (1991). Whale strandings in South Australia (1881-1989). *Transactions of the Royal Society of South Australia* **115**, 37–52.

Kemper C.M., Mole J., Warneke R., Ling J.K., Needham D.J. and Wapstra H. (1994). *Southern Right Whales in South-Eastern Australia During 1991-1993.* Report to BHP Petroleum Pty. Ltd, Melbourne.

Kemper C.M. and Samson C.R. (1999). Southern right whale remains from 19th century whaling at Fowler Bay, South Australia. *Records of the South Australian Museum* **32**, 155-172

Kemper C., Pemberton D., Cawthorn M., Heinrich S., Mann J., Wursig B., Shaughnessy P. and Gales R. (2003). Aquaculture and marine mammals: Co-existence or conflict? In: Gales N Hindell M Kirkwood R (eds). *Marine mammals and humans: fisheries, tourism and management issues* pp 208–225. CSIRO Publishing, Melbourne.

Kemper C.M., Flaherty A., Gibbs S.E., Hill M., Long M. and Byard R.W. (in press). *Cetacean captures, strandings and mortalities in South Australia 1881-2000 with special reference to human interactions*.

Knight M.A., Tsolos A. and Doonan A.M. (2003). South Australian Fisheries and Aquaculture Information and Statistics Report. *SARDI Research Report Series No. 58*. 84 pp.

Koslow J.A., Gowlett-Holmes K., Lowry J.K., O'Hara T., Poore G.C.B. and Williams A. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series* **213**, 111-125.

Kott P. (1975). The ascidians of South Australia III. Northern sector of the Great Australian Bight and additional records. *Transactions of the Royal Society of South Australia* **99**, 1-20.

Laist D.W., Knowlton A.R., Mead J.G., Collet A.S. and Podesta M. (2001). Collisions between ships and whales. *Marine Mammal Science* **17**, 35-75.

Larkum A.W.D., McComb A.J. and Shepherd S.A. (eds.) (1989). *Biology of Seagrasses. A treatise on the biology of seagrasses with special reference to the Australian region*. Elsevier. 841 pp.

Li Q., McGowran B., James N.P. and Bone Y. (1996). Foraminiferal biofacies on the mid-latitude Lincoln Shelf, South Australia: oceanographic and sedimentological implications. *Marine Geology* **129**, 285-312.

Li Q., James N.P. and McGowran B. (2003). Middle and Late Eocene Great Australian Bight lithobiostratigraphy and stepwise evolution of the southern Australian continental margin. *Australian Journal of Earth Sciences* **50**, 113-128.

Ling J.K. and Needham D.J. (1988). *Final Report on Southern Right Whale Survey, South Australia, 1988.* Unpublished report to the Australian National Parks and Wildlife Service.

Lisk M., Hall D., Ostby J. and Brincat M.P. (2001). Addressing the oil migration risks in the Great Australian Bight. In: Hill KC Bernecker T (eds). Eastern Australasian basins symposium 2001; A refocused energy perspective for the future. *Petroleum Exploration Society of Australia Special Publication* **1**, 553-562.

Lenanton R.C., Joll L., Penn J, and Jones G.K. (1991). The influence of the Leeuwin Current on coastal fisheries of Western Australia. *Journal of the Royal Society of Western Australia* **74**, 101-114.

Lowenstein J.M. (1989). Medicines from the sea. *Oceans*. **22**(1): 72.

Malcolm H., Bruce B.D. and Stevens J.D. (2001). *A review of the biology and status of white sharks in Australian waters*. CSIRO Marine Research, Hobart.

Mawson P.R. and Coughran D.K. (1999). Records of sick, injured and dead pinnipeds in Western Australia 1980-1996. *Journal of the Royal Society of Western Australia* **82**, 121-128.

Maxwell J.G.H. and Cresswell G.R. (1981). Dispersal of tropical marine fauna to the Great Australian Bight by the Leeuwin Current. *Australian Journal of Marine and Freshwater Research* **32**, 493-500.

McCauley R.D. (1994). *Environmental implications of offshore oil and gas development in Australia - seismic surveys*. Australian Institute of Marine Science Townsville, Queensland Independent Scientific Review. 121 pp.

McGarvey R., Fowler A.J., Feenstra J.E., Fleer D.A. and Jones G.K. (2003). *King George Whiting (Sillaginodes punctata) Fishery*. Fishery Assessment Report to PIRSA Fisheries for the MSF Fishery Management Committee. www.sardi.gov.au/pages/aquatics/sus_fish/finfish/kgwstockass.pdf

McLeay L.J., Sorokin S.J., Rogers P.J. and Ward T.M. (2003). *Benthic Protection Zone of the Great Australian Bight Marine Park. 1. Literature Review*. South Australian Research and Development Institute (Aquatic Sciences). Final Report to the National Parks and Wildlife South Australia and the Commonwealth Department for Environment and Heritage. 70 pp.

Mead J.G. (1986). Twentieth Century records of Right Whales *(Eubalaena gracilis)* in the northwestern Atlantic Ocean. In: Right Whales: Past and Present Status. *Reports of the International Whaling Commission Special Issue* **10**, 109-119.

Middleton J.F. and Cirano M. (2002). A northern boundary current along Australia's southern shelves: The Flinders Current. *Journal of Geophysical Research-Oceans* **107**, 3129-3143.

Morgan G.J. and Jones D.S. (1991). Checklist of the marine decapod Crustacea of southern western Australia. In: Wells FE Walker DI Kirkman H Lethbridge R (eds). *Proceedings of the Third International Marine Biological Workshop: The Marine Flora and Fauna of Albany*, Western Australia pp 483-497. Western Australian Museum, Perth.

Mulvaney D.J. and Kamminga J. (1999). *Prehistory of Australia*. Allen and Unwin.

Murray L., Lim T.K., Currie G. and Capon R.J. (1995). Aplidites (A-G): Macrocyclic Orthonitrates from an Australian tunicate, *Aplidium* sp. *Australian Journal of Chemistry*. **48**: 1253-1266.

Newton G. and Klaer N. (1991). Deep-sea Demersal Fisheries Resources of the Great Australian Bight: a Multivessel Survey. *Bureau of Rural Resources, Bulletin No. 10*. Australian Government Publishing Service, Canberra.

NIMPIS (2002a). *Undaria pinnatifida* species summary. National Introduced Marine Pest Information System (Eds: Hewitt C.L., Martin R.B., Sliwa C., McEnnulty, F.R., Murphy, N.E., Jones T. & Cooper, S.). Web publication <http://crimp.marine.csiro.au/nimpis

NIMPIS (2002b). *Maoricolpus roseus* species summary. National Introduced Marine Pest Information System (Eds: Hewitt C.L., Martin R.B., Sliwa C., McEnnulty, F.R., Murphy, N.E., Jones T. & Cooper, S.). Web publication <http://crimp.marine.csiro.au/nimpis

NOAA (1992). An introduction to coastal habitats and biological resources for oil spill response. *National Oceanic and Atmospheric Administration Report no. HMRAD 92-4*.

Norvack M.S. and Smith M.A. (2000). *The separation of Australia from Antarctica and its stratigraphic signal in southern Australian basins. Geological Society of Australia, Abstract No. 59*, p365. 15th Australian Geological Convention, Sydney, July 2000.

O'Hara T.D. and Poore G.C.B. (2000). Patterns of distribution for southern Australian marine echinoderms and decapods. *Journal of Biogeography* **27**, 1321-1335.

Okuno J. (1997). A new shrimp of the genus *Rhynchocinetes* from the Great Australian Bight (Crustacea: Decapoda: Rhynchocinetidae). *Records of the South Australian Museum* **30**, 13-18.

Overton E., Sharp W. and Roberts P. (1994). Toxicity of Petroleum. Chapter 5 In: Cockerham L Shane B (eds). *Basic Environmental Toxicology* pp 133-165. CRC Press, Boca Raton.

Parker A.J., Fleming C.M. and Flint R.B. (1985) Geology. In: Twidale CR, Tyler MJ and Davies M (eds.). *Natural History of the Eyre Peninsula*. Royal Society of South Australia, Adelaide. pp. 21-45.

Petrusevics P. (1991). Oceanography of the Great Australian Bight. In: *Collection of Abstracts: The Great Australian Bight: A Regional Perspective, Adelaide, 2 May 1991*. South Australian Department of Fisheries, Australian National Parks and Wildlife Service and the Australian Marine Sciences Association. Abstract.

Page, B., McKenzie, J., McIntosh, R., Baylis, A., Morrissey, A., Calvert, N., Haase, T., Berris, M., Dowie, D., Shaughnessy, P.D. & Goldsworthy, S.D. (2004) Entanglement of Australian Sea-lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem. *Marine Pollution Bulletin 2004.01.006*.

Phillips J.A. (2001). Marine macroalgal biodiversity hotspots. Why is there high species richness and endemism in southern Australian marine benthic flora? *Biodiversity and Conservation* **10**, 1555-1577.

Pidcock S., Burton C. and Lunney M. (2003). *The potential sensitivity of marine mammals to mining and exploration in the Great Australian Bight Marine Park Marine Mammal Protection Zone*. An independent review and risk assessment report to Environment Australia. Commonwealth of Australia. 114 pp.

Pogonowski J.J., Pollard D.A. and Paxton J.R. (2002). *Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes*. Environment Australia. www.deh.gov.au/coasts/species/marine-fish/threatening.html

Poore G.C.B. (1995). Biogeography and diversity of Australia's marine biota. In: Zann L (ed). *The State of the Marine Environment Report for Australia*. Technical Annex 1: The Marine Environment pp 75-84. Department of Environment, Sport and Territories, Canberra.

Probert P.K. (2002). Ocean science and conservation: catching the wave. *Aquatic Conservation: Marine and Freshwater Ecosystems* **12**, 165-168.

Reeves R.R. (1992). Whale responses to anthropogenic sounds: a literature review. *Science and Research Series no.47*. Department of Conservation, Wellington, New Zealand.

Reilly P.N. (1974). Breeding of Little Penguins along the Great Australian Bight. *Emu* **74**, 198-200.

Richardson W.J., Greene C.R.J., Malme C.I. and Thomson D.H. (1995). *Marine Mammals and Noise*. San Diego, Academic Press.

Robinson A.C., Delroy L.B. and Jenkins R.B. (1982). The conservation and management of the Cape Barren Goose *Cereopsis novaehollandiae* Latham in South Australia. *South Australian National Parks and Wildlife Service Special Publication No. 1*.

Rochford D.J. (1980). *Nutrient Status of the Oceans Around Australia. Report 1977-1979*. CSIRO Division of Fisheries and Oceanography, Hobart, Australia.

Rochford D.J. (1986). Seasonal changes in the distribution of Leeuwin Current waters off southern Australia. *Australian Journal for Marine and Freshwater Research* **37**, 1-10.

RV Franklin (2001) *Cruise Summary FR01/01* (GABSEEPS Cruise). Unpublished report.

SARDI (2001). *Help us stop the spread of invasive seaweed*. SARDI website http://www.sardi.sa.gov.au/pages/showcase/media_releases/2002/flyer.pdf

Schratzberger M. and Jennings E.S. (2002). Impacts of chronic trawling disturbance on meiofaunal communities. *Marine Biology* **141**, 991-1000.

Shaughnessy P.D. (1994). Increase in Some Australian Marine Mammal Populations. *Australasian Wildlife Management Society, 7th Annual Conference, Alice Springs, December 1994*. Abstract.

Shaughnessy P.D. (1999). *Action Plan for Australian Seals*. Environment Australia, Canberra.

Shaughnessy P.D. and McKeown A. (2002). Trends in abundance of New Zealand fur seals, *Arctocephalus forsteri*, at the Neptune Islands, South Australia. *Wildlife Research* **29**, 363-370.

Shaughnessy P.D., Gales N.J., Dennis T.E. and Goldsworthy S.D. (1994). Distribution and abundance of New Zealand fur seals, *Arctocephalus forsteri,* in South Australian and Western Australia. *Wildlife Research* **21**, 667-95.

Shaughnessy P.D., Kirkwood R., Cawthorn M., Kemper C. and Pemberton D. (2003). Pinnipeds, cetaceans and fisheries in Australia: a review of operational procedures. In '*Marine Mammals: fisheries, tourism and management issues*'. Eds. N.J. Gales, M. Hindel and R. Kirkwood. pp. 136-152. CSIRO Melbourne.

Shepherd S.A. (1979). The ecology of a deep-water red algal community off Cape Northumberland, South Australia. *Department of Fisheries Series Report No. 4*. 255 pp.

Shepherd S.A. and Veron J.E.N. (1982). Stony Corals (Order Scleractinia or Madreporaria). In: Shepherd SA Thomas IM (eds). *Marine Invertebrates of South Australia* pp 169-178. Government Printer, South Australia.

Short A.D., Fotheringham D.G. and Buckley R.C. (1986). Coastal Morphodynamics and Holocene Evolution of the Eyre Peninsula Coast, South Australia. *Coastal Studies Unit Technical Report No. 86/2*. Department of Geography, University of Sydney.

Simmonds M. and Mayer S. (1997). An evaluation of environmental and other factors in some recent marine mammals mortalities in Europe: implications for conservation and management. *Environmental Review* No. 5.

Simpson K. and Day N. (1999). *Field guide to the birds of Australia*. Penguin Books Australia, Victoria.

Slater J. (ed.) (1998). Working Draft. *Workshop to identify research and monitoring priorities for the Great Australian Bight Marine Park. Environment Australia. Technical Report No. 1*.

Stevens J. (1998). Sharks and Marine Protected Areas in the Great Australian Bight. In: Slater J (ed). Working Draft. *Workshop to identify research and monitoring priorities for the Great Australian Bight Marine Park. Environment Australia. Technical Report No. 1*.

Surman C.A. and Wooller R.D. (2000). Seabirds off the south-western coast of Australia. *Emu* **100**, 312-317.

Tasker M.L., Camphuysen C.J., Cooper J., Garthe S., Montevecchi W.A. and Blaber S.J.M. (2000). The impacts of fishing on marine birds. *ICES Journal of Marine Science* **57**, 531-547.

Terhune J.M. and Verboom W.C. (1999). Right whales and ship noise. *Marine Mammal Science* **15**, 256-258.

Terrens G.W., Gwyther D. and Keogh M.J. (1998). Environmental assessment of synthetic-based drilling mud discharges to Bass Strait, Australia. *APPEA Journal* **38**, 610-625.

Tilbury L.A. and Fraser A.R (1981). Submarine valleys on the Ceduna Terrace off South Australia. *BMR Journal of Australian Geology and Geophysics*. **6**: 259-264.

Tindale N.B. (1974). *Aboriginal Tribes of Australia.* University of California Press, USA.

URS Australia Pty. Ltd. (2001). *Review of Environmental Impacts of Petroleum Exploration and Appraisal Activities in Commonwealth Waters*.

Venema S., Boxall V. and Ward T.M. (2003). *Survey of Recreational Rock Lobster Fishing in South Australia*. Final Report to the PIRSA Fisheries Policy Group.

Ward T.M., Hoedt F., McLeay L., Dimmlich W.F., Jackson G., Rogers P.J. and Jones K. (2001). Have recent mass mortalities of the sardine *Sardinops sagax* facilitated an expansion in the distribution and abundance of the anchovy *Engraulis australis* in South Australia? *Marine Ecology Progress Series* **220**, 241-251.

Ward T.M., McLeay L.J. and Rogers P.J. (2003a). *Benthic Protected Zone of the Great Australian Bight Marine Park: 2. Monitoring Sustainable Use*. South Australian Research and Development Institute (Aquatic Sciences). Final Report to the National Parks and Wildlife South Australia and the Commonwealth Department for Environment and Heritage. 82 pp.

Ward T.M., Sorokin S.J., Rogers P.J., McLeay L.J. and Turner D.J. (2003b). *Benthic Protection Zone of the Great Australian Bight Marine Park: 3. Pilot Study for Performance Assessment (Volume 1)*. South Australian Research and Development Institute (Aquatic Sciences). Final Report to the National Parks and Wildlife South Australia and the Commonwealth Department for Environment and Heritage. 43 pp.

Wass R.E., Connolly J.R. and MacIntyre R.J. (1970). Bryozoan carbonate sand continuous along southern Australia. *Marine Geology* **9**, 63-73.

Watson J.E. (1982). Hydroids. In: Shepherd SA Thomas IM (eds). *Marine Invertebrates of South Australia* pp 77-114. Government Printer, South Australia.

Weimerskirch H. (2004). Diseases threaten Southern Ocean albatrosses. *Polar Biology* **27**, 374-379.

Weimerskirch H., Inchausti P., Guinet C. and Barbraud C. (2003). Trends in bird and seal populations as indicators of a system shift in the Southern Ocean. *Antarctic Science* **15**, 249-256.

Willcox B (1998) The Great Australian Bight: Regional geology, exploration activities and their relationship to the Great Australian Bight Marine Park, sanctuaries and conservation areas. In: Slater J (ed). Working Draft. *Workshop to identify research and monitoring priorities for the Great Australian Bight Marine Park. Environment Australia. Technical Report No. 1*.

Willcox J.B. (1978). *The Great Australian Bight – a regional interpretation of gravity, magnetic and seismic data from the Continental Margin Survey*. Bureau of Mineral Resources Report. p.201.

Willcox J.B., Stagg H.M.J. and Davies H.L. (1988). Rig Seismic research cruises 10 and 11: structure, stratigraphy and tectonic development of the Great Australian Bight region. Preliminary Report. Bureau of Mineral Resources, Australia. *Report No. 88/13*.

Willcox J.B. and Stagg H.M.J. (1990). Australia's southern margin; a product of oblique plate extension. *Tectonophysics*, 173, 269-281.

Williams A., Koslow J.A. and Last P.R. (2001). Diversity, density and community structure of the demersal fish fauna of the continental slope off western Australia (20 to 35°S). *Marine Ecology Progress Series* **212**, 247-263.

Wilson B.R. and Allen G.R. (1987). Major components and distribution of marine fauna. In: Dyne GW (ed.) *Fauna of Australia. Volume 1A. General Articles* pp 43-68. Australian Government Publishing Service, Canberra.

Womersley H.B.S. (1981). Biogeography of marine algae. In: Clayton MN King RJ (eds.). *Marine Botany. An Australasian Perspective* pp 293-307. Longman Cheshire, Melbourne.

Woodley T.H. and Lavigne D.M. (1993). Potential effects of incidental moralities on the Hooker's sea-lion *(Phocarctos hookeri*) population. *Aquatic Conservation* **3**, 139-48.