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***ENVIRONMENTAL RESOURCE ATLAS
OTWAY BASIN EXPLORATION PROGRAM***

NOVEMBER 1999

Prepared for VIC/P43 Joint Venture

By Ecos Consulting (Aust) Pty Ltd



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1 INTRODUCTION

Exploration Permit VIC/P43 was awarded in August 1999 for a term of 6 years to a joint venture between:

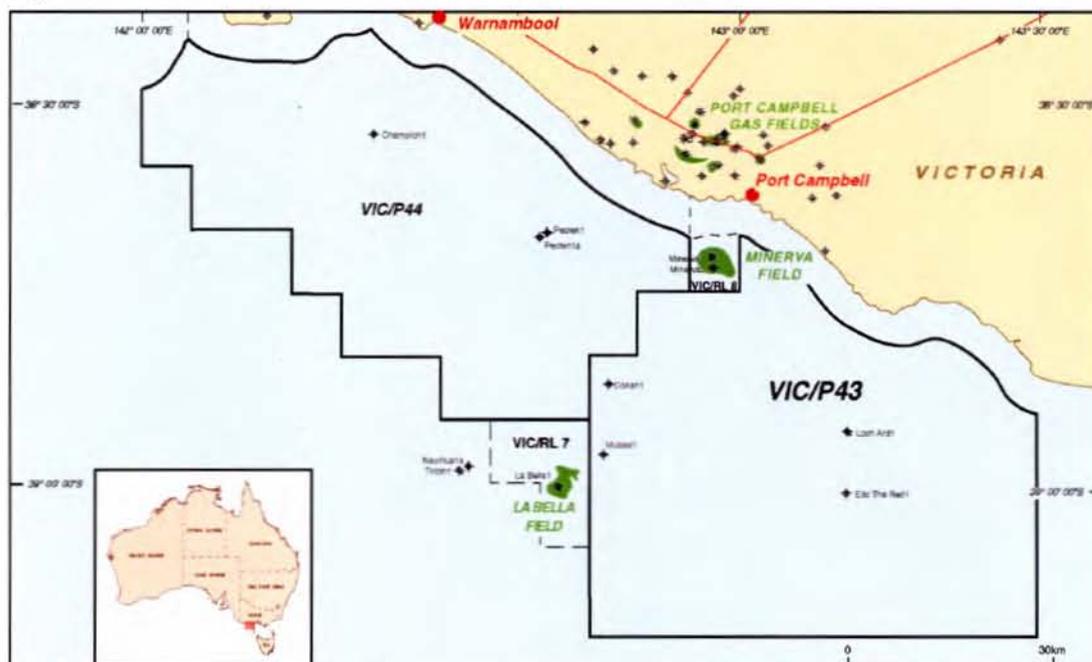
- Boral Energy Resources Limited (25%);
- Woodside Energy Limited (50%); and
- CalEnergy Gas (UK) Limited (25%).

The Joint Venture companies share a common goal of participating in the eastern states gas market, and bringing increased competition and supply security. Boral is the operator of the permit and Woodside is the seismic and drilling operator for the first three years.

The Joint Venture is planning to conduct a 3D seismic survey in the permit area between December 1999 and February 2000. This Environmental Resource Atlas has been developed as a planning tool for seismic and drilling operations and for oil spill contingency planning.

The Study Area includes all coastal areas plus marine environments below the level of the highest tide, including all intertidal and subtidal areas. A review of the movement of an oil spill in the exploration areas of VIC/P30 and VIC/P31 (BHP Petroleum, 1995) indicated that the shorelines that could possibly be impacted are those between Warrnambool and Cape Otway. The Study Area for this report therefore includes the coastal and marine environments between Port Fairy and Apollo Bay as well as the permit area VIC/P43. For completeness Lady Julia Percy Island has also been included. The location of the Permit Area is illustrated in Figure 1.

Figure 1: Location of VIC/P43



5 cm

The objective of the atlas is to identify, collate and document relevant environmental and cultural data pertaining to the permit area and adjacent coastal and marine areas.

The information and data included within this atlas and its supporting Geographical Information System (GIS) database have been sourced from a comprehensive review of the following sources (full details are included in Section 7):

- Published and publicly available literature;
- Government maps, reports and survey data; and
- Consultation with relevant government and university researchers and officers.

This report documents the results of the information acquisition and review undertaken to compile the GIS database and provides a regional perspective on the marine and coastal environmental resources within the Otway Basin study area.

2 PHYSICAL ENVIRONMENT

2.1 Climate

The region is temperate and characterised by warm, dry summers and cool winters. It is dominated by the subtropical high pressure system in summer and the subpolar low pressure systems in winter. The low pressure systems are accompanied by strong westerly winds and cool, wet conditions. The day to day variation in weather conditions is caused by the continual movement of the high pressure systems from west to east across the Australian continent roughly once every ten days (Cribb, 1989; Short, 1996).

Meteorological records are collected by the Bureau of Meteorology at Warrnambool and Cape Otway. Measurements taken include rainfall, air temperature, wind speed and direction, humidity, and sea state (Cape Otway only).

Air Temperature

The region has large seasonal temperature differences that can range from 43.3°C (measured at Cape Otway) to -3.6°C (measured at Warrnambool). The average monthly minimum and maximum temperatures for locations near the permit area are summarised as yearly averages in Table 1.

Table 1: Average Annual Temperature

LOCATION	AVERAGE MINIMUM TEMPERATURE (°C)	AVERAGE MAXIMUM TEMPERATURE (°C)
Warrnambool	8.2	17.8
Cape Otway	10.4	17.3

Bureau of Meteorology data, 1862-1996

Rainfall

The average annual rainfall is 934mm at Warrnambool and 899mm at Cape Otway. The region is characterised by winter dominant rainfall with significant seasonal changes in monthly rainfall. The wettest and driest monthly rainfall for these two locations is summarised in Table 2.

Table 2: Wettest and Driest Average Monthly Rainfall

LOCATION	WETTEST AVERAGE MONTHLY RAINFALL (MM)	DRIEST AVERAGE MONTHLY RAINFALL (MM)
Warrnambool	115.2 (August)	33.6 (February)
Cape Otway	105.8 (July)	41.8 (February)

Bureau of Meteorology data, 1862-1996

Winds

Annual Bureau of Meteorology wind rose data for Cape Otway show the wind direction to be predominantly from southwest to northwest. Table 3 summarises the predominant seasonal morning and afternoon wind directions. Winds are moderate to strong in winter (7 to 15m/sec) and moderate to fresh in summer (7 to 9.5m/sec) (BHP Petroleum, 1995).

Table 3: Predominant Wind Direction at Cape Otway

TIME OF MEASUREMENT	SUMMER	AUTUMN	WINTER	SPRING
0900 hours	SW-W; E	NW-N	NW-N	SW-NW
1500 hours	SW-W; E	SW-NW; E	W-NW	SW-W

Bureau of Meteorology wind rose data, 1997

2.2 Oceanography

Water Temperature

The sea surface temperature ranges from approximately 12°C (August-September) to 18°C (February-March) (Short, 1996; Kailola *et al.*, 1993).

Salinity

Salinity ranges from 35.1 to 35.6 parts per thousand (Short, 1996; Kailola *et al.*, 1993).

Currents

At the surface, Bass Strait receives water flowing east from South Australia; this is called Bass Strait Water. It is most dominant along the Victorian coast in winter and is characterised by low temperature (13°C) but higher salinity (Short, 1996). The West Wind Drift that moves clockwise around the entire Southern Ocean is generally located too far south to impact the Victorian coastal waters. However, some of the cold water does reach the east and west areas of Bass Strait as sub-surface water.

In addition to the Bass Strait currents, local winds will exert a force on the sea surface and produce local currents, particularly in times of strong winds. Along the Victorian coast, the strong westerly winds are prominent (Short, 1996).

Overall, currents within the study area are from the south-southwest and south-southeast in winter and predominantly from the north-northwest with some currents from the south-southeast during summer. Current velocities of 1kph are common (BHP Petroleum, 1995; LCC, 1993; Short, 1996).

During summer upwelling of cold, nutrient rich water occurs just to the west of Port Fairy. (Kailola *et al.*, 1993; LCC, 1993).

Tides

The tidal characteristics for Apollo Bay, Port Campbell and Warrnambool are summarised in Table 4. The tide arrives at Apollo Bay one hour before it arrives at Port Campbell and Warrnambool. The variation in the height of the tide and its time of arrival is due to a number of factors, including:

- the tidal wave approaches from the east reaching eastern Victoria first and Portland last;
- it is further slowed and refracted by Tasmania and enters Bass Strait from both sides;
- it is amplified by the shallow waters of the Bass Strait; and
- it decreases in height west of Cape Otway. (LCC, 1993; Short, 1996).

Table 4: Tidal Characteristics

LOCATION	SPRING TIDE RANGE (M)
Apollo Bay	1.3
Port Campbell	0.6
Warrnambool	0.5

Adapted from Short, 1996

Waves

Mid-latitude cyclones move continuously across the Southern Ocean and generate most of the waves arriving at the western Victorian coast. In summer the waves will occur as long, moderate to high swells due to the cyclones being far to the south of Australia at this time of year. In winter the cyclones are closer to the coast producing higher seas and swells, and associated onshore winds.

Waves arrive from the south-west and are on average 2-3.5m high with a spectral peak period of between 12 and 15 seconds (Lawson and Treloar, 1996; Short, 1996). Wave conditions are more severe in winter, but all seasons show a relatively high level of wave activity with 50% of waves at the Minerva field offshore location exceeding 3.3m (approx. 12km south of Port Campbell National Park). A wave-rider buoy was deployed in 90m of water 30km south-west of Cape Nelson (west of the permit area) during 1990/91 by the Coastal Investigations Unit of the Port of Melbourne Authority. Results indicated that the median significant wave height was just over 2.8m and rarely dropped below 1.0m. Wave periods of between 8 and 12 seconds occurred approximately 70% of the recorded time (LCC, 1993).

2.3 Bathymetry

The project area is within the relatively shallow waters of the continental shelf. The water depth within the area of interest reaches a maximum of 150m in the south-western corner of the permit area, VIC/P43. The bathymetry of the area is shown in Map 4.

2.4 Geology

Mesozoic feldspathic sandstones and mudstones (180-70 million years old) that were uplifted episodically during the past 100 million years dominate the coast from Apollo Bay to Moonlight Head. Paleocene to Eocene sediments (70-40 million years old) outcrop along the coast between Moonlight Head and Princetown. Between Princetown and Peterborough, tertiary marine limestones and marls (40-10 million years old) compose the famous cliffs and stacks. Numerous small beaches, barriers and estuaries, including extensive Quaternary coastal dune deposits are present between the bedrock outcrops that occur from Cape Otway to Rotten Point (Cuttiss, 1998; Short, 1996; Parks Victoria, 1997).

From Warrnambool to Port Fairy there is a series of large bays infilled with extensive Quaternary marine deposits. The intervening headlands are composed of Quaternary volcanics that dominate south-western Victoria outcrops. The most recent eruption at Tower Hill occurred only 7,300 years ago, with the lava reaching the adjacent coast at Sisters Point. Small outcrops of dune calcarenite (cemented dune limestone) occur west of Warrnambool (Short, 1996; Cuttiss, 1998). The general geology of the coastal area is illustrated in Map 5.

There is a general dearth of information regarding the geology of the seafloor within the study area. In general, it can be assumed that the geology of the seabed will reflect the geology of the coastline itself (LCC, 1993). Therefore the substrate is likely to consist of calcarenite, limestone, sandstone and marl. There will also be areas of sand with varying grain size.

A study was undertaken, as part of the Minerva Gas Field development process, at various sites in an area reaching from the coastal region of Port Campbell National Park south to approximately 8 km out in the Southern Ocean. The results indicated that the seabed substrate is quite variable and included ridged sand, shell grit sands, coarse sand, rocky outcrops, rocky bottom overlain with sand and reefs (Biosis Research, 1995). In some areas close to the coast, there is considerable seabed relief including subsea cliffs up to 10m high.

2.5 Coastal Geomorphology

Geomorphological features evolve as a result of interactions between rock substrate and coastal processes such as swell, waves, wind, current and tidal activity. Port Fairy is partially sheltered from the predominant south-west swell by Griffiths Island. This has allowed the development of a port. Channel dredging of the Moyne River and the building of training walls have reduced the movement of sediment from west to east. There is an accumulation of sand adjacent to the training walls which is associated with the loss of sand from Eastern Beach, western Port Fairy Bay.

A natural offshore basalt reef at the western end of Armstrong Bay decreases the wave energy reaching the shoreline and has allowed the accumulation of sand forming Killarney Beach. Further east towards Warrnambool, the beach is exposed to high wave energy and a wide dune barrier has formed with many ancient and active blowout dunes. Pleistocene calcarenite cliffs and shore platforms are present at the eastern end of the bay, at Thunder Point. Lady Bay, Warrnambool is partly sheltered

from the swell by these formations. This natural shelter has been enhanced by the construction of the Warrnambool Harbour breakwater. Sand accumulation within the locality of the breakwater has created 11ha of land, and water depths have significantly decreased.

East of Warrnambool the coast changes from wide beaches with high, grassed dunes to 30-60m high vertical cliffs and narrow shore platforms of Pleistocene calcarenite or Miocene limestone. Some cliffs in the area are created from limestone overlaid by softer Pliocene sandy clays, which form a bevelled cliff top unlike the sheer cliffs described previously. These cliffs actively erode and block slumping is a regular occurrence due to the undercutting effect of wave action, strong winds, rainfall and runoff. Some natural arches, such as *London Bridge* have collapsed due to this process leaving a small arch isolated from the headland. One block of Pleistocene dune calcarenite which has fallen to the foreshore and been weathered into capping pinnacles, forms the *Crown of Thorns* rock at Newfield Bay, west of Port Campbell. Clifton Beach, Port Campbell National Park offers further examples of this process with large blocks of rock from the calcarenite layer being present at beach level (Dames & Moore, 1996; Department of Conservation, 1990; LCC, 1993).

High wave energy in this area is related to the orientation of the coast to the south-west swell and the narrow, steeply shelving offshore profile of the continental shelf. Vertical jointing controls erosion of the relatively soft sedimentary rock. Solution along the joints has produced numerous caves, sink holes and offshore stacks which include *Sentinel Rock*, *The Arch* and *The Twelve Apostles*. Coastal sediment accumulation is restricted to small coves and areas sheltered by offshore reefs, such as Peterborough.

From Moonlight Head to Apollo Bay the coastline is predominantly cliffs of Lower Cretaceous Otway Group sandstones. Many streams reach the sea along this stretch of coast and the deep mouth of the Aire River is infilled with lagoonal and alluvial deposits. Vertical cliffs are present from Rotten Point near Glenaire and around Cape Otway with large deposits of calcarenite present. Extensive shore platform development occurs throughout the Otway region.

Holocene dunes are found at Apollo Bay where structural movements within the bedrock have formed depressions enabling the deposition and preservation of sediments. Apollo Bay harbour is regularly dredged due to natural infill caused by the net northerly littoral drift (Dames & Moore, 1996; Department of Conservation, 1990; DNRE, 1999b-e; LCC, 1993; Parks Victoria, 1997a-c).

2.6 Interim Marine and Coastal Regionalisation Classification

Victoria has adopted the Interim Marine and Coastal Regionalisation for Australia (IMCRA) system which has been developed as a regional framework for planning marine and coastal resource development and biodiversity conservation. IMCRA is a hierarchical classification of Australia's marine and coastal areas at continental province (macro-scale - >1000s of km), regional (meso-scale - 100s - 1000s of km), local (micro scale - 10s-100s of km) and site (pica-scale - <10 km) levels (IMCRA Technical Group, 1998).

The province classification is split into demersal and pelagic categories forming two macro-scale levels. These provide the coarsest layer of information in the IMCRA planning framework for the Australian Exclusive Economic Zone. The two levels were defined using biological and physical information. The study area is incorporated in the *West Bassian Biotone* and the *Southern Pelagic Province* classifications and these are described in Table 5.

Generally the meso-scale region classifications form a continuous, narrow-segmented band around the continent. These regions have been defined using biological and physical information plus geographic distance along the coast. *Otway* is the IMCRA meso-scale region for the study area and its description is given in Table 5.

Table 5: Description of IMCRA Provinces, Biotones and Meso-scale Regions

PROVINCE/BIOTONE /REGIONS NAME	AREA (KM ²)	LOCATION	REMARKS
West Bassian Biotone	89,751	Extends east from the South Australian Gulf Province penetrating past King Island to a southern limit at the north-western tip of Tasmania and a northern limit slightly north of Apollo Bay in Victoria.	Zone of faunal overlap of elements derived mainly from the Tasmanian and Bassian Provinces to the east, as well as a small suite of extralimital species from the Central Eastern Province. Also contains elements from the South Western Province and Gulf Provinces.
Southern Pelagic Province	482,000	Extending from near Albany in the west to Lakes Entrance in the east and enclosing Bass Strait and the Tasmanian waters.	Largely comprised of temperate species. The endpoint disjunctions also represent southern limits for tropical species. Intra-provincial disjunctions occur at Esperance and east of Point Dempster near the western edge of the Baxter Cliffs. In the east, disjunctions occur just east of Kangaroo Island and at Wilsons Promontory.
Otway Region		Cape Jaffa to slightly north of Apollo Bay and including King Island environs. (Narrow band across the western entrance of Bass Strait)	Very steep to moderate offshore gradients. High wave energy. Currents generally slow, but moderately strong through entrance to Bass Strait. Cold temperate waters subject to nutrient rich upwelling.

Source: IMCRA Technical Group, 1998

3 BIOLOGICAL ENVIRONMENT

3.1 Marine Biogeography

Endemism is a term used to describe the 'uniqueness' of a plant or animal to a specific region. The invertebrate marine fauna of temperate southern Australia is characterised by relatively low diversity and very high species endemism (usually over 90%).

The cold waters of southern Australia contain some of the highest levels of biodiversity for algae (over 1000 species of seaweeds), seagrasses, bryozoans (lace corals) and ascidians (sea squirts) in the world. These high level of diversity and endemism are the result of Australia's extensive temperate southern coastline and many millions of years of isolation of the continent, which has allowed the species to evolve their own unique characteristics (LCC 1996; Tsernjevski, 1995; Wilson & Allen, 1987).

3.2 Plankton

Planktonic organisms are divided into numerous categories. At the highest level two broad divisions are made - phytoplankton and zooplankton. Of the zooplankton the group can be further categorized as:

- holoplankton (remain their entire life in plankton form);
- meroplankton (organisms that only spend part of their life as plankton (eg: larvae of rock lobster); and
- pleuroston (whose bodies lie simultaneously in air and water, and which are usually characterised by some form of float) (McCauley 1994).

The planktonic biota on the Victorian continental shelf have not been thoroughly researched. The limited data available has concentrated on the zooplankton of estuaries and embayments (Arnott & McKinnon, 1985; Jenkins, 1986; Neale & Bayley, 1974).

Phytoplankton are strongly dependant upon physical dynamic processes which move nutrient-rich deeper water into the upper zones where light can penetrate (Hallegraeff, 1995). It is therefore reasonable to assume that there will be phytoplankton blooms associated with the summer upwelling that occurs just west of Port Fairy.

3.3 Intertidal and Benthic Communities

Research on the marine communities of Victoria is relatively sparse. However, the Marine Research Group (1984) did survey the whole of the Victorian coastline for the larger invertebrates during 1980 to 1984. The results of Minerva Gas Field Development surveys, conducted by Biosis Research (1995) and Sinclair Knight Merz (1996), confirmed that the marine and coastal habitats within the study area include

sand beach, cliff, intertidal rock platform, shallow rocky reef, deep rocky reef and sandy substrates of varying grain size.

Sand Beach

The sands in western Victoria are mainly calcareous and are derived from the shells and skeletons of dead organisms. The majority of beaches along the coast of the project area are subjected to high wave energy and are characterised by unstable, coarse sand. There are a few more sheltered beaches and these are described in Section 2.5. The sand beach habitat type supports a low species diversity that commonly includes amphipods and polychaetes. Generally, the coarser the grain size the lower the population density of invertebrates (LCC, 1993; Sinclair Knight Merz, 1996; Wass *et al.*, 1970).

Cliff

The sheer limestone cliffs of Shelly Beach (1.5km west of Port Campbell) are exposed to high wave action. The community recorded here consisted of encrusting coralline algae, chitons and gastropods. A general pattern of zonation based on the degree of exposure during low tide was observed in the cliff and rock rubble. Upper areas were dominated by littorinid gastropods, *Nodilittorina unifasciata* and *N. praetermissa*. On the boulders closer to the sea scattered colonies of the mussel *Xenostrobus pules* were identified. There were also further areas of encrusting coralline algae and a variety of gastropods (LCC, 1993; Sinclair Knight Merz, 1996).

Intertidal Rocky Shores

Intertidal rocky shores are the predominant habitat from Port Fairy to Apollo Bay. The type of rock and the degree of exposure to prevailing storm waves are the most significant factors affecting the species composition within this type of habitat.

The headlands between Port Fairy and Warrnambool are Quaternary basalt. Basalt provides a firm surface ideal for adhering invertebrates. It also weathers to form crevices and cracks providing abundant protection sites for cryptic species. There is a known basalt reef in Armstrong Bay. The limestones, marls and sandstones between Apollo Bay and Warrnambool are relatively soft and erode more rapidly than the basalt. This type of rocky shore offers a less stable habitat for adhering and cryptic invertebrates, but is nevertheless species rich (DNRE, 1999c; LCC, 1993; Short, 1996).

As recorded on the cliff and rock rubble at Shelly Beach, the intertidal rocky shore features a characteristic vertical zonation of organisms reflecting the low and high tide levels. The area above high tide is called the Supralittoral Zone and contains the most desiccation-resistant species such as littorinid snails (*Nodilittorina* spp.), which graze algae off rocks in the highest splash zone, and barnacles (*Chthamalus* spp.). The Littoral or Intertidal Zone exists between the high tide and low tide levels and is typically dominated by grazing snails, mussels and barnacles. Below the low tide level is the Sublittoral Zone and this is often algae-dominated with chitons, other molluscs and numerous crustaceans.

Species that inhabit the intertidal zone of western Victoria include the macro-algae Neptune's Necklace (*Hormosira banksii*) and Sea Lettuce (*Ulva lactuca*); the littorinid snail *Littorina praetermissa*; the limpets *Cellana tramoserica*, *Notoacmea mayi*, *Patelloida alticostata* and *P. latistrigata*; the top shell *Austrocochlea constricta*; the chitons *Plaxiphora albida*, *Ischnochiton australis* and *I. elongatus*; the polychaete worm *Galeolaria caespitosa*; the sea squirt *Pyura stolonifera*; the Beaked Mussel (*Aystrorhynchus rostratus*) and the Little Black Horse Mussel (*Xenostrobus pulex*); the Surf Barnacle (*Catomerus polymerus*); the Lineated Cominella (*Cominella lineolata*); the Green Sea Star (*Patiriella exigua*) and the Common Sea Star (*Patiriella calcar*); the Common Brittlestar (*Ophionereis schayeri*); the Hairy Stone Crab (*Lomis hirta*) and the Red Bait Crab (*Plagusia chabrui*); the Dog Winkle (*Thais orbita*); and the Cone Shell (*Conus anemone*).

A number of sessile colonial invertebrates also occur in the intertidal zone, attached to the underside of boulders and ledges. These filter-feeding organisms include encrusting sponges, bryozoans and ascidians (DNRE, 1999c; Hendreck and O'Hara, 1994; LCC, 1993).

Shallow Rocky Reef

Victoria's shallow rocky reefs occur either as extensions of intertidal rocky shores or as isolated offshore reefs. They can take the form of banks of stones or cobbles, large underwater boulders, cascading shelves of rock, or as canyons, caves and arches carved out of the seafloor. They are scattered throughout Victorian waters from the low-water mark to a depth of 20-30 metres.

Generally, the shallow reef is dominated by kelps or other species of large brown seaweeds. An understory of smaller plants and animals occurs beneath these kelp canopies. Bubble Weed (*Phyllospora comosa*) and the large, fleshy Bull Kelp (*Durvillaea potatorum*) commonly occupy exposed localities. Understorey species include species of *Cystophora*, *Sargassum*, *Codium*, *Cladophora* and *Caulerpa*. Many small red algae such as *Laurencia*, *Champia*, *Plocamium* and *Polysiphonia* form turf-like beds. Gastropod molluscs such as abalone (*Haliotis* spp.); the Purple Sea Urchin (*Helicoidaris erythrogramma*); seastars (e.g. Eleven Arm Sea Star, *Coscinasterias calamaria*), the Southern Rock Lobster (*Jasus edwardsii*); the polychaete feather duster worms (*Sabellastarte* spp.); the Common Feather Star (*Comanthus trichoptera*); and the Pink-throated Ascidian (*Herdmania momus*) are typical of this habitat (DNRE 1999e; LCC, 1993).

Sinclair Knight Merz (1996) identified a kelp reef in a water depth range of 3-7m offshore Shelly Beach. Large brown algae dominated this area, in particular *Phyllospora comosa* and *Durvillaea potatorum*. In areas where the effects of wave action and surge were low a diverse understory of red and green algae occurred as well as sponges, ascidians and molluscs (including abalone). Areas of stronger wave action were devoid of the algal understory and invertebrate community with the exception of limpets. *Ecklonia* reefs were also identified. The water depth for this habitat type ranged from 7-15m. It was dominated by the brown alga *Ecklonia* sp. Some of the exposed reef was covered by encrusting coralline algae (of the family Corallinaceae). Other species identified included turf algae, green algae, ascidians,

bryozoans, echinoderms and sponges. Banded Morwong (*Cheilodactylus spectabilis*), wrasse (*Labridae* sp.) and abalone were also observed in this habitat.

Deep Rocky Reef

Deep rocky reefs are found in water depths of greater than 20-30m. At this depth the algae found on shallower reefs are replaced by invertebrates such as sponges, bryozoans, corals, sea whips, and ascidians. Examples of the invertebrates that may inhabit the permit area include the ascidian *Pyura spinifera*; the gorgonians *Mopsella* spp. and *Mopsea whiteleggei*; the bryozoans *Cornucopina grandis* and *Vitacella* sp.; the hydroids *Clathrozoon wilsoni*, *Halopteris sulcata* and *Halocordyle wilsoni*; and the sponges *Spirastrella* sp., *Crella* sp. and *Clathria* sp. A number of species are harvested commercially and recreationally from the deep rocky reefs. These include Southern Rock Lobster, Purple Sea Urchin, Wrasse (*Labridae* sp.), Sweep (*Scorpius lineolatus*), Morwong, Long-fin Pike (*Sphyræna novaehollandiae*), Bastard Trumpeter (*Latridopsis forsteri*) and Southern Calamari (*Sepioteuthis australis*) (DNRE, 1999e; LCC, 1993).

A survey, conducted by the Victorian Institute of Marine Sciences as part of the Minerva Gas Field development process, was undertaken in 1993/94 (Currie, 1995). Samples were collected before and after drilling at varying distances from the exploration well located in the Minerva field approximately 12km south of Port Campbell. The seafloor was composed of coarse, well-sorted sand (Currie and Jenkins, 1994).

The results identified 196 species and a total of 5,035 individuals. These comprised 63% crustaceans, 15% polychaetes, 8% molluscs, 5% echinoderms. The most abundant species were the bivalve *Katlysia* sp. (12.4 individuals/m²), the sarconid *Triloculina affinis* (8.9 individuals/m²), the tanaid isopod *Apseudes* sp. (8.3 individuals/m²), the spionid polychaete *Prionospio coorilla* (4.8 individuals/m²) and a second species of *Apseudes* (2.0 individuals/m²).

Sandy Bottom

Common bivalves found in gravelly to coarse sand substrates in open waters off Victoria are *Mysella donaciformis* and *Legrandina bernardi*. Several gastropod molluscs are found primarily on sand including the Blemished Dog Whelk (*Nassarius burchardi*), Flat Sand Snail (*Polinices incei*), and the Conical Sand Snail (*P. conicus*). The Sand Octopus (*Octopus kaurna*) also inhabits sandy sediments (LCC, 1993). Ascidians and polychaetes were identified in this habitat at a water depth of 15m by Sinclair Knight Merz (1996).

3.4 Reptiles

The Leatherback Turtle (*Dermochelys coriacea*) is a rare visitor to the south western Victorian coastline and has been recorded along the coastline of the Otway National Park. There are no breeding rookeries in the study area (Parks Victoria, 1999a; Marsh *et al.*, 1995). Leatherback Turtles are listed as an Endangered species in Victoria.

3.5 Fish

Port Campbell Creek, Curdies Inlet, and Barham Creek are breeding areas for several estuarine and coastal fish species including Black Bream (*Acanthopagrus butcheri*), Estuary Perch (*Macquaria colonorum*), Yellow-eyed Mullet (*Aldrichetta forsteri*), Luderick (*Girella tricuspidata*), and Australian Salmon (*Arripis* sp.) (BHP, 1996; McCarraher, 1986). Gummy Shark (*Mustelus antarcticus*) and School Shark (*Galeorhinus galeus*), are known to pup in the shallow coastal areas and bays of western Victoria, and to protect these areas fishing activity for these species is confined to outside the 3 nautical miles coastal zone (K. Dunn, Australian Fisheries Management Authority, pers. comm.; K. McLoughlin, Bureau of Rural Sciences, pers. comm.).

Intertidal rocky shores provide habitat for a number of fish including the Common Shore-eel (*Alabes dorsalis*); the Cardinal Clingfish (*Creocele cardinalis*) and the Dragonet (*Bovichthys variegatus*).

Rocky reef habitats support many fish species including Blue-throat Wrasse (*Notolabrus tetricus*), Saddled Wrasse (*N. fucicola*), Senator Wrasse (*Pictilabrus laticlavus*), Old Wife (*Enoplosus armatus*), Shaw's Cowfish (*Aracana aurita*), leatherjackets (Family *Monacanthidae*), Globefish (*Diodon nichthemerus*), Southern Gobbleguts (*Vincentia conspersa*), Common Bullseye (*Pempheris multiradiata*), Port Jackson Shark (*Heterodontus portusjacksoni*), Varied Catshark (*Parascyllium variolatum*), Draughtboard Shark (*Cephaloscyllium laticeps*), Southern Red Scorpioncod (*Scorpaena papillosa*), Beardie (*Physiculus barbata*), Sea Sweep (*Scorpius aequipinnis*), Silver Sweep (*S. lineolatus*), Barber's Sea Perch (*Caesioperca rasor*), Butterfly Sea Perch (*C. lepidoptera*), Southern Hulafish (*Trachinops caudimaculatus*), Magpie Morwong (*Cheilodactylus nigripes*) and Red Mullet (*Upeneichthys lineatus*). Transient predators over the reef regularly include Long-finned Pike (*Dinolestes lewini*), Bastard Trumpeter (*Latridopsis forsteri*) and Barracouta.

Fish species found on sandy bottoms include Greenback Flounder (*Rhombosolea taparina*), Long-snouted Flounder (*Ammotretis rostratus*), Southern Sand Flathead (*Platycephalus bassensis*), Eastern Stargazer (*Kathetostoma laeve*), Gummy Shark (*Mustelus antarcticus*), Saw Shark (*Pristiophorus nudipinnis*), Elephant Shark (*Callorhynchus milii*) and Southern School Whiting (*Sillago bassensis*).

Pelagic fish species that may occur in the study area include Silver Trevally (*Pseudocaranx dentex*), Warehou (*Serirolella* spp.), Barracouta (*Thyrsites atun*), pilchards (e.g. *Sardinops neopilchardus*), anchovies (e.g. *Engraulis australia antipodum*) and Jack Mackerel (*Trachurus declivis*) (LCC, 1993).

3.6 Avifauna

A number of seabird breeding colonies are located within the study area. These are detailed in Table 6 and shown on Map 7. Seabirds breeding in these areas include Little Penguin (*Eudyptula minor*), Short-tailed Shearwater (*Puffinus tenuirostris*), Fairy Prion (*Pachyptila turtur*), Common Diving Petrel (*Pelecanoides urinatrix*),

Silver Gull (*Larus novaehollandiae*), Crested Tern (*Sterna bergii*), and Black-faced Shag (*Phalacrocorax fuscescens*). A search of the Atlas of Victorian Wildlife database identified a total of 67 species of seabirds recorded within the area 142°00'-144°00'E and 38°20'-39°20'S. The activities of seabirds in the marine environment are not well documented (LCC, 1993; Lindsey, 1986; Parks Victoria, 1997a & b, 1999a; Stone *et al*, 1997). A summary of the sea and coastal birds recorded in this area that have Victorian conservation status is given in Appendix B.

Specific areas of importance for birds include (LCC, 1993; Parks Victoria, 1997a, Tsernjavski, 1995):

- **Lady Julia Percy Island** – breeding area for Little Penguin, Fairy Prion, Common Diving Petrel and Short-tailed Shearwater.
- **Little River Beach** (west of Port Fairy) - important area for Sanderling (*Calidris alba*), Golden Plover (*Pluvialis apricaria*), Grey Plover (*Pluvialis squatarola*), Whimbrel (*Numenius phaeopus*) and Ruddy Turnstone (*Arenaria interpres*).
- **Port Fairy Shore and Griffith Island** – breeding colonies of Little Penguin and Short-tailed Shearwater. Beaches and rocky coast used by waders.
- **Killarney Reef (Armstrong Bay)** – breeding site for Crested Tern and Silver Gull.
- **Rogers Rocks** (small area of sand, kelp and basalt reefs at the western end of Armstrong Bay) - designated as a gathering area for waders in February and March, before they start on their northward migratory path.
- **Tower Hill Beach** - identified as a gathering area for many species of waders prior to migration. This site is also a significant feeding area for migrant species including Sanderling, Curlew (*Numenius spp.*), Ruddy Turnstone, and Sharp-tailed Sandpiper (*Calidris acuminata*).
- **Middle and Merri Islands** – Little Penguin breeding colony.
- **Bay of Islands Coastal Reserve** - Rufous Bristlebird (*Dasyornis broadbenti*) feeds and nests close to the ground in dense thick sword grass tussocks and lower branches of Coast Beard-heath, banksias and daisy bushes in this area.
- **Curdies Inlet** - habitat for the Australasian Bittern (*Botaurus poiciloptilus*).
- **Port Campbell National Park**- feeding area for various Dotteral (including *Erythrogonys cinctus* and *Charadrius rubricollis*), Bar-tailed Godwit (*Limosa lapponica*), Common Sandpiper (*Actitis hypoleucos*) and Hooded Plover (*Charadrius rubricollis*). The heathlands in this area provide breeding habitat for the Rufous Bristlebird.
- **Port Campbell Cliffs and Hinterland** – breeding area for Little Penguin, Black-faced Shag, Short-tailed Shearwater and Peregrine Falcon (*Falco peregrinus*).

- **Otway National Park** – the beach is a breeding area for Hooded Plover.

The Otway National Park is a large area of natural vegetation and wildlife. It is located in the Otway Basin and is one of the largest remaining areas of natural vegetation in the region. The park is home to a wide variety of native plants and animals, including the Hooded Plover. The beach area of the park is a breeding area for Hooded Plovers, which are a species of shorebird that is found in coastal areas. The park is also a popular destination for tourists and is a great place to see some of the region's natural beauty.

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Table 6: Breeding Colonies of Seabirds

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS	BREEDING LOCATION	BREEDING SEASON	COMMENTS
Short-tailed Shearwater (Mutton bird)	<i>Puffinus tenuirostris</i>	None	Lady Julia Percy Island, Griffith Island, Muttonbird Island.	Sept-April	Absent from Australian seas from mid-May to late Aug
Little Penguin	<i>Eudyptula minor</i>	None	Lady Julia Percy Island, Griffith Island, Middle Island, Merri Island, Bay of Islands, Twelve Apostles to London Bridge, Apollo Bay breakwater.	July-Dec	Adults are fairly sedentary around the breeding colony, but may make foraging trips of several hundred kilometres over several days. Immature birds disperse widely and return to colony at about 3 years
Silver Gull	<i>Larus novaehollandiae</i>	None	Killarney Reef.	Variable	
Black-faced Shag	<i>Leucocarbo fuscescens</i>	Vulnerable	Bay of Islands, Twelve Apostles to London Bridge.	Aug-Dec	Endemic to southern Australia; sedentary
Common Diving-Petrel	<i>Pelecanoides urinatrix</i>	Lower risk, near threatened	Lady Julia Percy Island	July-Jan	Relatively sedentary; often encountered resting in rafts on the water surface
Crested Tern	<i>Sterna bergii</i>	Lower risk, near threatened	Killarney Reef	Variable	High juvenile mortality
Fairy Prion	<i>Pachyptila turtur</i>	Lower risk, near threatened	Lady Julia Percy Island	Aug-Feb	Adults mainly sedentary, juveniles dispersive

Adapted from a search of the Atlas of Victorian Wildlife database search; LCC, 1993; Lindsey, 1986; Simpson and Day, 1984

3.7 Marine Mammals

All cetaceans in Australian waters are protected under State legislation to three nautical miles from the coastline, and under Commonwealth legislation from 3 to 200 nautical miles. Thirty-one species of cetaceans and seals have been recorded in or near the permit area. These are summarised in Table 7. Of these thirty species, only four are known to breed in Victorian waters. These are:

- **The Southern Right Whale (*Eubalaena australis*)** has a circumpolar distribution in the Southern Hemisphere. It migrates each year between its summer feeding grounds in the Southern Ocean and warmer northern waters (to about 30°S) where it breeds. The coast for about 8km east of Warrnambool is a locally important calving and nursing site. The area is used by the Southern Right Whale in most years between June and early November (Menkhorst, 1995; Stone *et al.*, 1997). The exact migratory path to this area remains unknown (Kemper *et al.*, 1997; C. Kemper, Southern Australian Museum, pers. comm.).
- **The Common Dolphin (*Delphinus delphis*)** is social and highly gregarious and occurs in herds of 5 to 50 throughout the year in Victorian waters. Births occur throughout the year. The numerical status of the Common Dolphin in Victorian waters has not been systematically studied, but frequent strandings and sightings of large aggregations indicate that it is locally common (LCC, 1993; Menkhorst, 1995). Anecdotal evidence indicates the presence of very large aggregations of this species (up to 1,000 individuals) in the Cape Otway area during the summer months.
- **The Bottlenose Dolphin (*Tursiops truncatus*)** is commonly encountered in the Bass Strait and along the entire Victorian coast. They enter all bays, estuaries and coastal lakes, and occasionally ascend the tidal reaches of large and small rivers. Mating and births occur during the summer months. Numbers of Bottlenose Dolphins in Victorian waters have not been estimated. However, sizeable groups are often sighted and frequent strandings are recorded indicating that it is locally common (LCC, 1993; Menkhorst, 1995).
- **The Australian Fur Seal (*Arctocephalus pusillus doriferus*)** is considered to be a subspecies of the Cape Fur Seal (*Arctocephalus pusillus*) of southern Africa. There is a breeding colony of approximately 10,000 to 12,000 Australian Fur Seals on Lady Julia Percy Island. They gather on the rocks and beaches, particularly on the western shore. Births occur from late October to late December and cows mate 5 to 6 days later (Cuttiss, 1998; LCC, 1993; Menkhorst, 1995; Shaughnessy, 1999; Stone *et al.*, 1997).

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Table 7: Marine Mammals that Frequent South West Coastal Waters of Victoria

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS*	BREEDING	COMMENT
Andrew's Beaked Whale	<i>Mesoplodon bowdoini</i>	NCA(a)	Unknown	Very little is known about this species.
Australian Fur Seal	<i>Arctocephalus pusillus doriferus</i>	LR,cd	Births and mating occur from late October to late December	Breeding colonies occur at Lady Julia Percy Island.
Australian Sea Lion	<i>Neophoca cinerea</i>	LR,cd	Not known to occur in coastal waters off Victoria	Sightings of individuals only.
Blainville's Beaked Whale	<i>Mesoplodon densirostris</i>	NCA(a)	Unknown	Very little is known about this species.
Blue Whale	<i>Balaenoptera musculus</i>	EN	Not known to occur in coastal waters off Victoria	Feed in summer in sub-Antarctic and Antarctic. Over-winter on breeding grounds in warmer waters at low latitudes. Known to use the shelf waters between Warrnambool and the SA border as a feeding ground from summer to autumn.
Bottlenose Dolphin	<i>Tursiops truncatus</i>	NCA(a)	Mating and births occur during summer	Commonly sighted along the entire Victorian coast.
Bryde's Whale	<i>Balaenoptera edeni</i>	NCA(a)	Not known to occur in coastal waters off Victoria	Restricted to tropical and temperate waters between 15° and 40°S.
Common Dolphin	<i>Delphinus delphis</i>	NCA(b)	Births occur throughout the year, but peak in summer and autumn	Occur in small herd of 5 to 50 throughout the year in Victorian waters.
Crabeater Seal	<i>Lobodon carcinophagus</i>	LR,lc	Not known to occur in coastal waters off Victoria	Sightings of stragglers only.
Cuvier's Beaked Whale	<i>Ziphius cavirostris</i>	NCA(b)	Unknown	Very little is known about this species.
Fin Whale	<i>Balaenoptera physalus</i>	V	Not known to occur in coastal waters off Victoria	Feed in summer in sub-Antarctic and Antarctic. Over-winter on breeding grounds in warmer waters at low latitudes.

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS*	BREEDING	COMMENT
Fraser's Dolphin	<i>Lagenodelphis hosei</i>	NCA(a)	Not known to occur in coastal waters off Victoria	Only one individual stranding recorded from Victoria.
Ginkgo-toothed Whale	<i>Mesoplodon ginkgodens</i>	NCA(a)	Unknown	Very little is known about this species.
Gray's Beaked Whale	<i>Mesoplodon grayi</i>	NCA(b)	Unknown	Very little is known about this species.
Humpback Whale	<i>Megaptera novaeangliae</i>	V	Migrate each year from feeding grounds in the Southern Ocean to tropical waters between 15° and 20°S to breed and mate	Sightings of stragglers from the group which migrates up the east coast of Australia have been increasing in recent years.
Killer Whale	<i>Orcinus orca</i>	NCA(c)	Unknown	Mostly sighted in autumn and spring to early summer.
Leopard Seal	<i>Hydrurga leptonyx</i>	LR,lc	Not known to occur in coastal waters off Victoria	Uncommon seasonal visitor (usually July to October).
Long-finned Pilot Whale	<i>Globicephala melas</i>	NCA(b)	Mating occurs in spring and early summer. Births are throughout the year, but mostly in late summer.	Widely recorded by strandings on the southern coasts of Australia.
Minke Whale	<i>Balaenoptera acutorostrata</i>	S	Not known to occur in coastal waters off Victoria	Feed in summer in sub-Antarctic and Antarctic. Over-winter on breeding grounds in warmer waters at low latitudes.
New Zealand Fur Seal	<i>Arctocephalus forsteri</i>	LR,cd	Not known to occur in coastal waters off Victoria	Individuals range into Bass Strait and are often seen at Lady Percy Island.
Pygmy Blue Whale	<i>Balaenoptera musculus brevicauda</i>	NCA(a)	Not known to occur in coastal waters off Victoria	Feed in summer in sub-Antarctic and Antarctic. Over-winter on breeding grounds in warmer waters at low latitudes. Strandings and sightings recorded in Victorian waters. Known to use the shelf waters between Warrnambool and the SA border as a feeding ground from summer to autumn.
Pygmy Right Whale	<i>Caperea marginata</i>	NCA(b)	Not known to occur in coastal waters off Victoria	Sightings uncommon.

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS*	BREEDING	COMMENT
Pygmy Sperm Whale	<i>Kogia breviceps</i>	NCA(a)	Not known to occur in coastal waters off Victoria	Sightings are uncommon.
Risso's Dolphin	<i>Grampus griseus</i>	NCA(a)	Not known to occur in coastal waters off Victoria	Only three individual strandings recorded from Victoria.
Southern Bottlenose Whale	<i>Hyperoodon planifrons</i>	NCA(b)	Unknown	Very little is known about this species.
Southern Elephant Seal	<i>Mirounga leonina</i>	V	Not known to occur in coastal waters off Victoria	Sightings of stragglers only.
Southern Right Whale	<i>Eubalaena australis</i>	V	Mating occurs in winter and births occur from June to August	8km east of Warrnambool is a locally important nursing site. Cow-calf pairs resident until early November.
Sperm Whale	<i>Physeter macrocephalus</i>	K	Not known to occur in coastal waters off Victoria	Victorian coastal waters offer no suitable habitat. Strandings and strays only recorded.
Strap-toothed Whale	<i>Mesoplodon layardii</i>	NCA(b)	Unknown	Very little is known about this species.
Sub-Antarctic Fur Seal	<i>Arctocephalus tropicalis</i>	EN	Not known to occur in coastal waters off Victoria	Sightings of individuals only.
True's Beaked Whale	<i>Mesoplodon mirus</i>	NCA(a)	Unknown	Very little is known about this species.

Compiled from Menkhorst, 1995; Rafic, 1999; a search of the Atlas of Victorian Wildlife database (area 142°00' to 144°00'S Longitude and 38°20' to 39°20'E Latitude)
*Conservation Status as defined in The Action Plan for Australian Cetaceans (Bannister et al, 1996) and The Action Plan for Australian Seals (Shaughnessy, 1999). EN – Endangered; V – Vulnerable; K – Insufficiently known; LR,cd – Lower risk, conservation dependent; LR,lc – Lower risk, least concern; NCA(a) – No category assigned because of insufficient information; NCA(b) – No category assigned but possibly secure; NCA(c) – No category assigned but probably secure; S - Secure

4 ISLANDS, PARKS AND RESERVES

4.1 Islands

- **Lady Julia Percy Island** lies 19km off the coast east of Port Fairy. It was formed during two periods of volcanic activity, the first left the 'boulder tuff', the later eruption left the dense basalt. The island was formed about one million years ago in the upper Pleistocene period. The island rises 46m above sea level and depressions on the island are probably caused by collapsing underground lava tunnels. The shallow soil is rich and black and supports bracken fern and grasses. The island is an important breeding area for bird and fur seal colonies (Stone *et al.*, 1997).
- **Griffiths Island** is located at the mouth of the Moyne River, Port Fairy and is home to a Short-tailed Shearwater (commonly called the 'mutton bird') colony. A viewing platform on the island allows visitors to watch the flocks of birds fly in to the island to settle on the ground for the night (Stone *et al.*, 1997).
- **Merri Island and Middle Island** are two relatively small islands located at the mouth of the Merri River near Warrnambool. They are the location of breeding colonies of Little Penguin.

4.2 National Parks and Reserves

Ninety-five percent of the Victorian coast is crown land. The Coastal Reserves and National Parks detailed below are all managed by Parks Victoria. The coastal environment between Childers Cove (17km east along the coast from Warrnambool) and Gibson's Steps (15km west along the coast from Moonlight Head) is listed under the Australian Heritage Commission Register of the National Estate. However, the intertidal and subtidal marine environments are not included in this listing despite the fact that these environments are an integral part of the natural and historical significance of the area. This is evident by the fact that these habitats have the highest species richness on limestone in Victoria. This is thought to be due to the availability of a diverse range of invertebrate habitats (Tsernjavski, 1995).

- **Otway National Park** has a total area of 13,000km. Some of the most rugged and inaccessible coastline in Victoria lies in the 60km stretch from Apollo Bay to Princetown (Parks Victoria, 1999a).
- **Port Campbell National Park** is a park of 1,750ha including a 27km stretch of Victoria's southern ocean coastline. The sheer cliffs and gorges, the arches and the offshore stacks form one of the most scenic and best known coastal landscapes in Australia. The Park is a major tourist attraction and it is listed in the Register of the National Estate (Department of Conservation & Environment, 1990; Parks Victoria, 1997a).

- **The Bay of Islands Coastal Reserve** is a 32km long narrow strip extending from Peterborough almost to Warrnambool. The parts accessible to the public are concentrated at the Peterborough end of the reserve. The coast in the Bay of Islands area features rock stacks, offshore islands and accessible beaches (Parks Victoria, 1997a, b).
- **Thunder Point Coastal Reserve** is located 2km south-west of Warrnambool. Thunder Point is the inland section of an 80,000 year old sand dune. The sea section has been eroded away and all that is left are island platforms. Within the 50ha reserve there are a number of multiple-layered Aboriginal middens (Parks Victoria, 1995).
- Two further reserves, **Warrnambool Foreshore Coastal Reserve** and **Port Fairy Coastal Reserve** are situated within the project area (Parks Victoria, 1995).

4.3 Marine Park Area

Marine parks are designated areas primarily to protect the habitats and associated biota represented in the park. Activities that disturb the biota are generally prohibited. Zones with sanctuary status are identified within each park to provide the highest level of protection for biodiversity and to maintain representative examples of natural ecosystems as benchmarks for scientific reference (ECC, 1998).

The Commonwealth and the States are now committed to an expansion of Australia's existing marine reserve system through the establishment of a National Representative System of Marine Protected Areas (NRSMPA), which would manage a range of appropriate uses and promote public education. As part of the NRSMPA, Victoria is currently assessing a number Marine Park Areas (MPA) and the final recommendations will be available in mid-2000 (ANZECC, 1999; Ferns, 1999).

Some areas between Port Fairy and Apollo Bay were recommended for Marine Park Status by the Land Conservation Council in the Marine & Coastal Special Investigation Draft Final Recommendations, 1996. This gives an indication of the ecological sensitivity and value of this coastal area (LCC, 1996). These proposed areas are shown on Map 7.

4.4 Coastal Flora

The distribution of coastal vegetation is affected by species tolerability to environmental factors such as parent rock material, wind, salt and the natural instability of many coastal landforms. On steep cliffs such as at Port Campbell National Park, vegetation is restricted to cliff tops and crevices, but on more gentle slopes vegetation may develop right to the shoreline.

Exposed slopes and cliff-tops may support tussock grassland dominated by Blue Tussock-grass (*Poa poiformis*) or Prickly Spear-grass (*Stipa teretifolia*). A number of species such as Pale Turpentine Bush (*Beyeria lechenaultii*), Sticky Daisy-bush (*Olearia glutinosa*) and Moonah (*Malaleuca lanceolata*) have a preference for

calcarene coasts. The limestone cliff tops of the Port Campbell coast support heaths dominated by Prickly Tea-tree (*Leptospermum continentale*) and Scrub She-oak (*Allocasuarina paludosa*), behind a narrow zone of Blue Tussock-grass and Cushion Bush (*Leucophyta brownii*) grassland. Species such as Sea Box (*Alyxia buxifolia*), Coast Beard-heath (*Leucopogon parviflorus*) and Coast Wattle (*Acacia sophore*) also occur within the project area.

Species that are typically found at the base of cliffs in the splash zone include Rounded Noon-flower (*Disphyma crassifolium*), Creeping Brookweed (*Samolus repens*), and Beaded Samphire (*Sarcocornia quinqueflora*). Grasses and herbs, such as Hairy Spinifex (*Spinifex sericeus*), Coast Saltbush (*Atriplex cinerea*) and the introduced Marram Grass (*Ammophila arenaria*), colonise dunes and bind these substrates together (Cuttiss, 1998; DNRE, 1999a; LCC, 1993; Parks Victoria 1997b and 1999; Stone *et al*, 1997).

5 FISHERIES

5.1 Commercial Fisheries

The Department of Natural Resources and Environment (DNRE), Victoria manage Victorian fish stocks within the 3 nautical mile zone to meet commercial and recreational needs through the Fisheries Management Program. Through this program, the DNRE provide advice, regulation, licensing, education and enforcement for the fishery resources of Victorian State waters.

The *Fisheries Act 1995* provides the basis for licensing commercial fishers, regulating their activities, and where appropriate setting of catch quotas for particular fisheries by the DNRE. Supporting Regulations specify closed seasons, minimum sizes, and gear restrictions. Within the study area, the State is responsible for the management of the Abalone, Rock Lobster, Eel and Victorian Zone Scallop Fisheries. Victoria works cooperatively with adjacent States and the Commonwealth for a number of fisheries including the Southern Shark Fishery and the Southern Squid Jig Fishery.

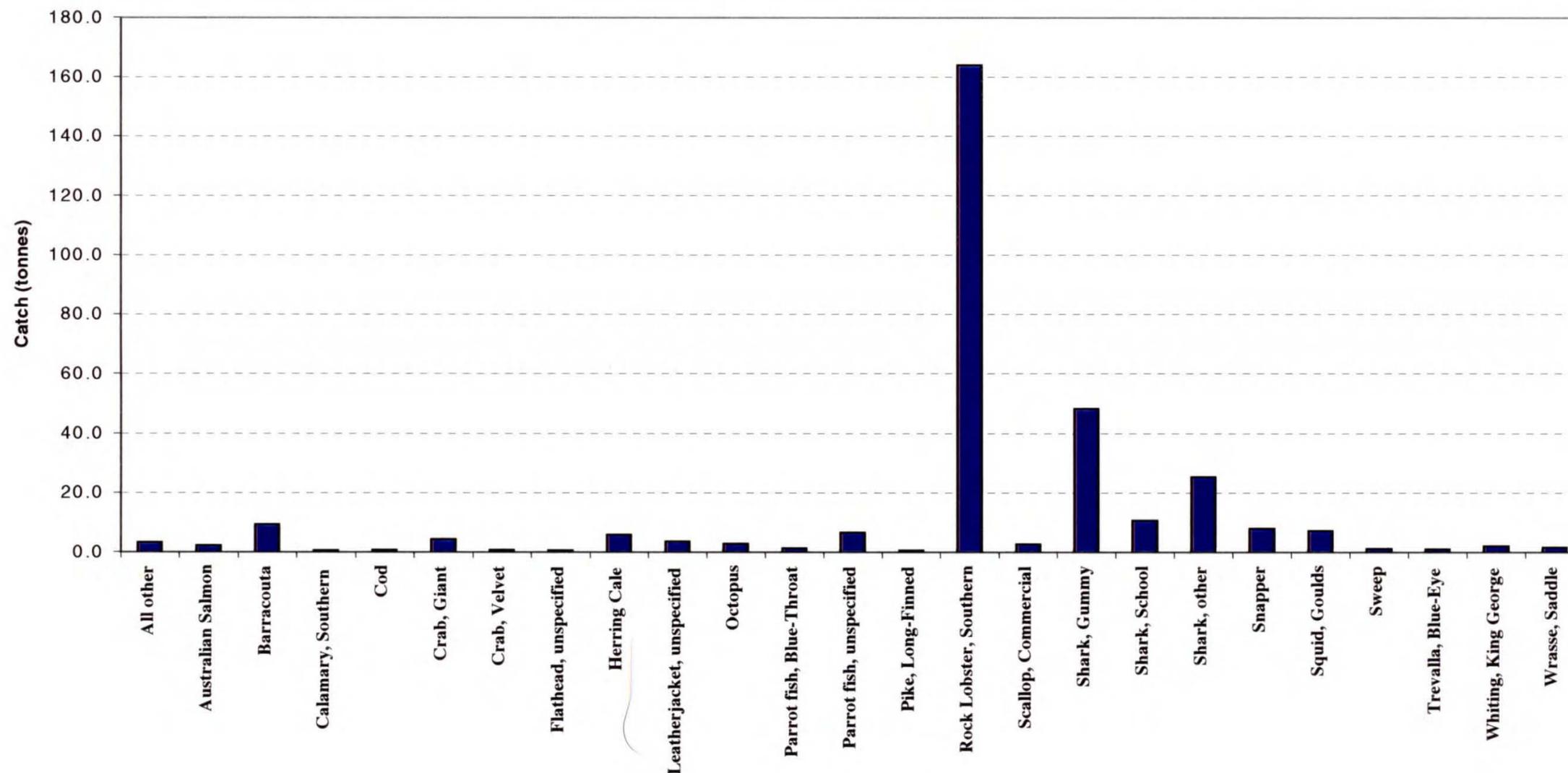
The Australian Fisheries Management Authority (AFMA) is the Commonwealth statutory authority responsible for ensuring the sustainable use and efficient management of Commonwealth fisheries resources under the *Fisheries Administration Act 1991* and the *Fisheries Management Act 1991*. AFMA manages fisheries within the 200 nautical mile Australian Fishing Zone (AFZ) and, in some cases, by agreement with the Australian States and Territories, to the low water mark.

AFMA is responsible for supplying management, advisory, compliance and licensing services, and implementing appropriate fisheries management arrangements. Within the study area, the Commonwealth is currently responsible for the South East Trawl, South East Non-Trawl, Bass Strait Central Zone Scallop, Southern Shark and Southern Squid Jig Fisheries.

Upwelling of cold, nutrient rich waters occur just to the west of Port Fairy during summer. The nutrients originating from this upwelling probably promote the productivity of the fisheries resources located in the permit area (Kailola *et al.*, 1993; LCC, 1993).

The total commercial catch by species during the 12-month period from April 1998 to March 1999 for the area bounded by longitudes 142° 00' and 144° 00' and latitudes 38° 20' and 39° 10' are shown in Figure 2. The data are based on mandatory fishing returns submitted by commercial fishers, and do not take account of returns not received or processed by the Marine & Freshwater Resources Institute (MAFRI). Within the permit area, VIC/P43, the AFMA database indicated no activity in Tuna, Jack Mackerel, Scallop or Squid fisheries during 1997 to 1999. The Fishery Access Licences as at October 1999 are summarised in Table 8.

Figure 2: Total Commercial Catch by Species (AFMA database 142°00'-144°00' and 38°20'-39°10') During the 12-Month Period, April 1998 to March 1999



'All other' combines the following species (less than 500kg) eels, tiger flathead, garfish, gurnard, hapuka, knife jaw, latchet, ling, mackerel, morwong, mullet, perch, redfish, tailor, trevally, trumpeter and warehou.

Source: MAFRI, pers. comm., 1999.

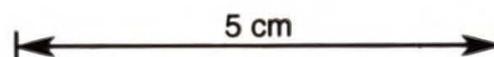


Table 8: Victorian Fishery Access Licence Summary (as at October 1999)

Licence	Number of Licences
Abalone	71
Bait (General)	31
Eel	18
Inland	5
Ocean	588
Purse Seine (Ocean)	2
Rock Lobster	159
Scallop (Ocean)	93
Trawl (Inshore)	61
Wrasse (Ocean)	58

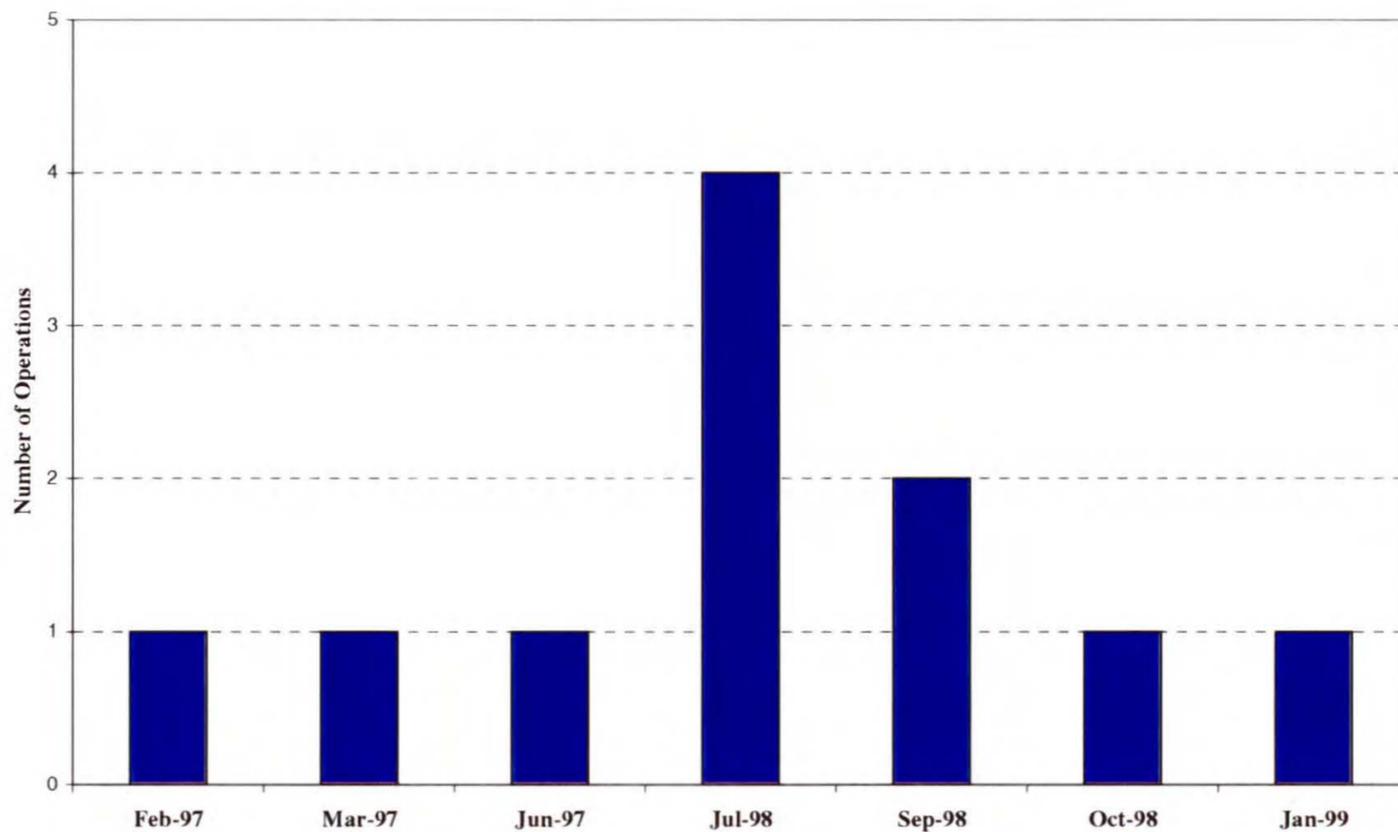
Source: MAFRI, pers. comm. 1999.

The fisheries that operate in the area are detailed below and illustrated in Map 8. The relevant commercial fish species are summarised in Table 9 at the end of this section.

South East Trawl Fishery (Western Zone)

Summaries of catch species for 1998 indicate that the main species caught by fishers of the South East Trawl Fishery, Western Zone (SETF) in areas of water depth consistent with that in the permit area include Blue Warehou (*Seriolella brama*), Spotted Warehou (*Seriolella punctata*), Pink Ling (*Genypterus blacodes*) and Tiger Flathead (*Neoplatycephalus richardsoni*). These species are subject to quota management arrangements in the SETF. The number of operators working within the permit area during 1997 to January 1999 is shown in Figure 3.

The South East Trawl Fishery Management Advisory Committee (SETMAC) was established in 1984. SETMAC was established to provide consultation on management issues between industry, researchers and managers (AFMA, 1999d; AFMA and BRS, 1999; DNRE, 1999g; Tilzey, 1999).

Figure 3: Reported Activity in Permit Area VIC/P43 by South East Trawl Fishery Trawlers, 1997-99

Source: AFMA database, 1999

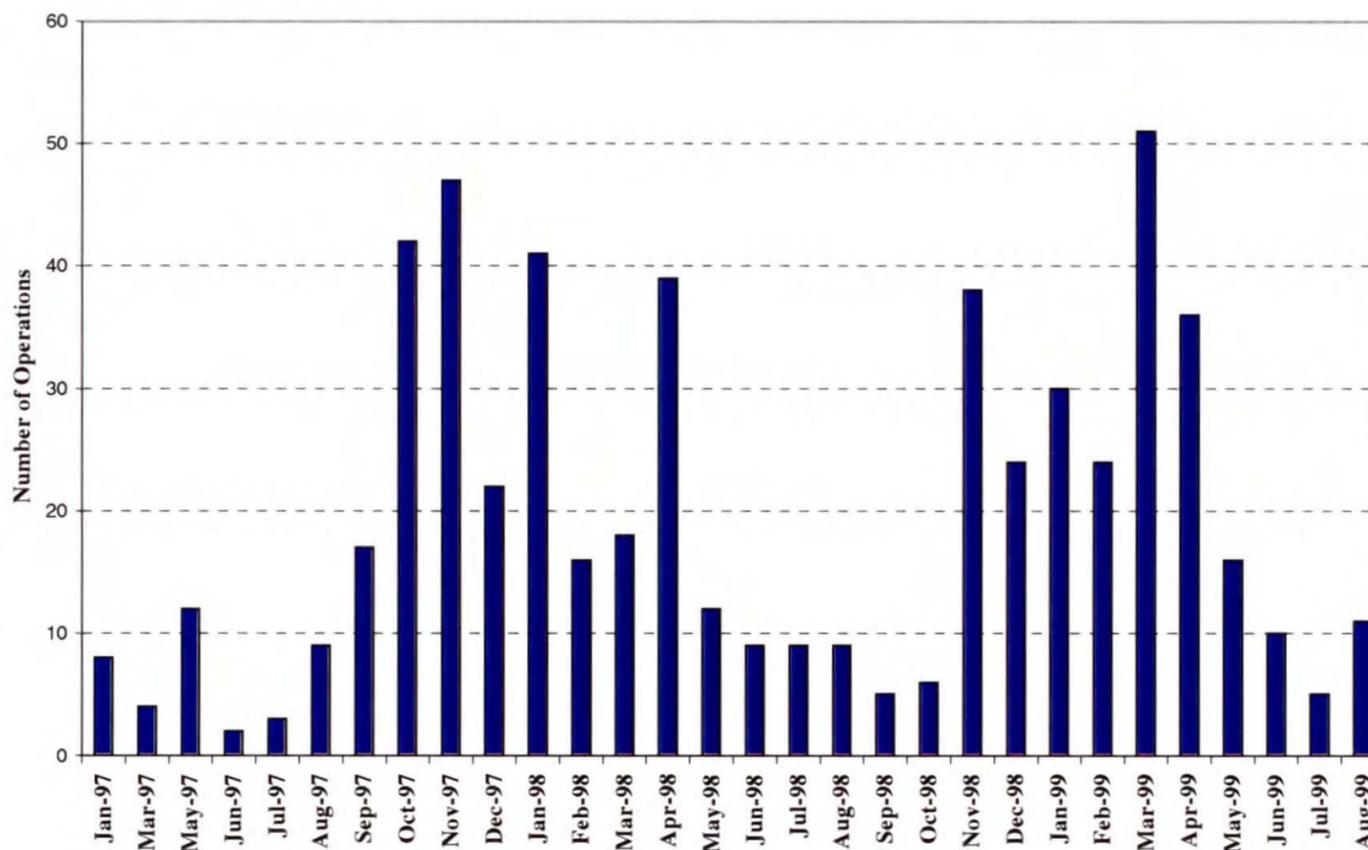
South East Non-Trawl Fishery

The main target species of the fishery are Blue-eye Trevalla (*Hyperoglyphe antarctica*), Pink Ling and Blue Warehou. It is unlikely that many Blue-eye Trevalla are caught within the permit area as the water depth is too shallow for this species (i.e. <200m water depth).

Many South East Non-Trawl Fishery (SENT) operators are involved in a variety of other Commonwealth and State managed fisheries including: the South East Trawl Fishery, the Southern Shark Fishery, State rock lobster fisheries, and the East Coast Tuna Fishery. The number of SENT operators working within the permit area during 1997 to August 1999 is shown in

Figure 4.

In 1998, the South East Non-Trawl Management Advisory Committee (SENTMAC) was established to provide advice and make recommendations to the AFMA Board on issues relating to management arrangements, research, environmental issues and compliance. SENTMAC acts as the key liaison body between AFMA and those who have an interest in the Fishery ((AFMA, 1998; AFMA, 1999a; Tilzey, 1999).

Figure 4: Reported Activity in Permit Area VIC/P43 by South East Non-Trawl Fishery Gillnetters, 1997-99

Source: AFMA database, 1999

Southern Shark Fishery

The Southern Shark Fishery (SSF) is based on several species of temperate water sharks inhabiting the continental shelf and slope of southern Australia. It primarily targets Gummy Shark and School Shark, which make up approximately 80% of the total shark catch. Other demersal sharks are also taken in the Fishery, including Saw Shark species (*Pristiophorus* spp.), Elephant Fish (*Callorhinchus milii*), Whiskery Shark (*Furgaleus macki*) and Dog Shark species (*Squalus* spp.). Shark is also caught as a bycatch by operators in other Commonwealth and State fisheries.

The SSF generally operates all year, but is heavily reliant on weather conditions. Fishing effort tends to be concentrated in summer and autumn when calmer seas prevail. Many rock lobster fishers also hold shark endorsements, contributing to an upsurge in shark fishing during the rock lobster closed season or during poor seasons. A number of shark gillnet operators also target scale fish as part of the South East Non-trawl Fishery (ABARE, 1998; AFMA, 1999b; Kailola *et al.*, 1993; Walker, 1998; Walker *et al.*, 1998a, b). Victorian coastal waters inside the 3 nautical mile limit are currently closed to Southern Shark fishers as this area is a known shark pupping location (C. Dunn, AFMA, pers. comm. 1999; LCC, 1993)

The Southern Shark Fishery Management Advisory Committee (SharkMAC) is the principal forum where issues relating to the Fishery are discussed. SharkMAC provides an avenue for consultation between industry, managers and scientists.

Eastern Tuna and Billfish Fishery

The Eastern Tuna and Billfish Fishery (ET&BF) is the largest fishery, by area, in Australia. It is a complex multi-species, multi-method fishery, which extends east along the entire eastern seaboard from north of Cape York to the southern limit of the 200 nautical mile Australian Fishing Zone below Tasmania and the border of Victoria and South Australia. Commercial fishers, recreational game fishers and charter fishing operators all access the resources of the fishery.

The major species caught in the study area are Striped Marlin (*Tetrapturus audax*) and Broadbill Swordfish (*Xiphias gladius*). Sharks and finfish are also caught as bycatch. (ABARE, 1998; Bob Miller, AFMA, pers. comm. 1999).

The Eastern Tuna Management Advisory Committee (Eastern Tuna MAC) is the principal forum where issues relating to the management of the Fishery are discussed. Through the MAC process, industry, management, research, commercial, recreational fishing, and conservation members develop recommendations for consideration by the AFMA Board (ABARE, 1998; Kailola *et al.*, 1998).

Southern Squid Jig Fishery

In recent years the most productive fishing grounds of the Southern Squid Jig Fishery have occurred between Queenscliff and Portland, off the Victorian coast in the 50-100 metre depth range. These grounds incorporate the permit area.

The principal species, Arrow Squid, is also taken as bycatch in the South East Trawl Fishery, particularly in the 100-220 metre depth range. The jig fishery operates at night in depths between 50m and 150m. Most of the jig catch is taken between January and July, with the highest catches concentrated in April and May. Trawl catches of squid remain at a relatively constant level throughout the year, with the catch off western Victoria being concentrated around Portland.

The Squid Management Advisory Committee (SquidMAC) was appointed in 1998. Management policies are developed in conjunction with SquidMAC, which has a membership drawn from industry, State government, research and environmental sectors (AFMA, 1999e; DNRE Victoria, 1999b; Scott *et al.*, 1998).

Bass Strait Scallop Fishery

The Bass Strait Scallop Fishery is divided into three zones. The Central Zone is managed under Commonwealth jurisdiction, in accordance with policies developed by the Bass Strait Scallop Consultative Committee (BSSCC). The Victorian and Tasmanian Zones of the Fishery, which are generally 20 miles off the respective coastlines, are managed by those States under Offshore Constitutional Settlement (OCS) agreements. The permit area is partially within the Victorian Zone and the Central Zone.

The Fishery is primarily a winter fishery with operators targeting squid and rock lobster during the summer months. It is closed during summer to allow spat settlement, to protect juvenile scallop beds and to increase the likelihood of operators targeting export quality scallops. Scallop abundance varies greatly from year to year,

and in 1998 scallop catches seriously declined prompting the closure of the Fishery during 1999 (ABARE, 1998; AFMA 1999c; DNRE Victoria, 1999e).

Abalone Fishery

The Victorian abalone catch represents the State's most valuable fishery. Its value depends on export prices, but is estimated at between \$30-\$60 million per annum. The majority of Victoria's abalone is exported and this corresponds to approximately 10% of world abalone production. The Victorian Abalone Fishery is divided into three zones; Eastern, Central and Western, with 23, 34 and 14 divers respectively in each zone. The study area is within both the Western and Central zones. The boundary between these two zones is located near the mouth of the Hopkins River, Warrnambool, at 142° 30'E. A closed season applies to Greenlip Abalone (*Haliotis laevigata*) in all Victorian waters from 1 October each year to 31 March the following year (Fisheries Regulations 1998. S.S. No. 23/1998).

Abalone are gastropod molluscs that inhabit inshore reef areas of most temperate seas. In Victorian waters the two main species commercially and recreationally fished are the Blacklip Abalone (*Haliotis rubra*) and to a lesser extent the Greenlip Abalone. Blacklip Abalone occur in exposed or high wave energy coastal waters to depths of at least 40m, concealed in rocky gutters, fissures or overhangs, and rocky bottoms covered with kelp. Greenlip Abalone inhabit mainly shallow, rocky reefs, in the vicinity of seagrass beds in water depths less than 40m. It prefers turbulent and exposed areas, often on barren rocks where tidal flow is high. Blacklip and Greenlip Abalone spawn between October and April or May respectively and the larvae are briefly pelagic (2-6 days) before settling on reefs (DNRE Victoria, 1999a; Kailola *et al.*, 1993; Yearsley *et al.*, 1999).

Australia's abalone fisheries are described as one of the last sustainable wild abalone fisheries in the world. The total commercial catch of abalone for 1996/97 for the area bounded by longitudes 142° 00' and 144° 00' and latitudes 38° 20' and 39° 10' was 39,542kg.

Rock Lobster Fishery

This is one of Victoria's major fisheries with an annual catch of about 500 tonnes, over half of which is exported to Asia. The 173 licensed boats in the fishery operate in two zones roughly east and west of Cape Otway at 143° 40'E. Eighty percent of the Southern Rock Lobster catch is taken west of Cape Otway. Between Cape Otway and Wilson's Promontory the fishery is confined to a narrow strip of inshore reef up to 7km offshore.

The Southern Rock Lobster inhabits a variety of reef habitats on the continental shelf, in water depths of 1 to approximately 200m. They mate primarily between April and July. The eggs hatch into phyllosoma larval stages between September and November. The thin, leaf-like phyllosoma larvae are planktonic and become widely dispersed during a lengthy oceanic phase, estimated to last up to 23 months. During this period they can be carried by ocean currents at least 1,100km from land. After various different phyllosoma stages, they metamorphose into transparent puerulus larvae resembling miniature adult lobsters. The pueruli swim onto the continental

shelf where they settle in coastal waters. Onshore movement and settlement occurs in July to September. Soon after settlement, the pueruli moult into bottom-living juvenile lobsters (DNRE Victoria, 1999d; Kailola *et al.*, 1993; MAFRI, pers. comm. 1999; Yearsley *et al.*, 1999).

Closed seasons for rock lobsters apply in all Victorian waters. Females may not be taken from 1 June to 15 November and males may not be taken from 1 September to 15 November (*Fisheries Regulation 1998, S.R. No. 23/1998*).

Eel Fishery

The main Australian commercial eel fishery is in Victoria. Most of the catch is taken during spring and early summer from waters west of Melbourne, particularly in the Hopkins River, Barwon River and Lake Corangamite basins. Eels form the basis of a small but lucrative export industry, with annual catches up to 200 tonnes. The Short-finned Eel (*Anguilla australis*) accounts for 95% of the catch, with the remaining 5% comprising the Long-finned Eel (*Anguilla reinhardtii*).

The eels are taken in fyke nets which are set in swamps, lakes and some coastal streams. Many of the eels that are taken are not of sufficient quality for the demanding export markets which has led to the development of a form of extensive eel culture where they are transported to more productive waters for on-growing. These are generally Western District lakes.

Freshwater eels probably spawn in the Coral Sea waters deeper than 300m. The pelagic larvae are carried from there by ocean currents to the continental shelf where they develop into 'glass eels'; toothless, unpigmented forms which move into estuaries between late autumn and spring with the assistance of currents and tides. After about 12-18 months, the glass eels develop pigmentation and functional teeth and are called 'elvers'.

A second migration occurs during spring and summer when glass eels and elvers move from estuaries into lakes, swamps and the freshwater reaches of rivers and creeks. Following this, the eels enter a sedentary feeding stage when they are known as 'brown' or 'yellow eels'. As the eels reach maturity they move downstream to the entrances of rivers and creeks prior to the commencement of their spawning migration. Mature eels are referred to as 'silver eels' and do not feed. Silver eels leave the estuaries from late summer to autumn. It is thought that the mature eels die following spawning (Barnham, 1998; DNRE Victoria, 1999c; Kailola *et al.*, 1993). Therefore, although the eels are not caught directly from the study area, there is a potential that the eels are present within the area at some stage in their life cycle.

5.2 Recreational Fisheries

Recreational fishing is a popular activity within the project area. There is also recreational collection of molluscs, such as abalone and periwinkles, as well as diving for rock lobster.

Species recently caught in the area by anglers include: Silver Trevally (*Pseudocaranx dentex*), Silver Sweep (*Scorpiis lineolatus*), Snapper (*Pagrus auratus*), Barracouta (*Thyrsites atun*), Black Bream (*Acanthropagus butcheri*), Gummy Shark (*Mustelus antarcticus*), Flathead (*Platycephalidae* family), Australian Salmon (*Arripis trutta* & *A. truttaceus*), Yelloweye Mullet (*Aldrichetta forsteri*), and Southern School Whiting (*Sillago bassensis*).

The distribution and abundance of sport fish populations in selected estuaries within the project area were surveyed from 1975 to 1982 by McCarraher (1986). The estuaries of Curdies River, Aire River, Parker River and Barham River were identified as popular and productive angling sites. Important sports-fish species caught in these areas include Black Bream, Estuary Perch (*Macquaria colonorum*), Yelloweye Mullet, Luderick (*Girella tricuspidata*), and Australian Salmon (Barnham, 1998a,b,d,e)

Table 9: Major Commercial Fishery Species

NAME	HABITAT	REPRODUCTION	FISHING ACTIVITY
Arrow squid (<i>Nototodarus gouldi</i>)	From estuaries to ocean depths of about 500m	Spawn throughout the year	Seasonal jigging fishery. Not normally a target species of recreational fishers.
Blacklip Abalone (<i>Haliotis rubra</i>)	At least up to 40m water depth in warmer parts of their range, but most common in less than 5m depth.	Spawn from October to May	Abalone catch in Victoria is dominated by this species. Fished both commercially and recreationally.
Blue Warehou (<i>Seriotelella brama</i>)	Juveniles are pelagic and then move inshore where they are often found in bays and inlets. Adults inhabit continental shelf and slope waters from a depth of 50 to 400m	Spawn in late winter and early spring.	Caught in both the South East Trawl and Non-trawl Fisheries. Juveniles caught recreationally in large bays and estuaries.
Broadbill Swordfish (<i>Xiphias gladius</i>)	Inhabit surface waters at night and move to deeper waters during the day. Water depth up to 600m.	Spawning occurs mainly in water with a temperature of 24°C or more. Therefore spawning will not occur in the study area.	A significant bycatch of pelagic longlining in the Eastern Tuna and Billfish Fishery. Occasionally caught by recreational fishers.
Greenlip Abalone (<i>Haliotis laevigata</i>)	Water depth from 10m to 40m. Inhabit inshore rocky reefs	Spawn from October to March or April	Fished both commercially and recreationally
Gummy Shark (<i>Mustelus antarcticus</i>)	Intertidal waters to about 80m water depth.	Parturition is complete by December	One of the dominant species in the Southern Shark Fishery. A small number caught along bays, inlets and ocean beaches by recreational fishers.
King George Whiting (<i>Sillaginodes punctata</i>)	Water depth of 2 to 200m.	Spawn May – July. Larvae passively dispersed eastwards in 3-6 month period following spawning. Possibly a westerly movement through the study area prior to spawning period.	Smaller fisheries are located in central Victoria operating from September to November and to a lesser extent from April to June. Some caught as bycatch to Southern Sea Garfish Fishery. Popular recreational fish throughout their range.

NAME	HABITAT	REPRODUCTION	FISHING ACTIVITY
Pink Ling (<i>Genypterus blacodes</i>)	Water depth of 20 to 800m. Juveniles (<40cm length) are present in shallower shelf waters.	Spawn late winter – early spring	Important component of the South East Trawl Fishery caught year round. Rarely caught recreationally.
School Shark (<i>Galeorhinus galeus</i>)	Up to 550m water depth, but mostly <200m.	Parturition is complete by January	One of the dominant species in the Southern Shark Fishery. A small number caught along ocean beaches and in coastal bays by recreational fishers.
Shortfin Eel (<i>Anguilla australis</i>)		Spawn in Coral Sea; carried by currents to continental shelf; move into estuaries late autumn – spring with the help of currents and tides; second migration spring-summer; mature eels leave the estuaries when mature to spawn late summer – autumn.	The main commercial eel fishery. Commonly caught recreationally when fishing for other species, but can also be targeted.
Southern Rock Lobster (<i>Jasus edwardsii</i>)	Water depths from 1 to 200m in a variety of reef habitats on the continental shelf.	Mate April -July. Eggs hatch September – November. Onshore movement and settlement of puerulus stage larvae in July to September.	In Victoria, 80% of the catch is taken west of Cape Otway. Approx. 20% of the total catch is fished recreationally (throughout their range).
Southern Scallop (<i>Pecten fumatus</i>)	Found to at least 120m water depth over bare, soft sand or mud.	Spawning occurs over an extended period during winter and spring, peaking in early spring.	Fished both commercially and recreationally.
Spotted Warehou (<i>Seriotelella punctata</i>)	Juveniles are pelagic and then move inshore where they are often found in bays and inlets. Adults inhabit continental shelf and slope waters from a depth of 50 to 600m	Spawn in late winter and early spring.	Caught in the South East Trawl Fishery. Juveniles caught recreationally in large bays and estuaries.
Striped Marlin (<i>Xipias gladius</i>)	Water depth between 50 and 100m	Spawning probably does not occur in Victorian waters.	Caught in the Eastern Tuna and Billfish Fishery. Caught recreationally by trolling or handlining from boats.

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NAME	HABITAT	REPRODUCTION	FISHING ACTIVITY
Tiger Flathead (<i>Neoplatycephalus richardsoni</i>)	Water depth of 10 to 400m.	Spawn October – May in NSW waters.	No commercial fishery in study area. Caught by recreational anglers on inshore grounds in Victoria.

Compiled from Kailola et al., 1993 and Yearsley et al., 1999.

6 SOCIAL ENVIRONMENT

6.1 Population Centres

There are a number of towns and settlements along the south-west coast of Victoria, which is a popular tourist destination. These include:

Apollo Bay (Colac-Otway Shire)

Apollo Bay has a population of approximately 1,200 people and has facilities for golf, horse riding, tennis, squash, swimming, surfing and fishing. The western end of the bay is broken by a breakwater enclosing jetties that shelter a permanent rock lobster fishing fleet. A public boat ramp provides safe launching facilities for small craft in the wharf area.

Johanna (Colac-Otway Shire)

Johanna is a small farming settlement sandwiched between the coast and the Otway Ranges. Johanna is one of Victoria's best known surf beaches and is a popular surf-fishing area.

Princetown (Corangamite Shire)

Princetown forms the western boundary of the Otway National Park and the eastern boundary of the Port Campbell National Park.

Port Campbell (Corangamite Shire)

Port Campbell is a holiday resort from which boat charters to the Twelve Apostles and Lady Julia Percy Island, and scuba-diving charters to the shipwrecks in the area are operated. Port Campbell has one of the few safe, swimming beaches along this portion of the south-west coast.

Peterborough (Moyne Shire)

Peterborough is a popular yet quiet holiday town that is surrounded by small secluded beaches and coves. The Curdies River estuary is a sheltered safe swimming and windsurfing area. There are two boat launching ramps in Peterborough and a third at the Bay of Islands.

Warrnambool (Warrnambool City Council)

Sited on Lady Bay, Warrnambool is a provincial city that has retained its holiday atmosphere while expanding its manufacturing and service industries. It has a population of approximately 28,500. It is a major stopover for travellers on the Great Ocean Road. Warrnambool has an existing harbour and boat ramp facilities.

Port Fairy (Moyne Shire)

Port Fairy is situated on the eastern headland of Portland Bay, at the mouth of the Moyne River. It is a historic seaside town with a population of about 2,500. Sightseeing and fishing charters depart from the Port Fairy wharf. (Stone *et al*, 1997; Warrnambool City Council, 1999)

Table 10 summarises the values associated with each settlement and their locations along the coastline are shown in Map 1.

Table 10: City, Town and Village Attributes, Cape Otway to Warrnambool

		Port Fairy	Warrnambool	Peterborough	Port Campbell	Princetown	Johanna	Apollo Bay
SIZE	City		✓					
	Town	✓						✓
	Village			✓	✓	✓	✓	
NATURAL & CULTURAL VALUES	European History	✓	✓					
	Scenic Landscapes	✓	✓	✓	✓	✓	✓	✓
	Aboriginal Sites	✓	✓	✓	✓	✓	✓	✓
	Wildlife Viewing	✓	✓	✓	✓			
	Wetlands & ecosystems	✓		✓		✓		✓
SETTLEMENT/ DEVELOPMENT VALUES	Commercial Fisheries	✓	✓		✓			✓
	General Industry							
	Shipping/Port Harbour	✓	✓					✓
	Residential	✓	✓					✓
RECREATION AND TOURISM VALUES	Swimming Beaches	✓	✓	✓	✓			✓
	Surfing Beaches	✓	✓	✓	✓			✓
	Recreational Fishing	✓	✓	✓			✓	✓
	Boating	✓	✓	✓				✓
	Holiday Destination	✓	✓	✓	✓			✓
	Low Budget Accommodation	✓	✓	✓	✓	✓	✓	✓
	High Quality Resort	✓	✓					
	Eating and Dining	✓	✓					
Major Tourist Destination	✓	✓		✓			✓	

Adapted from Victorian Coastal Council, 1997.

6.2 Existing Infrastructure

Warrnambool has a fully serviced all-weather airport. Local ports such as those at Port Fairy, Warrnambool, Port Campbell and Apollo Bay, provide facilities for commercial and recreational vessels (Cuttiss, 1998). The nearest deep water docking

facilities are located at Portland. Infrastructure within the project area is shown on Map 2.

Infrastructure associated with the petroleum industry, including permit boundaries, gas fields, wells and pipelines are illustrated in Map 3. The Western Underground Gas Storage Facility owned by Texas Utilities is located west of Port Campbell and BHP Petroleum is planning the development of the Minerva gas field, situated approximately 12km due south of Port Campbell. An associated onshore gas treatment plant is planned to the west of Port Campbell.

6.3 Shipping and Navigation

Bass Strait is a major shipping lane for vessels moving around the coast of Australia and for international shipping arriving at Australian ports. The main shipping routes are shown on Map 2. Assuming that each vessel is travelling at 12 knots, it has been calculated that three vessels traverse the study area each day. The data includes commercial ships only. It does not include fishing, naval or recreational vessels using the area. Therefore the actual shipping traffic will be higher than the calculated 3-4 vessels/day.

6.4 Shipwrecks

The area between Moonlight Head and Warrnambool is known as the shipwreck coast. At least eleven ships were lost along this stretch of coast. At Port Fairy, a further 20 vessels were lost and another 15 were shipwrecked at Warrnambool. Known wrecks in the area are shown on Map 2 and details are given in Appendix A. All of these wrecks are archaeological maritime sites and are protected through the *Historic Shipwrecks Act 1976 (Commonwealth)* and *Historic Shipwrecks Act 1981 (Victoria)* (Foster, 1996; P. Harvey, Heritage Victoria, pers. comm.).

The Cape Otway Lightstation is an extensive complex that includes the oldest surviving officially built lighthouse on the Australian mainland. The lighthouse was completed in 1848. At the beginning of 1997 the lightstation was leased to a local company to operate for tours and accommodation (Parks Victoria, 1999b).

The Port Campbell National Park abounds in features of historical significance, mostly related to its position near the turn in the shipping lanes at Cape Otway, and a consequent high frequency of shipwrecks during the age of sail. The 'Loch Ard' disaster is the most famous. The historic Glenample Homestead, where survivors of the wreck were taken, lies a short distance north of the Park (Parks Victoria, 1997a,c).

6.5 Recreation and Tourism

The scenery along the south-west coast is spectacular with sculptured coastlines of sheer cliffs, deep caverns, great archways, grottos, gorges, blowholes and sand dunes. Famous formations such as the Twelve Apostles and London Bridge (refer to Section 4.5) make the region a popular tourist destination.

The area contains a number of recreational fishing areas. Belfast Lough is a safe windsurfing area and there are a number of beaches from which surfing is a popular activity. Other recreational activities in the area include sailing and boating, diving (shipwrecks, abalone, rock lobster), walking, camping, picnicking, and swimming.

6.6 Aboriginal Cultural Sites

Over 2,500 Aboriginal sites have been recorded along the Victorian coast. Most sites are less than 6,000 years old. Coastal Aboriginal sites may include:

- remains of shellfish meals;
- accumulated remains of camping and cooking sites;
- concentrations of stone chips the remains of tool manufacturing, or the area where stone tools were used, such as hunting blinds, camp sites and butchery sites;
- single or small groups of artefacts;
- tree scars resulting from the removal of bark for canoes, shelters or containers;
- freshwater traps involving the use of stone weirs and basket-work traps for fish and eels;
- natural rock overhangs and caves used as campsites;
- deliberate human burials;
- remains of campfires;
- naturally or artificially enlarged hollows in rock, where water accumulates from an aquifer, springs or rain;
- exposed rock outcrops used as sources of stone for stone artefact manufacture;
- sites such as rock shelters or caves where rock paintings or engravings have been preserved; and
- sites left by Aboriginal people from the European contact and post-contact period (Cuttiss, 1998).

6.7 Native Title

A search on 3rd August 1999 of the National Native Title Register and Schedule of Native Title Applications indicated that there were no claims at that time along the coastal area of interest. Claim VC99/7 includes the coastal area from the Shaw River west of Port Fairy to the South Australian border.

7 SOURCES

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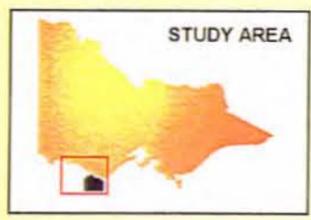
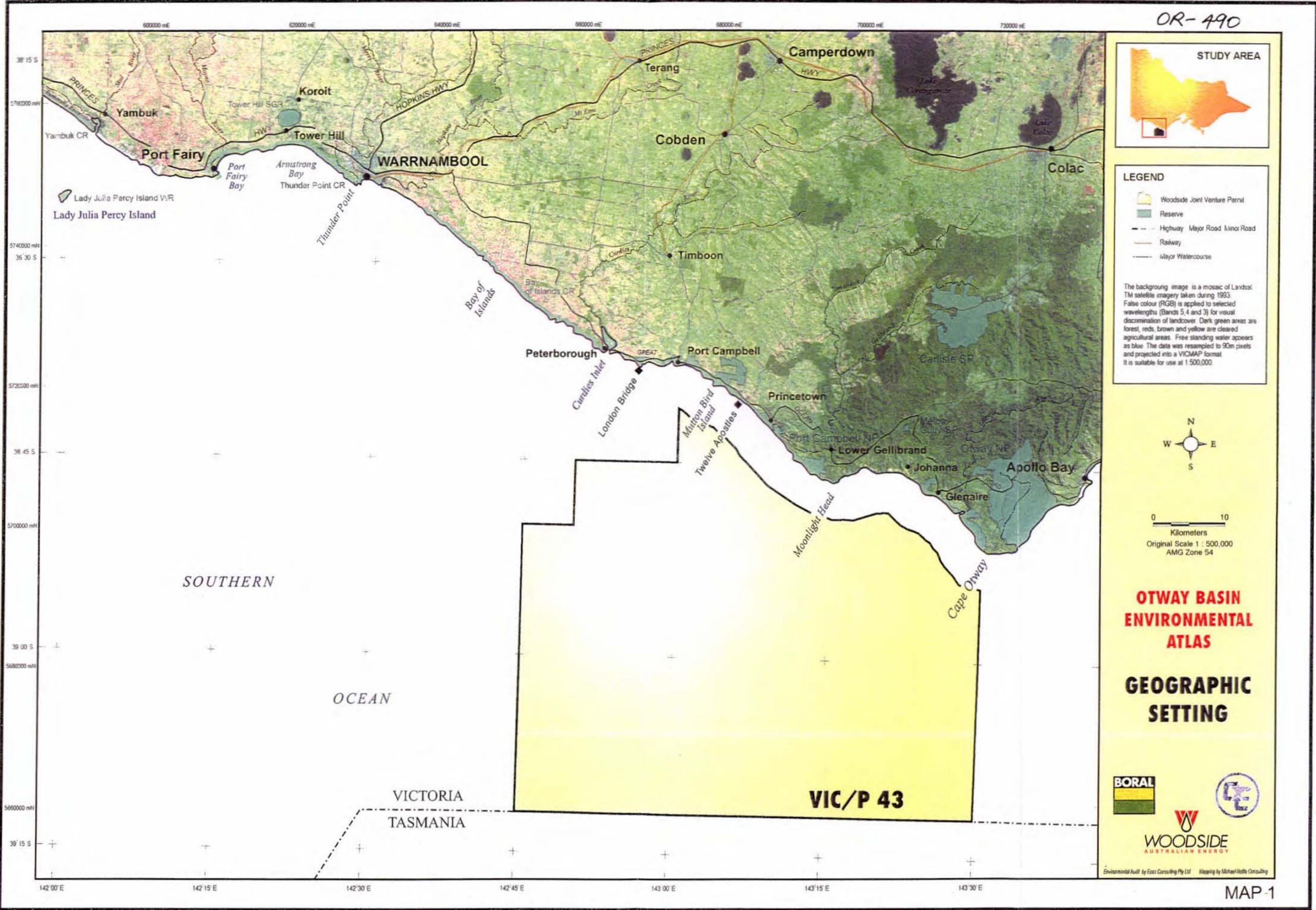
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8 MAPS

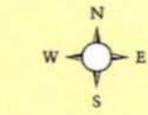
OR-490



LEGEND

- Woodside Joint Venture Permit
- Reserve
- Highway Major Road Minor Road
- Railway
- Major Watercourse

The background image is a mosaic of Landsat TM satellite imagery taken during 1993. False colour (RGB) is applied to selected wavelengths (Bands 5, 4 and 3) for visual discrimination of landcover. Dark green areas are forest, reds, brown and yellow are cleared agricultural areas. Free standing water appears as blue. The data was resampled to 90m pixels and projected into a VICMAP format. It is suitable for use at 1:500,000.



0 10
Kilometers
Original Scale 1 : 500,000
AMG Zone 54

**OTWAY BASIN
ENVIRONMENTAL
ATLAS**

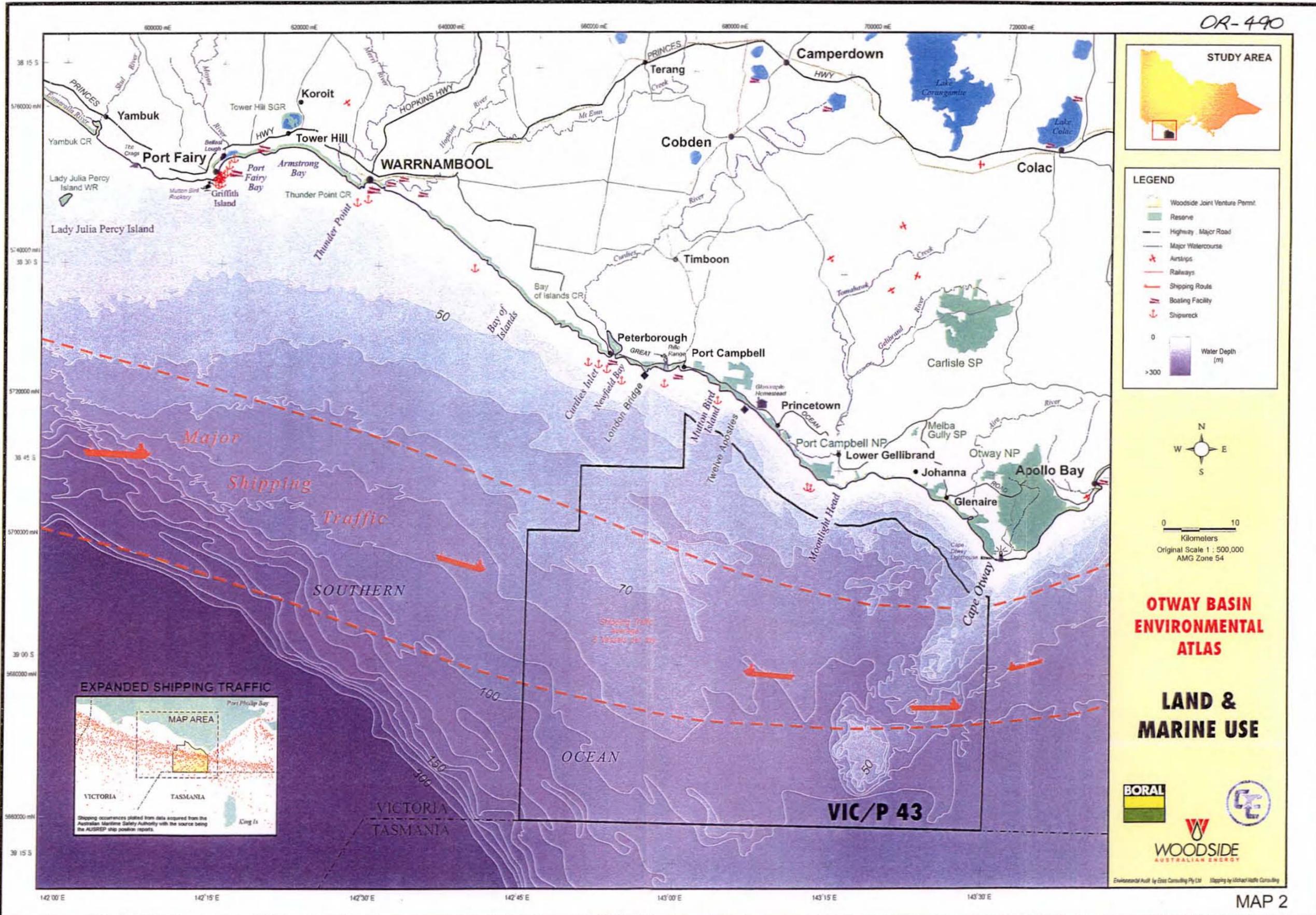
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SETTING**



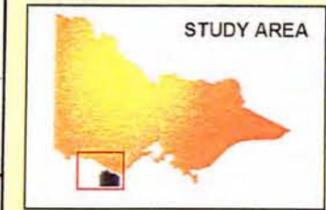
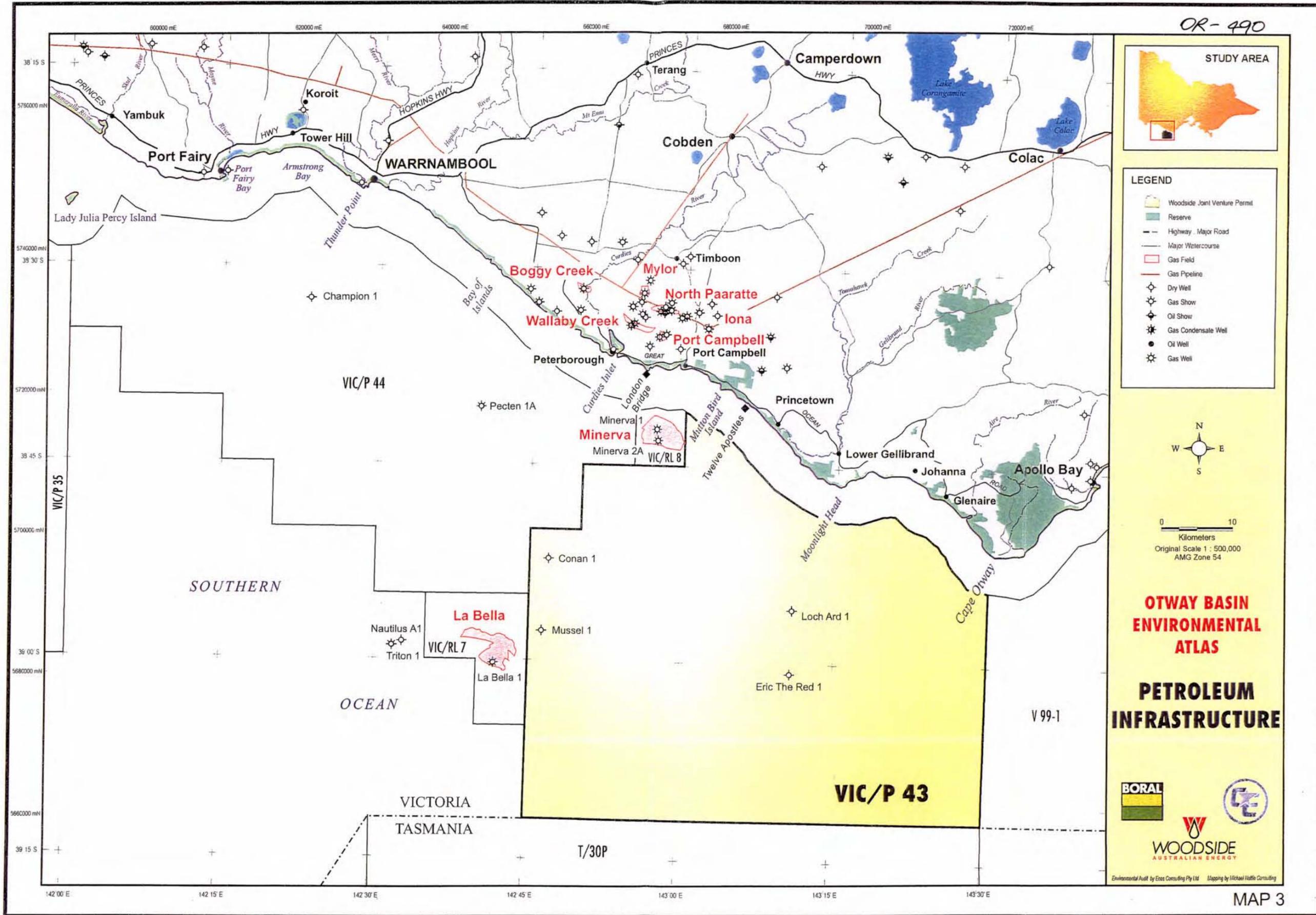
Environmental Audit by Ecoss Consulting Pty Ltd Mapping by Michael Heddy Consulting

MAP-1

5 cm

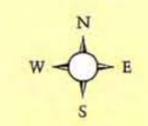


OR-490



LEGEND

- Woodside Joint Venture Permit
- Reserve
- Highway - Major Road
- Major Watercourse
- Gas Field
- Gas Pipeline
- Dry Well
- Gas Show
- Oil Show
- Gas Condensate Well
- Oil Well
- Gas Well



0 10
Kilometers
Original Scale 1 : 500,000
AMG Zone 54

**OTWAY BASIN
ENVIRONMENTAL
ATLAS**

**PETROLEUM
INFRASTRUCTURE**

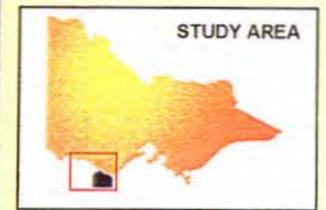
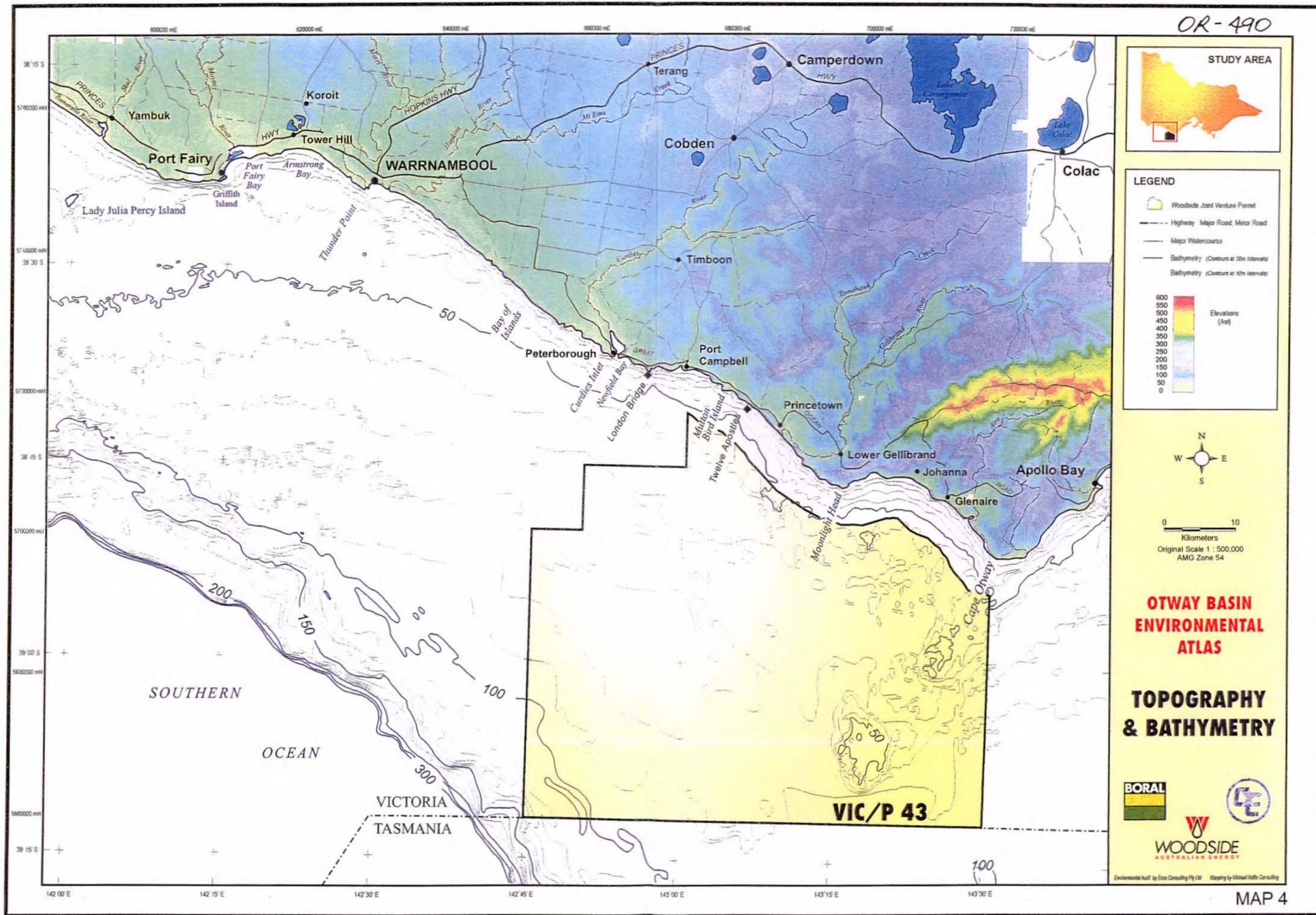


Environmental Audit by Ecoss Consulting Pty Ltd Mapping by Michael Haffis Consulting

MAP 3

5 cm

OR-490

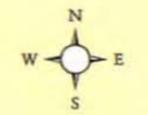


LEGEND

- Woodside Joint Venture Permit
- Highway Major Road, Minor Road
- Major Watercourse
- Bathymetry (Contours at 50m intervals)
- Bathymetry (Contours at 10m intervals)

Elevations (Asl)

600
550
500
450
400
350
300
250
200
150
100
50
0



0 10
Kilometers
Original Scale 1 : 500,000
AMG Zone 54

OTWAY BASIN ENVIRONMENTAL ATLAS

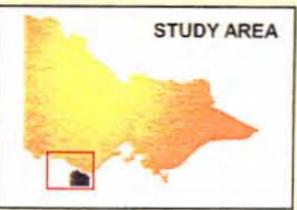
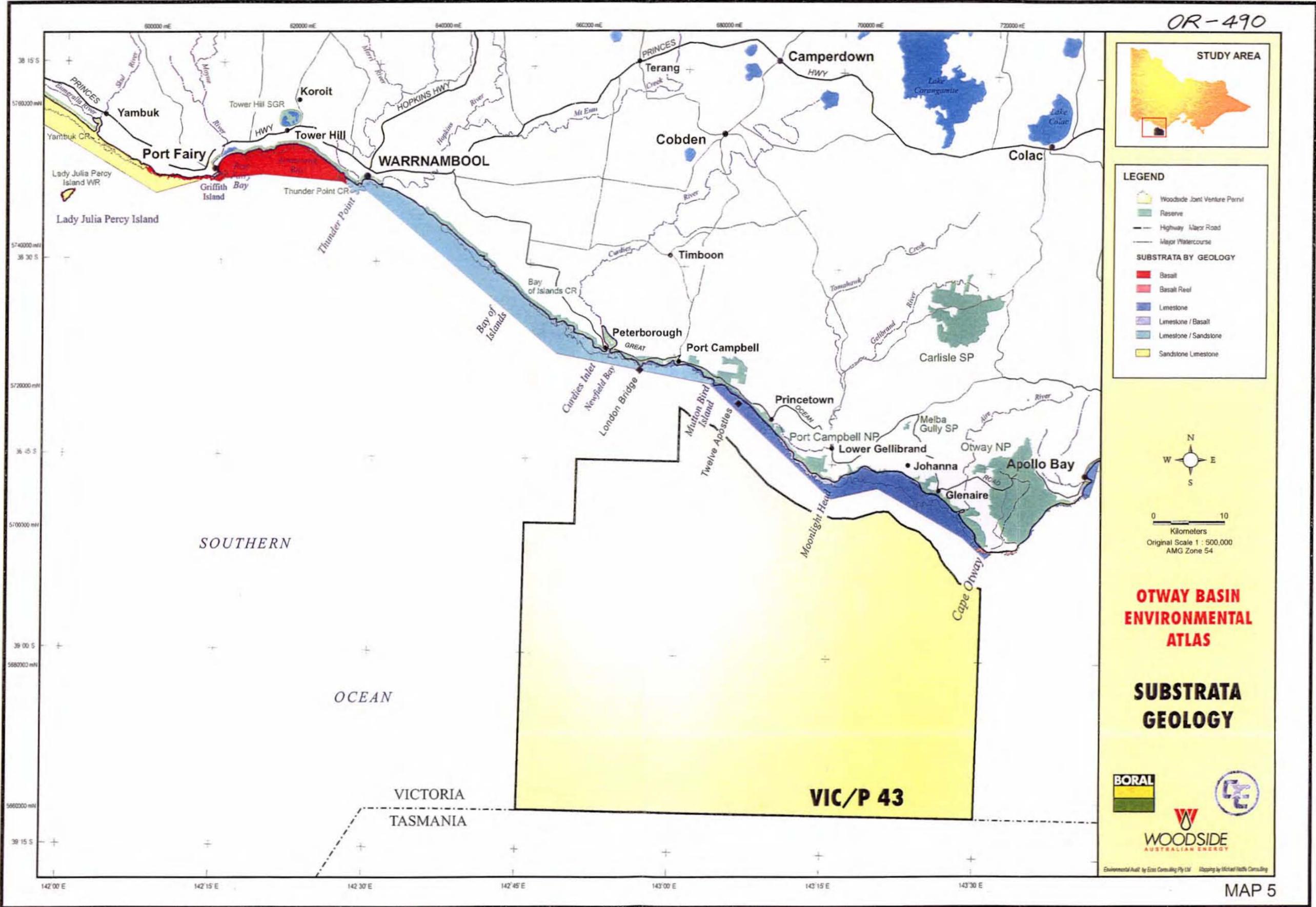
TOPOGRAPHY & BATHYMETRY



Environmental Audit by Ecos Consulting Pty Ltd Mapping by Michael Jellis Consulting

MAP 4

5 cm

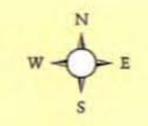


LEGEND

- Woodside Joint Venture Permit
- Reserve
- Highway / Major Road
- Major Watercourse

SUBSTRATA BY GEOLOGY

- Basalt
- Basalt Reef
- Limestone
- Limestone / Basalt
- Limestone / Sandstone
- Sandstone Limestone



0 10
Kilometers
Original Scale 1 : 500,000
AMG Zone 54

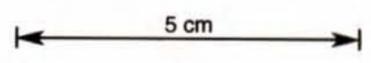
**OTWAY BASIN
ENVIRONMENTAL
ATLAS**

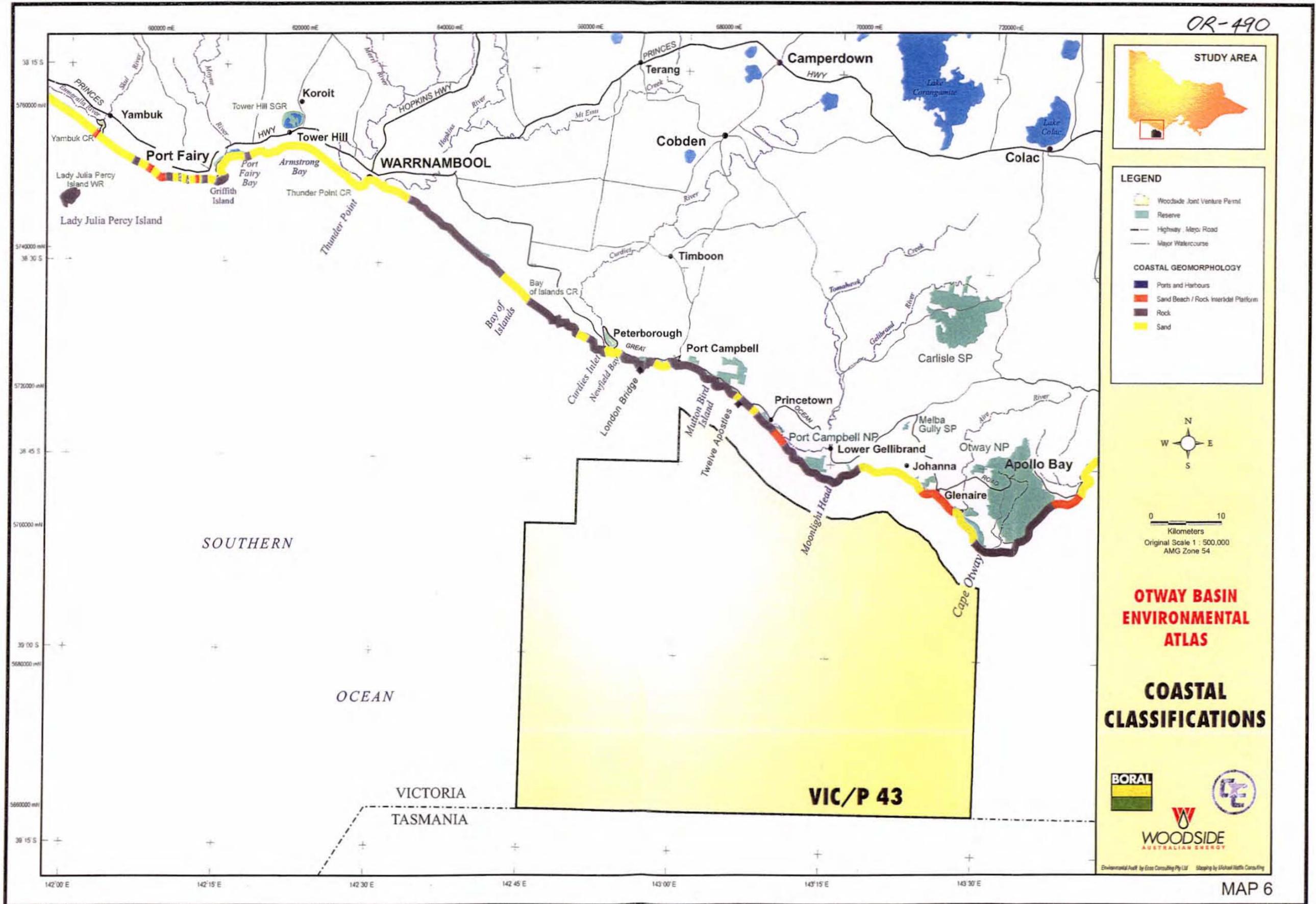
**SUBSTRATA
GEOLOGY**



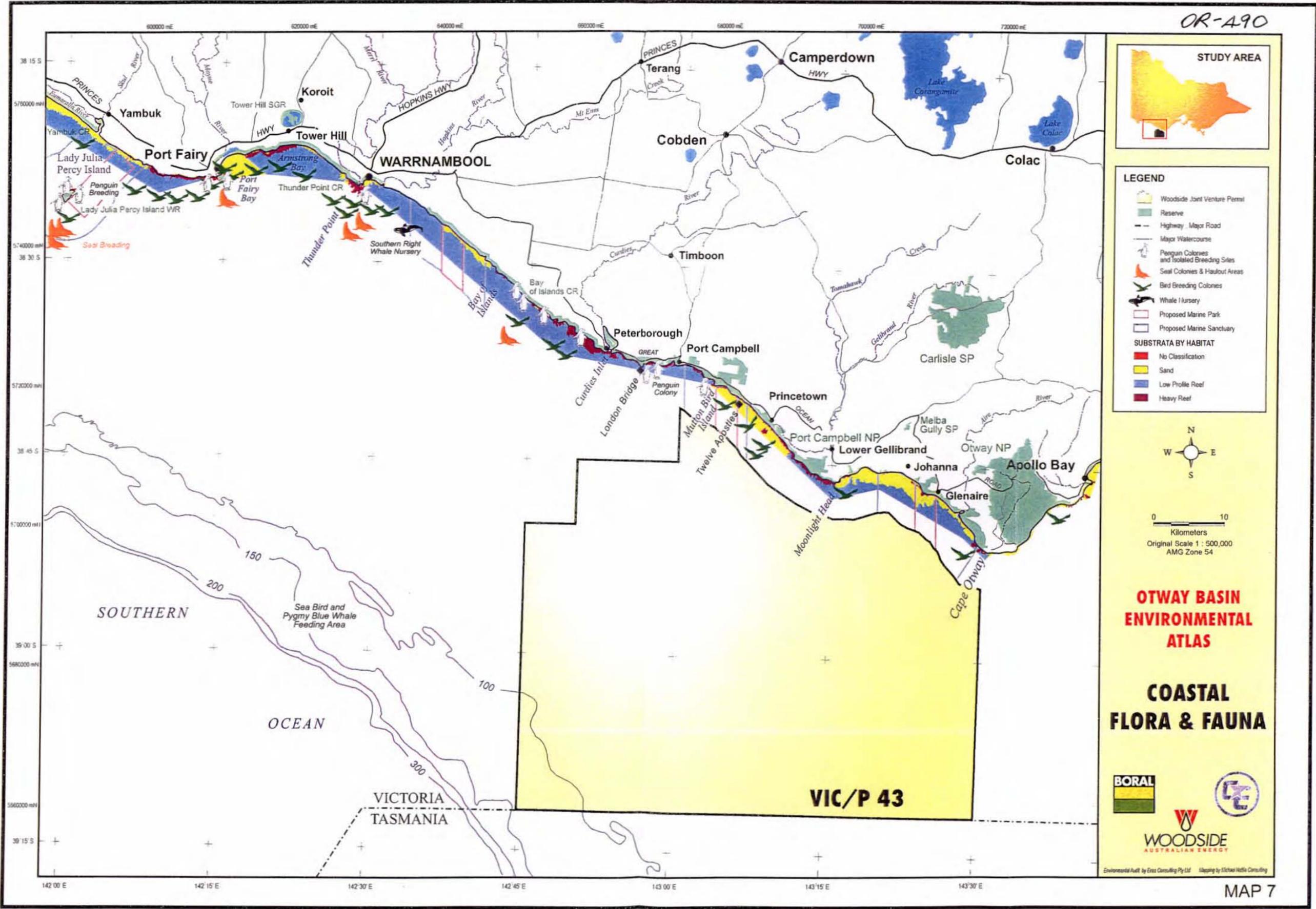
Environmental Audit by Ecos Consulting Pty Ltd Mapping by Michael Waddy Cartus.Blog

MAP 5



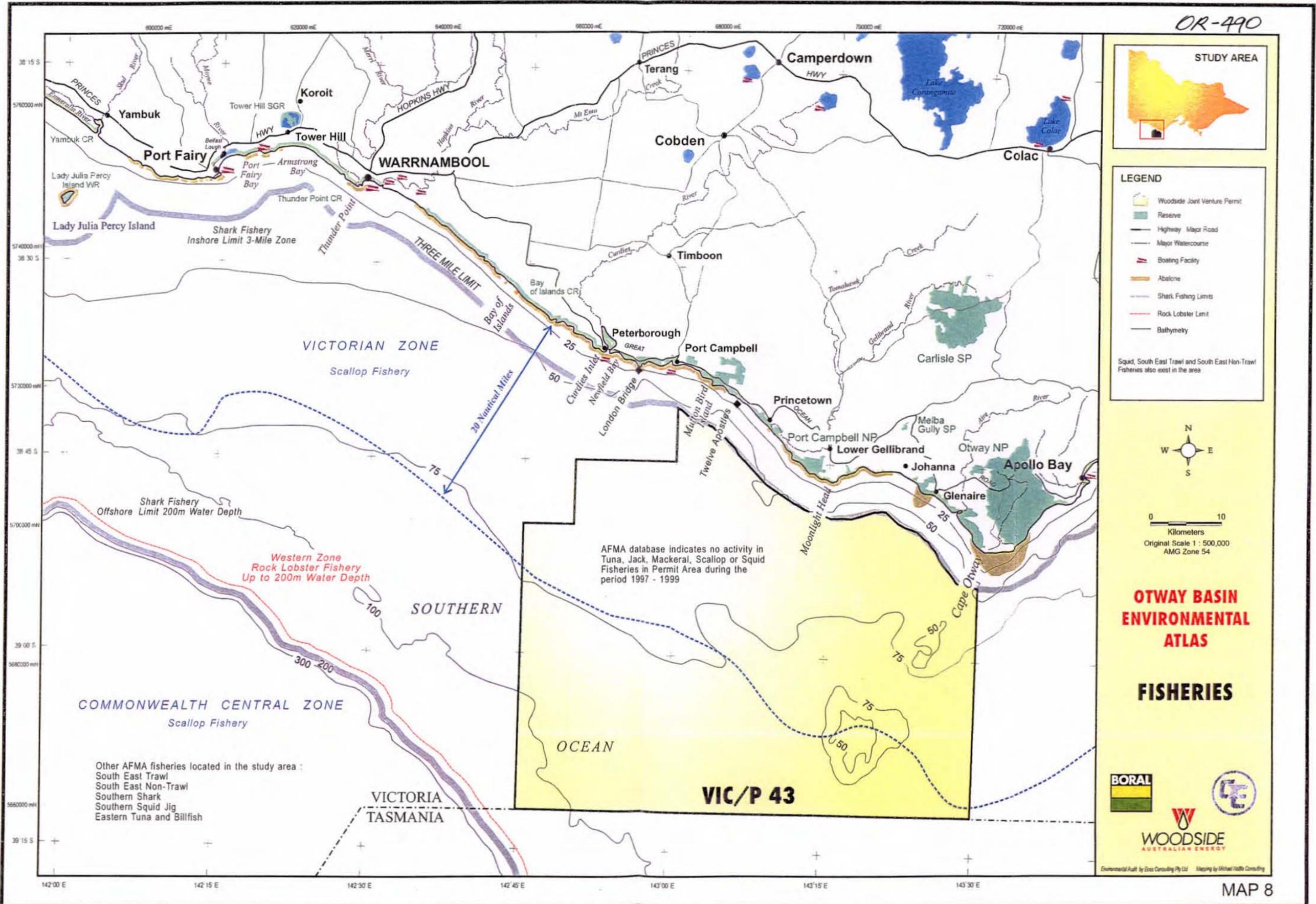


5 cm



MAP 7

5 cm



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*Environmental Resource Atlas Otway Basin Exploration Program
Rev C*

November 1999

APPENDICES

Appendix A

Shipwrecks Between Port Fairy and Moonlight Head

SHIP NAME	LOCATION	DATE LOST
Thomas	Port Fairy	1843/45
Children	Childers Cove	1838/39
Sarah Ann	Port Fairy	1836
Thistle	Port Fairy	1837
Essington	Port Fairy	1838
Mary	Mills Reef, Port Fairy	1840
Dusty Miller	Rocky Point off Griffiths Island	1842
Socrates	Port Fairy	1843
Diana	Port Fairy	1844
Squatter	Approximately 2 miles west of Port Fairy	1846
Lydia	Port Fairy	1847
Lady Mary Pelham	High on beach, level with Manifold St, Port Fairy	1849
Sara Louisa	Port Fairy	1849
Enterprise	Lady Bay, Warrnambool. Now under caravan park	1850
Sir John Byng	Port Fairy	1852
Lillias	Near mouth of Hopkins River, Warrnambool	1852
Archer	East of jetty, Warrnambool	1853
Freedom	Lady Bay, Warrnambool	1853
Dundee	Port Fairy	1854
Inellan	Port Fairy	1854
Swift	Port Fairy	1855
Schomberg	Curdies Inlet, Peterborough	1855
John Scott	Flaxman's Hill, 15 miles east of Warrnambool	1858
Maid of Julpha	Warrnambool	1859
Golden Spring	Warrnambool	1863
Fair Tasmanian	Lady Bay, Warrnambool	1864
Eliza	Port Fairy	1866
Jane	Lady Bay, Warrnambool	1867
Balmoral	Reefs at north part of bay, Port Fairy	1868
Marie Gabrielle	Moonlight Head, Wreck Beach	1869
Water Lily	Port Fairy	1876
Young Australia	Curdies Inlet, Peterborough	1877
Loch Ard	Loch Ard Gorge	1878
Napier	Port Campbell Inlet	1878
Alexandra	Lady Bay, Warrnambool	1882
Jane	Lady Bay, Warrnambool, west of jetty	1882
Olivia Davis	Warrnambool	1882
Yarra	Lady Bay, Warrnambool	1882
Edinburgh Castle	Lady Bay, Warrnambool	1888
Fiji	Wreck Beach, west of Moonlight Head	1891
Newfield	1 mile east of Curdies River, 100 yards from shore	1892
Freetrader	Lady Bay, Warrnambool	1894
La Bella	Warrnambool	1905
Falls of Halladale	Curdies Inlet, Peterborough	1908
Antares	22 miles east of Warrnambool, near Bay of Islands	1914

Compiled from Foster, 1996.

APPENDIX B

Endangered, Vulnerable and Rare Species of Bird Recorded between Longitude 142°00' - 144°00'S and Latitude 38°20' - 39°20'E

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS	HABITAT	RECORDS	COMMENTS
Australasian Bittern	<i>Botaurus poiciloptilus</i>	Endangered	Reedbeds, swamps, streams, estuaries	28	
Australasian Gannet	<i>Morus serrator</i>	Vulnerable	Oceans, bays	159	Breeding confirmed
Black-faced Cormorant	<i>Leucocarbo fuscescens</i>	Vulnerable	Rocky sea coasts	54	Breeding confirmed
Caspian Tern	<i>Sterna caspia</i>	Vulnerable	Coastal, inland watercourses	100	Breeding confirmed
Common Diving-petrel	<i>Pelecanoides urinatrix</i>	Lower risk near threatened	Oceanic	43	Breeding confirmed
Crested Tern	<i>Sterna bergii</i>	Lower risk near threatened	Estuaries, seas, islands	203	Breeding confirmed
Eastern Curlew	<i>Numenius madagascariensis</i>	Lower risk near threatened	Estuaries, mudflats, mangroves, sandspits	13	
Fairy Prion	<i>Pachyptila turtur</i>	Lower risk near threatened	Oceans, coastal breeding islands	61	Breeding confirmed
Fairy Tern	<i>Sterna nereis</i>	Vulnerable	Estuaries, seas, islands	27	
Great Egret	<i>Ardea alba</i>	Endangered	Floodwaters, rivers, shallows of wetlands, intertidal mudflats	223	Breeding confirmed
Gull-billed Tern	<i>Sterna nilotica</i>	Endangered	Coastal flats, inland lakes, ploughed and fallowed fields	7	
Hooded Plover	<i>Thinornis rubricollis</i>	Endangered	Ocean beaches	253	Breeding confirmed
Intermediate Egret	<i>Ardea intermedia</i>	Critically endangered	Shallows of wetlands, intertidal mudflats	6	
Kelp Gull	<i>Larus dominicanus</i>	Critically endangered	Coastal	17	
Lewin's Rail	<i>Rallus pectoralis</i>	Endangered	Grassy, reedy, or thickly vegetated coastal regions	16	Breeding confirmed

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS	HABITAT	RECORDS	COMMENTS
Little Egret	<i>Egretta garzetta</i>	Critically endangered	Floodwaters, rivers, shallows of wetlands and intertidal flats	37	
Musk Duck	<i>Bizura lobata</i>	Vulnerable	Permanent swamps with dense vegetation, large open lakes, inlets and bays	107	Breeding confirmed
Nankeen Night Heron	<i>Nycticorax caledonicus</i>	Vulnerable	Swamps, intertidal flats, estuaries, rivers, creeks	33	
Northern Giant-petrel	<i>Macronectes halli</i>	Endangered	Oceans, bays	1	
Pacific Gull	<i>Larus pacificus</i>	Lower risk near threatened	Coastal	100	
Pied Cormorant	<i>Phalacrocorax varius</i>	Lower risk near threatened	Coastal or inland lakes, rivers	93	Breeding confirmed
Pomarine Jaeger	<i>Stercorarius pomarinus</i>	Insufficiently known*	Oceanic	2	
Royal Spoonbill	<i>Platalea regia</i>	Vulnerable	Shallows of fresh and saltwater wetlands including intertidal flats	85	Breeding confirmed
Rufous Bristlebird	<i>Dasyornis broadbenti</i>	Lower risk near threatened	Dense coastal heaths	150	Breeding confirmed
Southern Giant-petrel	<i>Macronectes giganteus</i>	Endangered	Oceans, bays	34	
Wandering Albatross	<i>Diomedea exulans</i>	Critically Endangered	Oceanic, coastal seas	32	
Whiskered Tern	<i>Chlidonias hybridus</i>	Lower risk near threatened	Lakes, estuaries	59	Breeding confirmed
White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>	Endangered	Large rivers, fresh and saline lakes, reservoirs, estuaries, coastal seas, islands	10	
White-faced Storm Petrel	<i>Pelagodroma marina</i>	Vulnerable	Oceanic	12	

* Insufficiently known, but suspected of being in one of the categories critically endangered, endangered, vulnerable, rare or lower risk near threatened.
Adapted from a search of the Atlas of Victorian wildlife database

APPENDIX C

GIS Database: Sources and List of Tables

GIS data was obtained from two principle sources

- Victorian Department of Natural Resources and Environment, Land Information Group. Data sets selected from Corporate Geospatial Data Library. (**LIG**) Generally this data was supplied in 1:25,000 or 1:100,000 Map Sheet set which were combined into larger tables for this project.
- Victorian Department of Natural Resources and Environment, Petroleum Development Unit, Victorian Petroleum GIS Data CD. (**Pet CD**). Data sets were generally Victoria wide at a scale of 1:100,000

Other sources are listed in the table below. Many of these layers were created from hardcopy original data and are described in the bibliography of this report

Data reliability varies from layer to layer. Mapping was done at a 1:500,000 scale and all layers are useful to at least that scale. Some of the purchased data is accurate to 1:25,000.

Purchased LIG data came with meta-data, data about the data. These included look-up tables and digitising information. Data on the Pet CD was described very briefly in the accompanying handbook. Where appropriate text files about the source and reliability of the data were created and are stored separately from the data (\doc directory)

LAYER NAME	SCALE (1000)	SOURCE	COMMENT
Abalone	250	BHP Minerva EIS 1995	Digitised as polylines
Airports	25	LIG	Subset of Util100
Ausrep	500	AMISA	Digitised from fax
Australa	5000	MapInfo	Polygon For Inset map use only
Bathym250	250	LIG	Originally Depth250
Biosites	500	Land Conservation Council	Digitised from 1993 Report
Birds	250	BHP Minerva EIS 1995	Digitised from report
Boatfac_25	25	LIG	Boating facilities
Coast25g	25	LIG	Coastal Classification
Coastal_Reserve_100	100	Pet CD	No names provided
Elevations100	25	LIG	Simplified from Topo_100
Fieldgas	500	GpInfo	Published maps Gas Fields
Fishing	-	AFMA	Catch Information no GIS
Grid_Amg	25	GeoSolve	Generated for Mapinfo use
Grid_Geo	25	GeoSolve	Generated for Mapinfo use
Lakes	100	Pet CD	No names provided
Landpt	100	LIG	Boat Landing Points
Landuse	100	Pet CD	Undifferentiated Parks
Mabo54	100	Pet CD	Western Victoria land claims
Map_Area	100	GeoSolve	Polygon
Mar_Park	100	Pet CD	No names provided
Mar_Sanc	100	Pet CD	No names provided
Nat_Park	100	Pet CD	No names provided
Offshore	100	GeoSolve	Offshore / Onshore Polygons
Penguins	100	BHP Minerva EIS 1995	Digitised from report
Permits	50	Pet CD	Petroleum Permits 1999
Pipesgas	50	Pet CD	Pipelines
Railways	25,100	LIG ,PetCD	Layers combined
Rivers	500	Pet CD	Major Rivers no names
Roads_100	100	LIG	All Roads
Roads_1	500	Pet CD	Major Roads
Roads_2	500	Pet CD	Secondary Roads
Roads_3	500	Pet CD	Lessor Roads
Seals	100	BHP Minerva EIS 1995	Digitised from report
Shipping_lanes	1000	GeoSolve	Approximate from Ausrep
State_Boundary_Vic	100	Pet CD	Onshore and Offshore
Substrata25g_arc	25	LIG	Nearshore substrate polylines
Substrata25g_poly	25	LIG	Nearshore substrate polygons
Three_Mile_Limit	500	GeoSolve	Approx. limit
Tm50093	500	LIG	Thematic Mapper Image, Tif file
Topo100	100	LIG	Topography
Tourist	250	GeoSolve	From a variety of sources
Town25	25	LIG	Township Boundaries
Towns500	500	GeoSolve	From a variety of sources
Util100	100	LIG	Airport, Harbours etc
Viccoast	100	Pet CD	Goes with State_Boundary_Vic
Vicp43permit	100	Pet CD	Single Polygon
Victoria	5000	MapInfo	Polygon For Inset use only
Wells_Ot	50	Pet CD	Petroleum Wells
Wrecks	500	GeoSolve	Digitised from Book