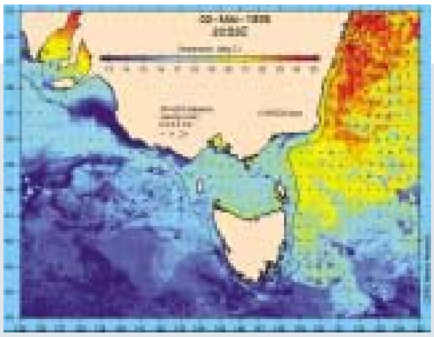
ASSESSMENT OF THE CONSERVATION VALUES OF THE BONNEY UPWELLING AREA

A component of the Commonwealth Marine Conservation Assessment Program 2002-2004



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Natural Heritage Trust
Helping Communities Helping Australia

Environment Australia
Department of the Environment

CSIRO
MARINE RESEARCH

Report to Environment Australia – December 2002

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Summary

The Minister for the Environment announced, on September 26, 2001, plans to assess the conservation values of 11 unique marine areas in Commonwealth waters. The assessment of the Blue Whale aggregation (now Bonney Upwelling) area is the second of those. CSIRO was asked to provide a summary of relevant, available data, and expert opinions, to reach a balanced conclusion, including degree of confidence, regarding the question: "does the area possess biodiversity values worthy of protection?" The assessment of the conservation values was to be done in accordance with the identification criteria outlined in *Guidelines for identification of MPAs* detailed in the *Strategic Plan of Action for the NRSMPA* (see Appendix 1); and it was to report on the components specified in Appendix 2. The conservation values assessment was *not* intended to give recommendations as to what protection measures may be appropriate, provide information relevant to reserve design, or deal with reserve management issues; nor was it expected to provide a social and/or economic impact assessment.

The original title for the area to be assessed – a Blue Whale aggregation site – reflects the reasons for its inclusion in the 11 unique areas; Blue Whales are regularly present between December and April/May, and their presence has been linked to surface swarms of coastal krill that form in response to the upwelling of nutrient rich, cool water – the Bonney Coast upwelling – other unidentified factors may also contribute to the whale's presence in the area. The objective of this assessment is to identify the conservation values of the Blue Whale aggregation *area*; thus it is *not* aimed at proposing an effective recovery plan for Blue Whales, and may indeed discover other values besides those associated with Blue Whales. For this reason we decided to change the name of the assessment area to 'the Bonney Upwelling area', since this more clearly suggests the focus on the geographic location, and on the oceanographic feature that amongst other things attracts Blue Whales. Despite this change in the name the Blue Whale focus of this conservation values assessment still remains, in accordance to our brief. Thus, we stress that, although we refer to some other values, this is not a complete assessment of all the conservation values of the Bonney Upwelling.

Classical upwelling plumes are regularly observed along the Bonney Coast (Robe, SA to Portland, Vic), between November/December and March/April. This is not the only upwelling in southeast Australia driven by the prevailing southeasterly winds, but it is the most prominent. The area is highly productive as a result of the upwelling. It boasts a distinct colder-water flora, and rich assemblages of sessile filter feeders such as sponges, bryozoans and corals. It provides a feeding ground for seabirds, fishes, whales as well as other higher order predators such as fur

seals and penguins. It is also a productive fishing ground, in particular for rock lobster, sustaining a relatively large fishing industry working out of several ports along the coast.

Blue Whales are listed as endangered species in the IUCN redlist and *EPBC Act.* Hunted to near extinction in the early part of this century, they are now protected under a variety of national and international treaties. Relatively little is known about their abundance, distribution or biology. Although treated as one species in respect to legislation and the present assessment, two sub-species, True Blue and Pygmy Blue, are sometimes distinguished, with the former ranging at higher latitudes, and being larger and more rare than the latter. Worldwide only 12 feeding sites of Blue Whales have been identified, two of which are in Australian waters: the Swan Canyon in WA, and the Bonney Upwelling (also called the Otway area) in Victoria. Whales observed in the Swan Canyon may belong to a separate population pool from those in the east; the Swan Canyon is another of the 11 unique areas to be assessed within the present project. Blue Whales have also been spotted feeding off Eden, during the humpback whale watching season (October to December), and between King Island and Tasmania, but these sightings are not confirmed to be as predictable as the ones in the Bonney Upwelling.

There are many identified anthropogenic processes that threaten whales: chemical pollution (acute and diffuse), climate change, collision with vessels, commercial whaling, competition for resources, displacement due to large fixed structures, gear entanglement, harassment, marine debris, noise pollution. Of particular concern in the Bonney Upwelling are: changes to the upwelling (e.g. through global warming), collisions with vessels, and noise pollution. While there is little evidence of significant current impacts — the region's fisheries mainly use low-risk gears, offshore oil and gas exploration is conducted within the guidelines of the *Environment Protection and Biodiversity Conservation Act* (*EPBC Act* 1999), there is no krill fishery, and no current reports of collisions with whales — we concluded that any new industries and/or increases in activity by existing users will have to be assessed on a case-by-case basis regarding their impact on the Blue Whales.

Does the Bonney Upwelling area possess biodiversity values worthy of protection? — The Bonney Coast has high productivity and most probably high species diversity due to the largest, most predictable upwelling event in southern Australia. In addition, it is one of 12 widely recognised and well-known feeding areas worldwide where Blue Whales are known to aggregate in relatively high numbers. For these reasons, we believe that the area does have biodiversity values worthy of protection, and that it has these values primarily as a result of the Bonney Coast upwelling event. In regard to threats to this biodiversity, the main concerns are (1) processes that may affect the upwelling system itself, and (2) processes that may directly affect the whales.

Background

This report is the second of two conservation values assessments to be provided by CSIRO to Environment Australia during 2002. On 26 September 2001 the Minister for the Environment announced plans to assess the conservation values of 11 unique marine areas in Commonwealth waters. The conservation values assessments are intended to provide information as to whether the Government should proceed with conservation measures for any of the areas, such as declaring new marine protected areas.

The 11 areas are divided into two groups:

- The Bass Strait sponge beds and Blue Whale aggregation site, in southeastern Australia, which are to be assessed within the framework of the South-east Regional Marine Plan process. The conservation values assessments for these two areas are to be provided during 2002.
- Nine areas to be assessed outside the SERMP framework – Eucla Canyon, Gulf of Carpentaria seagrass beds, Heywood Shoals, Naturaliste Plateau, Norfolk Seamounts, Pea Shoals, Sea Angel Bank, Swan Canyon and Wallaby Plateau.

This report concerns Area 2, initially called the Blue Whale aggregation site, but here referred to as the Bonney Upwelling.

Scope of the initial conservation values assessments

In summary, CSIRO was asked to provide a succinct summary of the relevant and available data and come to a balanced conclusion regarding the question "Does the area possess biodiversity values worthy of protection?" For example, does the site offer special/significant values in terms of, among other things, providing for:

- the special needs of rare, threatened or depleted species and threatened ecological communities;
- the conservation of special groups of organisms (eg species with complex habitat or migratory species, or species vulnerable to disturbance);
- centres of endemism, natural refugia for flora and fauna;
- recreational, aesthetic, educational or cultural needs; and
- a scientific reference site.

CSIRO was asked to include expression (with explanation) of degree of confidence in the conclusions, and necessity for any further information, and if appropriate to include conclusions about any specific sub-areas identified.

We were asked to identify and describe any areas of high conservation value in each of the areas and to provide an assessment of the conservation values of the areas in accordance with the identification criteria as outlined in *Guidelines for identification of MPAs* detailed in *the Strategic Plan of Action for the NRSMPA* (see Appendix 1) and to report on the components specified in Appendix 2, to the extent possible given available data. CSIRO was expected to consult with individuals and institutions with expertise and research interests in these areas and to make appropriate arrangements to access all available information and expertise; however, CSIRO was asked not to consult directly with stakeholders; this would be done by EA.

It is not the role of the initial conservation values assessment to recommend what protection measures may be appropriate, to provide information relevant to reserve design issues or to deal with reserve management issues. Similarly, while the assessment may provide information regarding current uses and threatening processes, it does not aim to provide a Social and Economic Impact Assessment. Should the Minister decide to pursue conservation measures for the area, (such as a Marine Protected Area – MPA) then a detailed social and economic impact assessment will be developed at a subsequent stage of the process, in conjunction with an analysis of the conservation benefits, design and management of the proposed conservation measures.

Bonney Upwelling (Blue Whale aggregation) area – original outline

EA initially provided CSIRO with the following summary:

The most significant aggregation of Blue Whales in Australian waters occurs in shelf waters off Portland, Victoria, during mid-December to mid-May. The area apparently supports high abundances of krill in localised regions of cold-water upwelling.

The assessment should verify the geographic location of the Blue Whale Aggregation area. Peter Gill has described a feeding area that covers the width of the continental shelf between the waters off Robe, South Australia (139°45'E), and Port Campbell, Victoria 143°E). This is a total area of approximately 12,000 km^2 [updated information extends the feeding area to Cape Otway, thus covering an area of 18,000 km^2 (Peter Gill pers comm.)]. *Blue Whales are almost invariably seen within the 200 m isobath, although some sightings have occurred near 300 m.*

Blue Whales have also been sighted less than half a nautical mile offshore in only 20-30 m depth.

Data availability:

- *Good bathymetry exists over most of the region;*
- *Regional seismic coverage and more detailed exploration coverage exists out to upper slope areas;*
- *Geological knowledge is well documented and based on both public data and other sources;*
- *Moderate sampling of sea floor biota;*
- *High level of knowledge of fisheries and other associated pelagic biotas.*

The area has been proposed for listing as critical habitat for Blue Whales under the EPBC Act.

While the habitat mapping commissioned by the National Oceans Office does not cover this area, the South-east Regional Marine Plan assessment reports will provide an important knowledge base for developing a conservation values assessment for this area.

Methods

This report is the result of a desktop study, presenting data and information currently available that is relevant to the Bonney Upwelling. For the conservation values assessment we concentrated on the region between Cape Jaffa and Cape Otway, which can also be described as the Bonney Coast or the Otway Basin. Data collation involved literature searches and reviews as well as consultation with data holders. CSIRO was asked not to consult directly with stakeholders but the Stakeholder Reference Group (SRG) for the Commonwealth MPA process, established by EA, was informed on several occasions of the work of the CSIRO team and was invited to draw to our attention any information, whether quantitative data or anecdotal observations. A workshop held by EA on June 3 2002, brought together stakeholders and potential data holders, and provided a good overview of relevant, available data and of views and opinions regarding the Blue Whale aggregation site. Appendix 3 lists the membership of the SRG, the participants in the workshop and the people we contacted directly in our search for data and expert opinions on issues related to the Bonney Upwelling. As part of the South-east Regional Marine Planning process, the NOO has released a series of reports in 2002 (NOO 2002a-f), and BRS compiled background information on the uses/users and presented it in a report to the NOO (Larcombe *et al.* 2002). As the Blue Whale aggregation area is contained in the South-east Marine Region and the present assessment was to tie into the framework of the

South-east Regional Marine Planning process we were able to draw from the information presented there.

The information received was compiled, abstracted and discussed within CSIRO Marine Research (primarily by F. Althaus, A. Butler and R. Bustamante, but also with other colleagues). A preliminary draft of this report was discussed with Environment Australia (EA).

Data collated under projects for the NOO are or will be recorded in the Neptune metadatabase; CSIRO's Marlin metadatabase contains records of CSIRO generated data. Both these databases are compliant with the ANZLIC guidelines. Other data stems from publications that are referenced.

Findings

Physical environment

Bathymetry

The southern shelf is the southern coastal boundary of the Australian mainland. It stretches some 2,000 km in a generally zonal orientation and provides a northern boundary to the southeast Indian Ocean. The southern shelf has a maximum width of 200 km in the central Great Australian Bight, which narrows to about 20 km south of Western Australia and on the Bonney Coast of South Australia. The depth on the shelf in the Bonney Coast increases gradually to 100 m where a distinct increase in steepness is then observed (Fig. 1). The continental slope and the abyssal plain (between 1,000 and 5,000 m) along the Eyre Peninsula and the Bonney Coast, are connected by over 20 very large and steep canyons (Fig. 1), the significance of which, as pathways of upwelling waters, has yet to be determined (Lewis 1981). The South Australian Basin, a major abyssal plain (depth 5,500 m) is located offshore, adjacent to the shelf region.

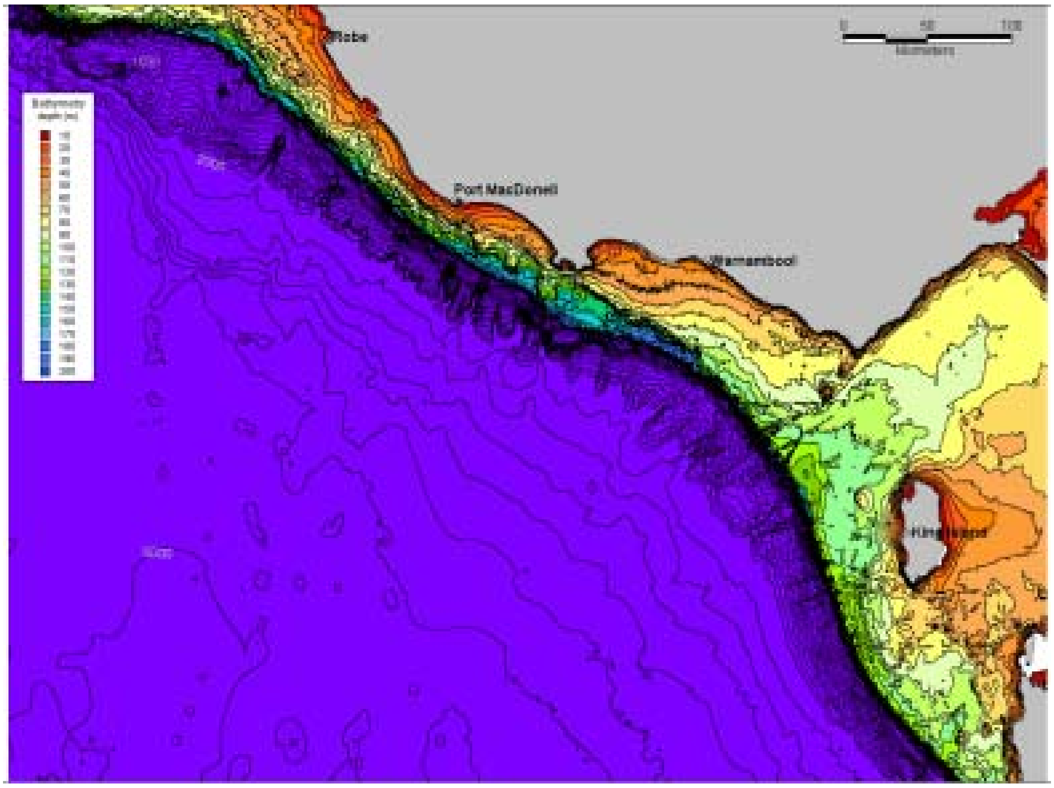


Fig. 1: Bathymetry of the Bonney Coast; depths off the continental shelf (>200m) dark purple. Data supplied by GA.

Geomorphology

Boreen *et al.* (1993) in their documentation of the surficial sediments describe the Otway continental margin as a swell-dominated, open, cool-water, carbonate platform that they divide into 7 depth-related zones. In the shallow shelf are exhumed limestone substrates that host dense encrusting mollusc, sponge, bryozoan and red algae assemblages. The middle shelf is a zone of swell-wave shoaling and production of mega-rippled bryozoan sands. The deep shelf is described as having accumulations of intensely bioturbated, fine, bioclastic sands. At the shelf edge and top of slope, nutrient-rich upwelling currents support extensive, aphotic bryozoan/sponge/coral communities. The upper slope sediments are a bioturbated mixture of periplatform bioclastic debris and pelleted foraminiferal/nanno-fossil mud. The lower slope is described as crosscut by gullies with low accumulation rates, and finally, at the base of the slope the sediments consist of shelf-derived, coarse-grain turbidites and pelagic ooze.

Maps collated in Edyvane (1998) depict the sedimentary habitats of the South Australian coast. In this publication the Otway Basin is sub-divided into three Biounits: Canunda, Nene and Piccaninnie. The sediment habitats of Canunda and Nene, between Cape Jaffa and Cape

Northumberland, contain mostly low profile, platform reef, with outcrops of heavy limestone or calcarenite reef outcrops inshore, and few patches of bare sand (Edyvane 1998). In general, bare-sand patches constitute a shallow layer of sand on hard surface (K. Gowlett-Holmes pers. comm.). The Piccaninnie area, east of Cape Northumberland to the South Australian boarder, shows an increase of bare sand (Edyvane 1998).

The sediments of the Bonney Coast are mostly coarse to very coarse sand (0.5-1 mm grainsize) with strong gravel patches (grainsize >1 mm) south-east of Robe, south-east of Port MacDonnell and south of the headland near Portland (Fig. 2). Fine sand and silt (grainsizes $\leq$0.1 mm) intrusions can be noted on the continental shelf edge between Port MacDonnell and south of the Portland headland (Fig. 2).

Geoscience Australia supplied information from its GEOMAP model on the mobility of sediments in this area.

To describe sediment transport, each of the variables Grainsize, Sorting, Rock and Carbonate distribution should be used (Jenkins 2000). Grainsize may be used as an initial guide to sediment mobility, however, a more accurate guide to long-term stability is available using particle size 'Grainsize + Sorting'. Rock depicts the distribution of hard grounds (rock outcrops, coral reef fronts, cementation of sediments) and Carbonate provides information on intragrain porosity and shape (carbonate materials have typically high internal porosity and irregularly shaped particles).

Figures 2 to 5 illustrate data for those variables. The GEOMAT model has the capacity to predict, from these data, the likelihood of mobilisation of sediments due to wave action and tidal currents. That information is not presented here because our focus is on the Blue Whales, and thus more pelagic.

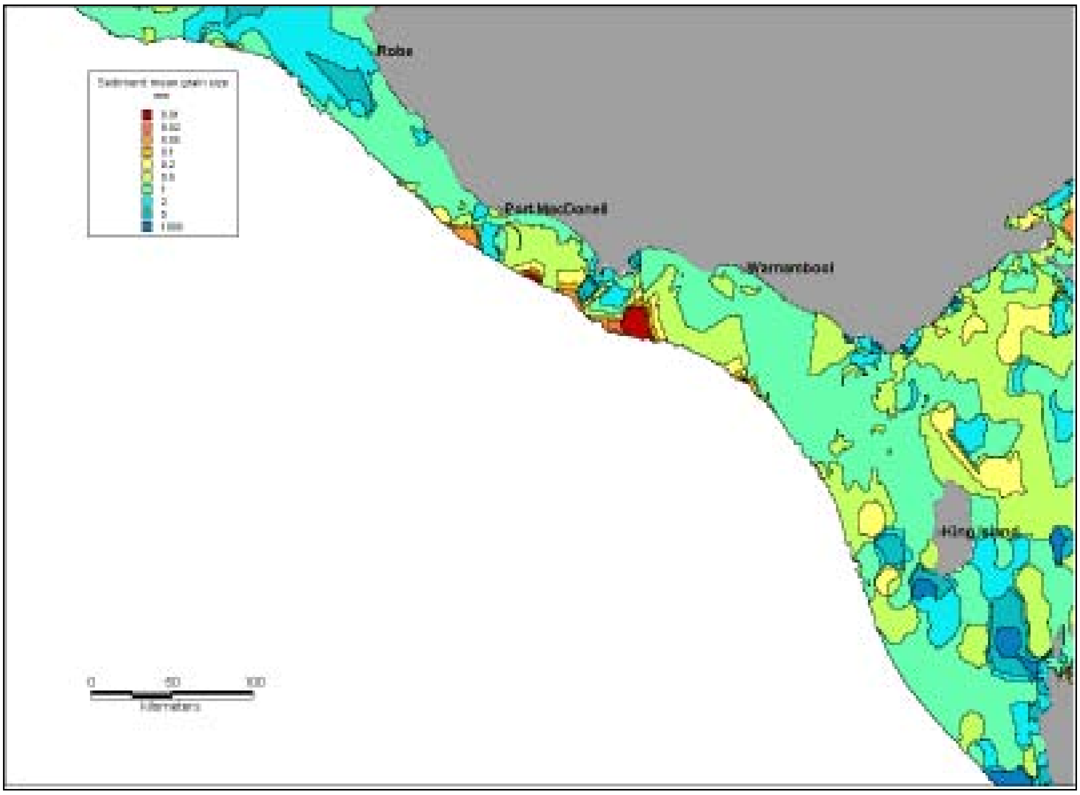


Fig. 2: Mean grain size distribution in the Bonney Coast. Data supplied by GA.

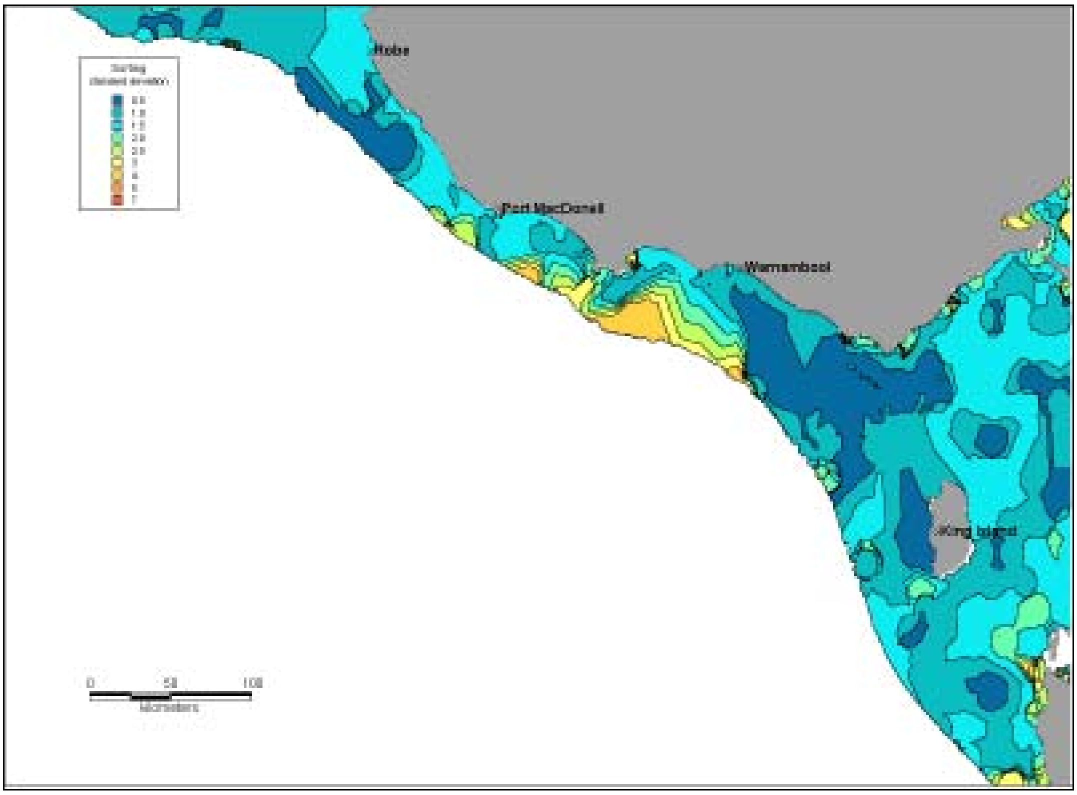


Fig. 3: Grain size sorting in the Bonney Coast. Data supplied by GA.

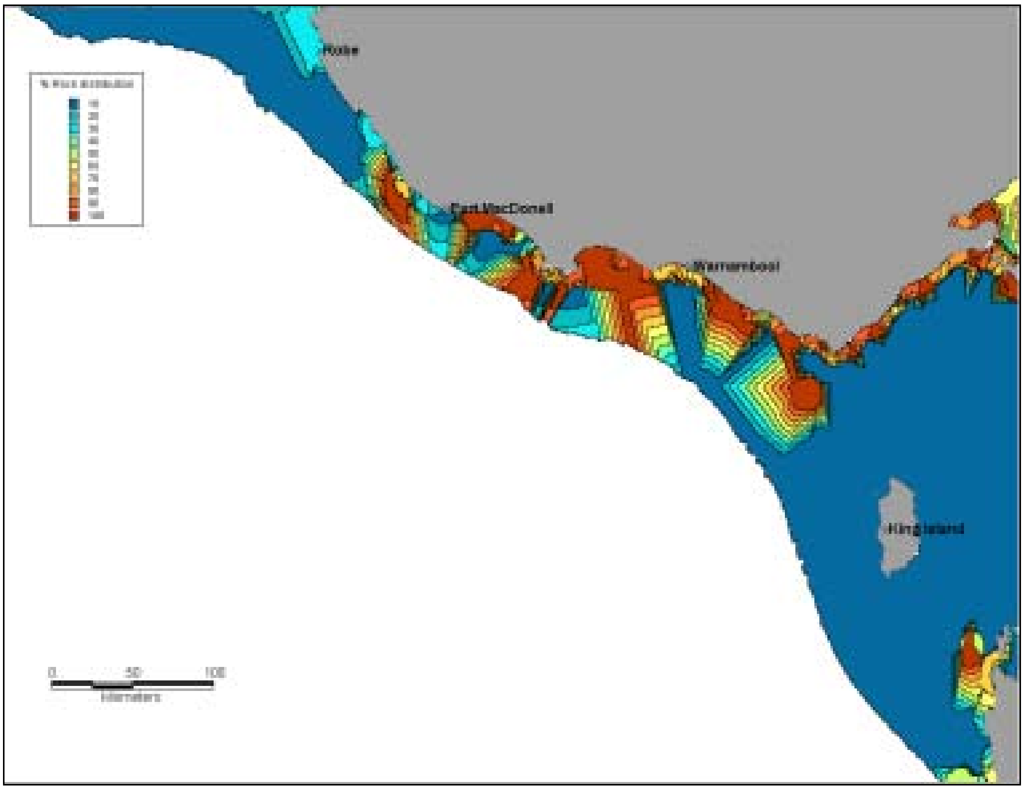


Fig. 4: Rock substrate distribution in the Bonney Coast. Data supplied by GA.

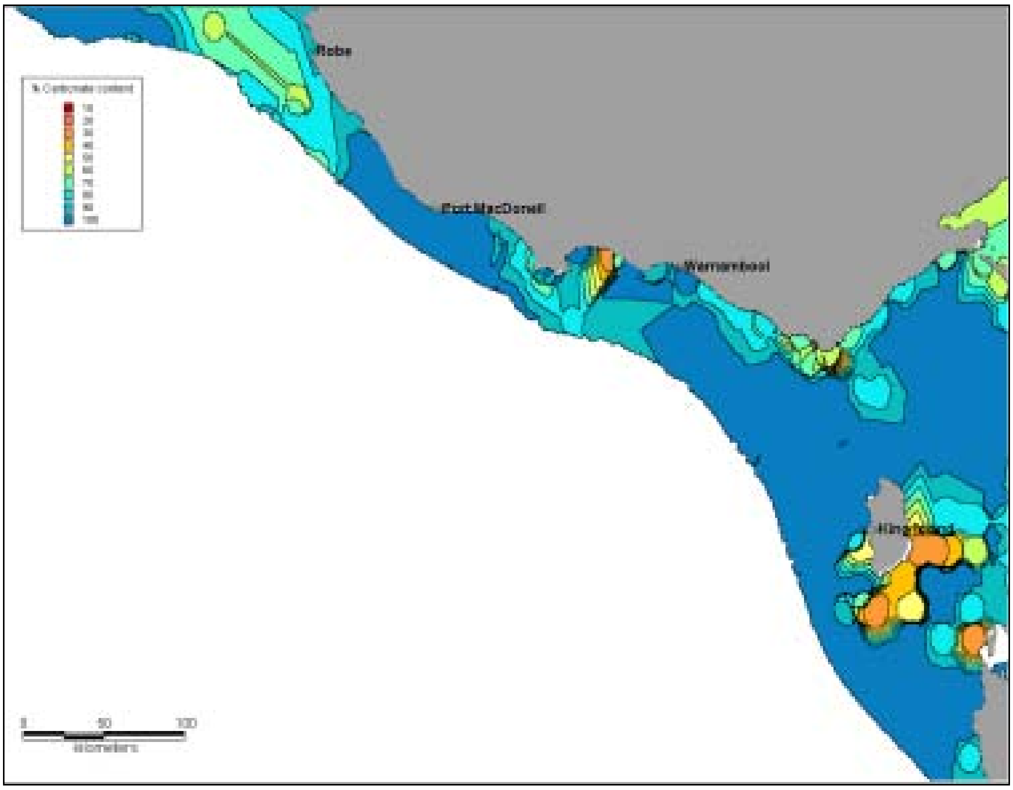


Fig. 5: Carbonate distribution in the Bonney Coast. Data supplied by GA.

Oceanography

Wind patterns

The zonally oriented coastline allows wind systems to propagate eastward, and readily promotes meridional exchange between continental and oceanic air masses. In summer a high-pressure ridge is maintained over the South Australian Basin that induces a consistent pattern of southeasterly wind. In contrast, in winter the anticyclone moves to the north over central Australia resulting in a predominantly westerly wind regime. Underlying these seasonal changes, there is consistent positive wind stress curl throughout the year over the South Australian Basin that drives a permanent deep-sea anticyclonic gyre (Middleton and Cirano 2001, Ridgway and Dunn in prep.).

Current regime

In the south, the Antarctic Circumpolar Current (ACC) represents an equally definitive transition to a more global regime. The open boundaries at the eastern and western endpoints allow a free exchange of properties between the major basins. The influence of the ocean gyre systems on the circulation within the region is likely to be expressed by an interaction with the East Australian Current (EAC) in the east and the Leeuwin Current in the west.

Coastally trapped waves

Coastally trapped waves of large amplitude (~0.5 m) are regularly observed along the southern shelf (Provis and Radok 1979, Church and Freeland 1987). These waves propagate in an eastward direction at speeds similar to that of the regional atmospheric systems and coherent signals are present in sea level data collected along the shelf. Typically, the amplitude of the signals reduces greatly when the waves approach the narrow Bonney Coast due to frictional dissipation.

The alongshore sea level also shows a coherent response on seasonal timescales (Pariwano *et al.* 1986). In fact, this seasonal signal develops throughout the southern shelf without any time lag.

Coastal circulation

Along the southern shelf the circulation is predominantly the result of wind forcing. Observations strongly suggest that there is a wintertime eastward current over the continental shelf flowing from Cape Leeuwin to the southern tip of Tasmania (Godfrey and Hahn 1986, Cresswell and Peterson 1997, Cirano and Middleton 2001). This results from the set-up of coastal sea level due to the onshore Ekman flux of the wind field (Cirano and Middleton 2001). In the summer, the coastal wind reverses and changes to an upwelling favourable system producing westward flow at the coastal boundary (Middleton and Platov 2002).

Coastal upwelling

We now describe the underlying mechanism associated with coastal upwelling. This is based on simple Ekman dynamics. If the ocean surface is forced by a steady wind stress there is a net transport of water at right angles to the left of the wind direction (southern hemisphere). This water movement occurs within a relatively shallow surface layer (called the Ekman layer). When the wind stress is aligned along a coastal boundary, with the coast on the right, then the Ekman transport will be directed offshore. To maintain continuity water must be upwelled within the coastal region. In the simplest case, this upwelling derives from an onshore transport in the bottom layer with a magnitude equal to that of the original offshore flow. In practice, the upwelling flow fields are complicated by several factors including the topography of the shelf and slope regions, the amount of stratification over the shelf, and the strength and persistence of favourable alongshore winds.

Throughout the summer period (November-March), a succession of slowly propagating, high-pressure, features move eastwards to the south of the continent. Due to their orientation, certain sections of the southern shelf are subject to southeasterly winds that produce upwelling favourable conditions. This happens off the Eyre Peninsula, Kangaroo Island, the Bonney Coast (Robe to Portland) and eastern Victoria (Lakes Entrance to Croajingalong) (see Fig. 6). The most prominent of these is along the Bonney Coast where classical upwelling plumes are regularly observed (Schahinger 1987). As Figure 6 shows, the upwelling plume is not restricted to our focus area, but reaches further northwesterly into Encounter Bay. It is possible that there is a southeasterly subsurface extension of this upwelling reaching into western Bass Strait. The upwelling observed along the Eyre Peninsula occurs even when the local winds are not favourable in the terms described above (Griffin *et al*. 1997).

In winter, the weather patterns are rather different; the belt of high pressure moves northward over the continent, producing persistent westerly winds.

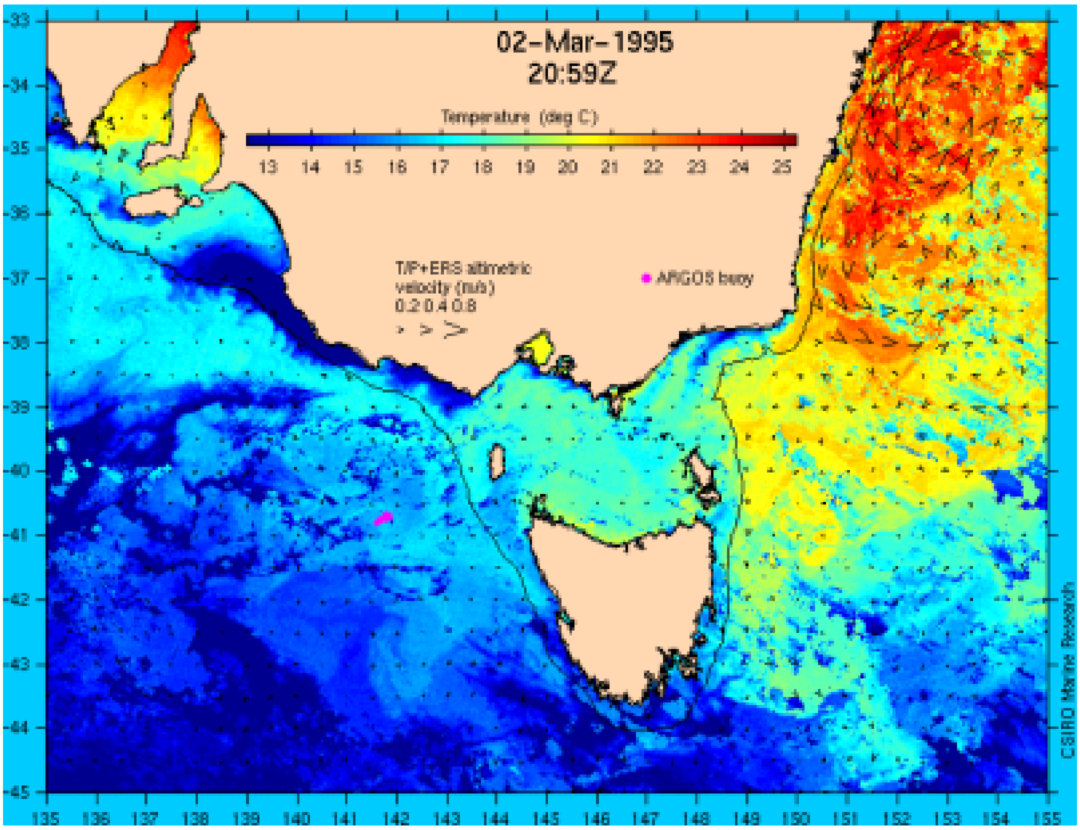


Fig. 6: SST image showing strong cold water upwelling in the Bonney Coast in March 1995. Cooler water can also be noticed off Eyre Peninsula, Kangaroo Island, between Tasmania and King Island, and in eastern Victoria (E of Lakes Entrance).

Interannual and decadal changes in the upwelling region

While the general characteristics of the Bonney Coast upwelling have been studied in some detail (Rochford 1977, Lewis 1981, Schahinger 1987) with an even more limited analysis of the Eyre Peninsula feature (Griffin *et al*. 1997), virtually nothing is known of the longer-term variability of the phenomenon. SST imagery provides a useful indicator of upwelling events. P. Gill is currently assessing within and between season variability of the upwelling on the Bonney Coast as part of his PhD (Gill in prep – PhD thesis).

Since the alongshore wind is the main mechanism driving the upwelling, any significant changes in the strength or frequency of upwelling favourable wind components are likely to influence the magnitude or frequency of upwelling events themselves. The other variable determining the nature of upwelling is the density profile of the water column. This affects both the region out from the coast where upwelling will occur, and also the thickness of the upper and lower Ekman layers (essentially the layers through which either surface wind forcing or bottom frictions acts on the water column).

An analysis of the wind-data time-series over southern Australia should be a useful index of the strength of southern Australian upwelling. However, some care needs to be applied to any interpretations from such time series since not all strong upwelling-favourable winds necessarily lead to strong upwelling events (Griffin *et al*. 1997). Considerable research has been conducted on variations in the position of the continental high-pressure area over Australia, which drives the westerly wind belt (eg. Thresher 2001). Harris *et al*. (1988) showed a clear cyclical pattern in the zonal westerly winds (ZWW) over Tasmania and suggested that interannual variations in the regional fisheries were outcomes of these changes in the wind forcing. Thresher (2001) presented time series for both summer and winter for the location of the sup-tropical ridge (STR) over eastern Australia. For example, from 1970 to 1990 in summer, the STR moved nearly 4^{o} of latitude to the north. There is likely to have been a corresponding effect on the frequency of upwelling-favourable winds along the southern coast.

Coastal sea level is the only routinely monitored parameter that is related to the other upwelling forcing variable, the density structure. Interannual variability of the Leeuwin Current off Western Australia has been inferred from the coastal sea level (Pearce and Phillips 1988). There is likely to be similar variations in both the coastal currents and the slope density structure in the upwelling region but this topic awaits further attention.

Distinct sub-regions within the assessment area

The assessment area is one meso-scale region — Otway — as described by the IMCRA Technical group (1998). Edyvane (1998) divides the Otway region into three Biounits – Canunda, Nene and Piccaninnie– based on major coastal physiographic features and the representation and distribution of major marine habitats. The bioregionalisation is described in detail below.

Biological environment

Bioregionalisation

There are several bioregionalisations of Victoria's marine environment. One of the earliest, by Bennet and Pope (1953), is based on the distribution of intertidal and shallow sub-tidal organisms. The Bonney Coast forms the western extension of the Maugean Province that encloses Tasmania's coastline. The biota of the Maugean Province is described as cool temperate marine, with similarities to the cool temperate Chilean coast, the Namaqua of South Africa and the shores of southern New Zealand (Bennett and Pope 1960). Dartnall (1974) confirms the separation of southern Australian biota into the Flindersian (western and central Great Australian Bight) and the Maugean Province. Based on macrophytes, Womersley (1984) describes the Bonney Coast as part of the Maugean sub-province, or ‘eastern floral element’ of the Flindersian province. The latter extends from Geralton WA to the NSW-Victoria border, while the Maugean sub-province includes the Australian southeast coast from Eyre Peninsula to the NSW-Victoria border, including Tasmania. The Interim Marine and Coastal Regionalisation for Australia (IMCRA) provided a new bioregionalisation based on fish distribution and sea floor topography, derived from expert field ecological knowledge and interpretation of existing regionalisations. IMCRA has a nested structure with meso-scale regions contained in demersal provinces, which in turn coincide with, or are part of, pelagic provinces (IMCRA Technical Group 1998). The Bonney Upwelling is contained within the Otway meso-scale region of the IMCRA (Fig. 7); Table 1 summarises the classification of that area. As mentioned above, Edyvane (1998) subdivided the South Australian part of the IMCRA meso-scale region into three Biounits, based on nearshore data, as described in Table 2. The bioregionalisation of the IMCRA Technical Group 1998) and of Edyvane (1998) does not extend beyond the shelf edge.

An interim, draft bioregionalisation for the continental slope and deeper waters of the South-east Marine Region has been prepared for the NOO by CSIRO Marine Research and Geoscience Australia. The report is not yet available but is summarised in NOO (2002a) pp. 13-17. The Bonney Upwelling is included within one provincial-scale (level 1) unit of this regionalisation (this unit may in fact be an ecotone, grading into a more westerly province, but this cannot be resolved because the regionalisation was done only for the SEMR). Within that unit, the bioregionalisation distinguishes level 2 biomes (continental shelf, slope and abyssal plain) and within them, sub-biomes which are depth zones (level 2b) distinguished by the fish fauna and corroborated by data on properties of water masses. Finally, it identifies level 3 geomorphological units, which are areas of similar seafloor geomorphology, identified primarily from bathymetry but corroborated with other data. Most of these units lie beyond the area of interest in this report, which is concerned primarily with the continental shelf (treated by IMCRA).

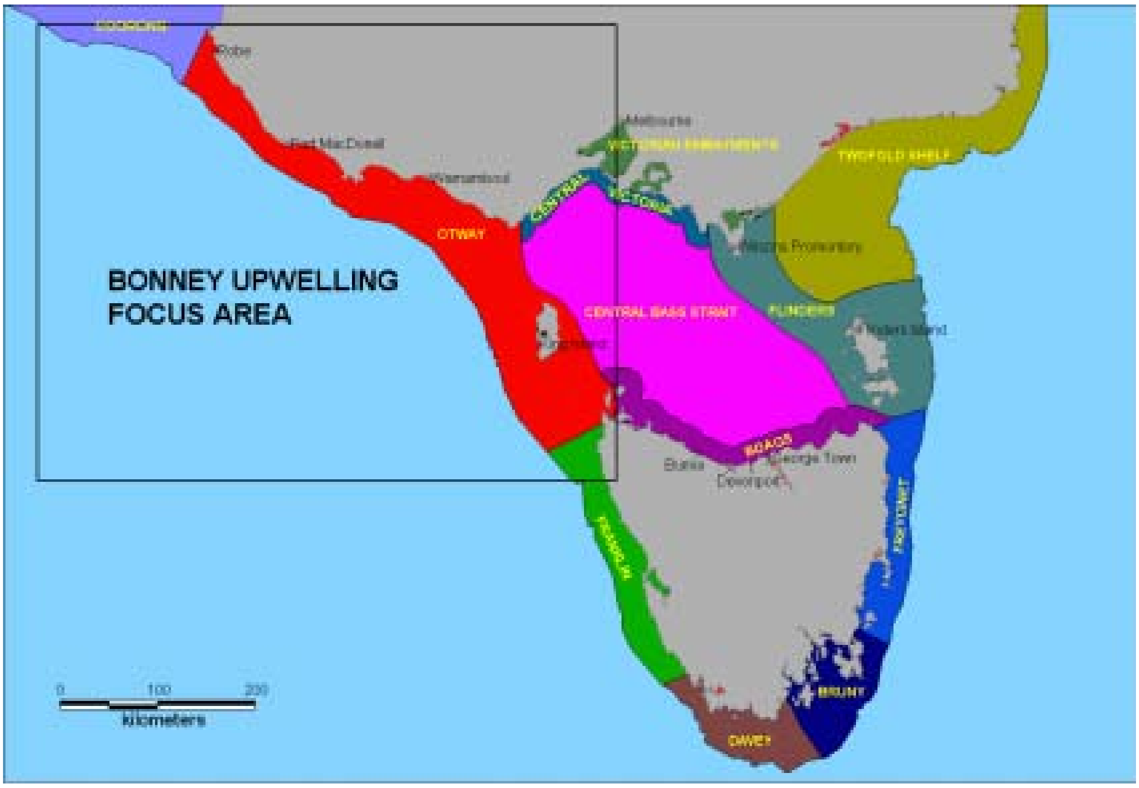


Fig. 7: Map of the Meso-scale regions in the Bonney Coast, as defined by IMCRA Technical group (1998).

Table 1: Bioregionalisation classification of the Bonney Coast according to IMCRA Technical group (1998)

Classification	Name	Description
Meso-Scale	Otway	Cape Jaffa to slightly north of Apollo Bay; 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 (detailed description Oceanography Climate, Geology/geomorphology, Biota on P.96/97 in IMCRA report).
Demersal	Western Bassian Biotope	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 and Gulf Provinces.
Pelagic	Southern Pelagic Province	Largely comprised of Flindersian cool temperate species. The endpoint disjunctions also represent southern limits or warm temperate species in the Eastern and Western Pelagic Biotones. 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.

Table 2: The three Biounits of the Otway meso-scale region as described by Edyvane (1998)

Biounit	Major feature	Physical/biological description	Inshore habitats
Canunda	Canunda NP	High energy, rocky coast,	Mostly reef (50,552 ha,

Biounit	Major feature	Physical/biological description	Inshore habitats
		dune barriers, offshore reefs	90.5%), some sand (5,333 ha, 9.5%) and sparse seagrass (2 ha, <0.1%)
Nene	Nene Valley CP	High energy rocky coast, offshore reefs	Mostly reef habitats (9,981 ha, 79.7%), and some sand habitat (243 ha, 2.3%)
Piccaninnie	Piccaninnie Ponds CP	Rocky coast, offshore reefs	Mostly sand habitats (2,798 ha, 79.6%), some reefs (675 ha, 19.2%) and sparse seagrass (44 ha, 1.3%)

List of taxa

Australia's South-east Marine Region appears to be noteworthy in its species diversity and endemicity (Womersley 1984, Kott 1997). Wilson and Allen (1987) note that species endemicity, in almost every group of marine animals in southern and in particular in southeastern Australia, is very high (usually over 90%). Table 3 lists a brief description of and references to the main biological groups occurring in the Bonney Upwelling region.

Table 3: List and brief description of broad biological groups found in the Bonney Coast

Broad category	General description and/or species	References
Marine mammals	In the Australian action plan for cetaceans, Bannister *et al.* (1996) list 23 cetacean species whose distribution includes southern Australia	Bannister *et al.* (1996)
	All true and eared seals are listed under the *EPBC Act*. They are detailed in Appendix 4.	*EPBC Act* (1999)
Marine Birds	All marine birds are listed under the *EPBC Act*. They are detailed in Appendix 4.	*EPBC Act* (1999)
Macrophytes	SE Australia has one of the richest macrophyte floras in the world (409 genera with 1124 species) with a high percentage of endemism	Womersley (1984)
	The benthic algal community off Cape Northumberland, South Australia, is described as including more than 200 species, of which 165 or so species are quite rare, the other 35 species being mostly red algae that are quite common.	Shepherd (1981)
Fish	Gomon *et al*. describe the nearly 200 cool-temperate fish species occurring in the southern part of the Flindersian Province, i.e. from Recherche Archipelago to Wilsons Promontory, excluding Tasmania.	Gomon *et al.* (1994)
Crustacea	There are no recent crustacean guides for southern Australian fauna. However, Jones and Morgan (2002) compiled a field guide to the crustaceans of Australia.	Jones and Morgan (2002)
	A new, comprehensive guide to crustaceans in Australia is going to be released by ABRS shortly. It will be accessible through ABRS' website.	ABIF (2002)
Invertebrates (general)	Detailed descriptions of marine invertebrates of southern Australia are given in a 3 part series of books edited by Shepherd and Thomas (1982, 1989) – Parts and II, and Shepherd and Davies (1997) – Part III. Groups covered are: cnidarians, worms, sipunculans, echiurans, bryozoans, echinoderms (Part I), mollusks (Part II), nemerteans, nodding heads, phoronids, brachiopods, acorn worm sea spiders, littoral insects and tunicates (Part III).	Shepherd and Thomas (1982, 1989); Shepherd and Davies (1997)
Benthic Invertebrates	The limestone subcrops of the Otway margin are generally encrusted by dense assemblages of molluscs, sponges, bryozoans and red algae.	Boreen *et al.* (1993)
	There are upwelling related rich/abundant Bryozoan/sponge/axoozanthellate coral assemblages particularly at the shelf edge and upper slope.	
	On the deep shelf off Portland a widespread proliferation of delicate cyclostome bryozoans can be found.	
	The analysis of benthic invertebrates from the Bass Strait Survey conducted by the Victorian Museum in the period of 1979-1984 showed no clear separation of stations from the eastern end of the Bonney Upwelling region (including its sub-surface extension to the SE), although a general longitudinal gradient could be observed in the data.	O'Hara (2002)

Key species

The key species, due to the focus of the present assessment, are clearly the Blue Whales (*Balaenoptera musculus*) and the coastal krill (*Nyctiphanes australis*), an abundant food source and a contributing factor for the whales to aggregate in the Bonney Upwelling region. However, other species occurring in the region are worth mentioning here; in particular, threatened and listed marine species including seabirds, marine mammals, non-commercial fishes, as well as the main commercial species.

Feeding Blue Whales (*Balaenoptera musculus*) have been sighted from, broadly, Robe to Cape Otway (Gill 2002). Blue Whales in Australia are currently recognised as one species with two sub-species, True Blue Whales (*Balaenoptera musculus musculus*) and Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) (Bannister *et al.* 1996, Rafic 1999). The two sub-species are distinguished on the basis of morphological characters such as the trunk/tail ratio, colouring, relative size of the baleen plates and length at sexual maturity (Ichihara 1966). Furthermore, it is suggested that the southernmost range of Pygmy Blue Whales is mid-latitudinal waters (40-54°S) while True Blue Whales are found south of 55°S (Kato *et al*. 1995). Most whales sighted in the Bonney Upwelling region appear likely to be Pygmy Blue Whales. It is, however, very difficult to distinguish the sub-species visually (e.g. Bannister *et al.* 1996) and the biological basis for distinguishing the two subspecies is still under examination (P. Gill per. comm.). Recent recordings of probable Pygmy Blue Whale 'songs' collected by McCauley from the Swan Canyon and south of Portland differ markedly from signals recorded near True Blue Whales in Antarctic waters. This suggests a differentiation in 'song' types between Pygmy and True Blue Whales (McCauley pers. comm.). The two subspecies have been treated as one for purposes of the *EPBC Act*, and listed as Endangered.

The coastal krill (*Nyctiphanes australis*) is the principal species of euphausiid in the area. It is observed in surface swarms, related to the upwelling event on the Bonney Coast (Gill 2002).

Seventy-eight species occurring in the area are covered by one or more provisions of the *EPBC Act*. Of these 8 species (5 whales, 2 sharks and 1bony fish) are not listed marine species but they are listed threatened species under the *EPBC Act.* The Bonney Upwelling area harbours, in total, 26 listed threatened species: one shark is listed as critically endangered; 5 birds and 2 whales are listed as endangered; and 11 birds, 1 shark, 3 whales and 1 bony fish are listed as vulnerable. The listed marine migratory species include18 birds and 3 whales (EA 2000a). Non-marine birds that overfly the region are not included. Appendix 4 summarises the listed threatened, listed marine migratory, and listed marine species occurring in the Bonney Upwelling region.

While Appendix 4 includes an indication of the type of presence of each species in the area, it is beyond the scope of this report to give details on habitat range, habitat restrictions and seasonality of habitat usage by each of the 78 species.

Nineteen species of fish and 7 species of invertebrates are consistently targeted by a variety of fisheries in commonwealth waters (Appendix 5) (Larcombe *et al.* 2002). In the South Australian state fisheries, more than 50 species are taken by commercial fishers, but less than 11 of these (see Appendix 5) are taken consistently (Larcombe *et al.* 2002).

Abundance and distribution

<u>Blue Whale (*Balaenoptera musculus*)</u>

Stock size (True and Pygmy Blue Whales combined) was estimated in 1994 as 700-5,500 animals (Kock and Shimadzu 1994). However, Clapham *et al.* (1999) state that no reliable abundance data exists on Pygmy Blue Whale (*B. m. brevicauda*) in any area. In fact, Clapham *et al.* (1999) say: "A reliable assessment of Antarctic Blue Whales (both 'true' and pygmy forms) is impossible at this time; we can only say that the population(s) remain small, and should be provisionally ranked among the most endangered baleen whale stocks." The Draft Recovery plan for Blue Whales (*Balaenoptera musculus*) in Australian waters (Rafic 1999) makes no distinction as to sub-species, due to the lack of knowledge about, and difficulty distinguishing between, True and Pygmy Blue Whales – no genetic markers distinguishing the two sub-species have yet been found (P. Gill pers. comm.). Blue Whales (*Balaenoptera musculus*) are listed as endangered under the *EPBC Act*.

Bannister *et al.* (1996) describe Blue Whale habitat as oceanic, worldwide, but not restricted to deeper waters. These authors go on to list locations of recent sightings of mostly Pygmy Blue Whales (1 'True' Blue in 15 sightings in February/March 1993) throughout the south coast of Australia, from near the Dampier Archipelago WA, to Bass Strait and southeast NSW, and around Tasmania. In EA's 'Guidelines on the Application of the Environment Protection and Biodiversity Conservation Act to Interactions Between Offshore Seismic Operations and Larger Cetaceans', Attachment 5a (EA 2001a) includes a map of the recognised distribution and migration routes of Blue whales (Fig. 8) On this map, three feeding areas are identified: Eden (early October to early December), Bonney Upwelling (early December to mid May), and Rottnest – Swan Canyon region (early November to mid May). Bonney Upwelling and Swan Canyon are indicated as possible breeding areas and a migration route through Bass Strait (November to December) is also marked (Fig. 8). Current data suggests that the summer feeding range of the Pygmy Blue Whale (*B. m. brevicauda*) is the mid-latitude (40-54°S) (Kato *et al.*

1995, Clapham *et al.* 1999), while True Blue Whales are found south of 55°S (Kato *et al*. 1995). P. Gill (pers. comm.) disagrees with the demarcation of the Bonney Upwelling and Swan Canyon as possible breeding grounds. He comments that Blue Whales are thought to breed during winter in tropical waters.

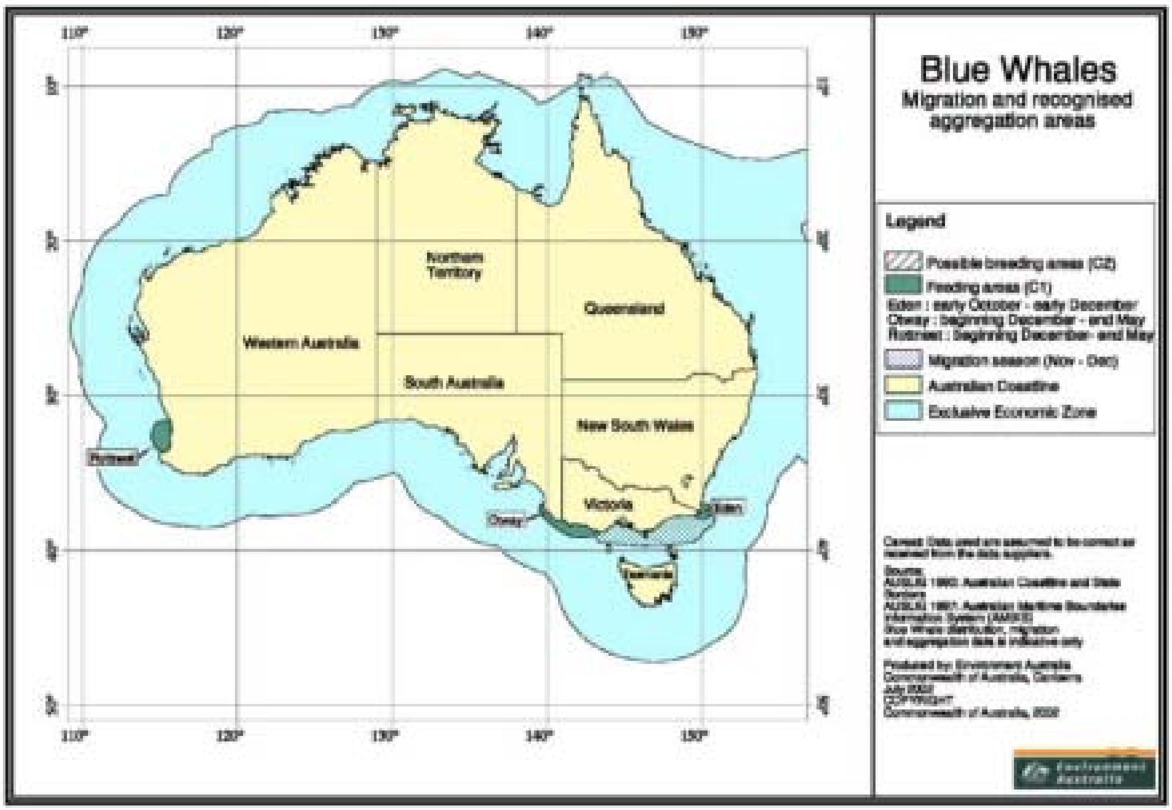


Fig. 8: Recognised distribution and migration routes of Blue Whales in Australia from EA (EA 2001a, Attachment 5a).

Our contacts have confirmed this general range for Blue Whale (no sub-species distinction). R. McCauley (pers. comm.) commented that, on the west coast of Australia, Blue whales have been sighted off Dampier, Exmouth, the Swan Canyon, Cape Naturaliste and Albany, and True and Pygmy Blue Whales have been acoustically recorded off the southern coast of Australia. C. Kemper (pers. comm.) noted that in the Great Australian Bight, Blue Whale sightings were recorded in a database for South Australia; the extent of sightings reached from west of Eyre Peninsula to the Bonney Upwelling, but unfortunately the database has been in disrepair for some time and will not be fixed in the near future (not before 2003). Blue Whales are regularly sighted in relatively large numbers in the Bonney Upwelling (Gill 2002). Gill (2002) recorded 261 Blue Whale sightings from dedicated surveys, reports from fishermen and incidental records in the Bonney Upwelling, between 1998 and 2001. Whales were observed between December and May, and they were associated with surface swarms of coastal krill in 48%, and feeding on krill in 36% of all sightings (Gill 2002). A maximum of 32 Blue Whales were sighted during one survey. The Arthur Rylah Institute for Environmental Research (ARI), commissioned by Woodside Energy, conducted 17 aerial surveys between April and June 2001. They sighted 12 Blue Whales in these surveys, with the last sighting recorded on May 19 2001 (Colman 2001). Mustoe (in prep.) states that in the east, Blue Whales have been observed feeding off Eden, NSW, during the humpback whale watching season in October to December, although they are not present there every year. Furthermore, in late February 2002, he observed Blue Whales, including one feeding on krill, between Tasmania and King Island. He suggests this may constitute an additional feeding area. It is interesting that a figure in Kato *et al*. (1995), presenting whale sightings from Japanese scouting vessels (1965/66–1987/88) and from the IWC/IDCR cruises (1978/79–1991/92) in the southern hemisphere summarised into 5° squares by month, appears to have specifically no Blue Whales sighted around Tasmania's south. However, recently revealed Soviet data shows that many blue whales were caught off southern Tasmania (Mikhalev 2000).Mustoe (in prep.) notes that, as reported by all other authors we have consulted, knowledge of Blue Whale distribution is incomplete and such propositions as the idea of migration routes through Bass Strait are uncertain. He carried out aerial surveys with the object of searching for whales in Bass Strait, initially in an area where a seismic vessel was operating and later targeting areas identified from sea surface temperature images, and did find Blue Whales, and elevated krill densities, in an area of cold water between King Island and northwest Tasmania. He points out, however, that his study illustrates that current knowledge of Blue Whale distribution is incomplete and he suggests it may fall short of a threshold at which confident management decisions can be made; an unknown proportion of Blue Whale habitat – including possible migration routes – still remains undiscovered. Furthermore, it is currently unknown if the Blue Whales in the Great Australian Bight and eastern Australia are from the same population pool as the ones along the West Australian coast. In Figure 8, Rottnest (Swan Canyon) and Bonney Upwelling are marked as possible breeding grounds; however, P. Gill (pers. comm.) indicated that although he observed cows and calves in the Bonney Upwelling, he did not suggest that Blue Whales calve there. There may be two population groups that migrate, up the east and west coasts of Australia respectively, to separate breeding grounds (P. Gill pers. comm.), although, considering the size of Blue Whales and their ability to travel vast distances, it is possible that there is continual interchange of animals between areas (P. Gill and R. McCauley pers. comm.). In addition, McCauley (pers. comm.) has recorded identical, probable Pygmy Blue Whale 'song' types from the Swan Canyon and south of Portland, suggesting a single population.

Further data on the distribution and abundance of Pygmy Blue Whales may be found in an unpublished report (Zemsky and Sahzinoz 1994) that has come to our attention too late for inclusion here.

Coastal krill (*Nyctiphanes australis*)

N. australis is abundant on the continental shelf off southeast Australia (including Tasmania). In fact, it is the principal species of euphausiid in southeast Australian and New Zealand shelf waters (Johannes and Young 1999). Blackburn (1980) indicates that *N. australis* in southeast Australia range from north of Sydney to just west of Ceduna (South Australia – 132°E). On the ARI surveys mentioned above, 526 krill surface aggregations were recorded between April and June (Colman 2001). Mustoe (in prep) reported surface swarms of krill between Tasmania and King Island. Although predominantly a summer phenomenon, krill swarms have been sighted in mid winter (McCauley pers. comm.).

Life history and behaviour

Blue Whale (*Balaenoptera musculus*)

There are many unanswered questions about the demographics of Blue Whales. Bannister *et al.* (1996) describe Blue Whales as long-lived animals (‘True’ 80-90 years, Pygmy ?<50 years) that reach sexual maturity at ca. 5-10 years (unknown for Pygmy) and calve at 2-3 year intervals. The gestation period is estimated at 10-11 months (NOO 2002a). The most common sounds produced by Blue Whales are low frequency long-duration pulses and tones, used for communication, and possibly for navigation, orientation and prey location (P. Gill pers. comm.). Blue Whales are baleen whales, which lunge feed on swarming planktonic prey (Acevedo-Gutierrez 2002), regardless of the swarm location in the water column – Gill (2002) observed feeding Blue Whales in both areas of surface swarms of krill and areas where sonar indicated krill swarms near the sea floor. They are generally stenophagous on euphausiids (Clapham *et al.* 1999), a Blue Whale consuming up to 4 tonnes of food per day (M. Prideaux pers. comm.). Gill (2002) reports convincing evidence that the Blue Whales observed in the Bonney Upwelling are feeding on *Nyctiphanes australis*, which is particularly abundant there during the active period of the upwelling, between December and May.

As noted above (see Abundance and Distribution), the Blue Whale is a highly migratory species with a life cycle and pattern of movement that is poorly understood, but is quite obviously not restricted to the Bonney Upwelling. Nevertheless, Blue Whales appear to be present in this area in greater abundance and more predictably than at other locations in southeast Australia (e.g. off Gippsland or near King Island) and so it is reasonable to conclude that, if we did have a detailed map and chronology of their movements and activities through an annual cycle, the Bonney Upwelling would feature prominently in that picture for a substantial number of animals.

Coastal krill (*Nyctiphanes australis*)

N australis are typically observed in sub-surface swarms, but surface swarms and benthic aggregations are not rare (Nicol and Endo 1997). In fact, Gill (2002) reports that *N austalis* tends to spend more time at the surface than most other euphausiid species. Colman (2001) notes that the abundance of krill aggregations (surface swarms) in the Bonney Upwelling appears to be influenced by the persistence of discrete area of colder surface water, presumably because these areas sustain higher levels of phytoplanktonic activity. Furthermore, he recorded that as sea state conditions deteriorated, probably resulting in reduced persistence of the areas of colder surface waters, densities of krill aggregations appeared to be reduced. However, Gill (in prep) also observed krill swarms associated with warmer surface water that may overlie a cool sub-surface layer. Also, Gill (pers. comm.) points out that the sightability of krill swarms decreases as sea conditions worsen. Coastal krill live approximately 1 year (Ritz and Hosie 1982), reach sexual maturity at 3-4 months (Hosie 1982), reach a maximum length of 20 mm (Ritz and Hosie 1982) and weight of 40 mg (Johannes and Young 1999), and are known to be omnivorous (Ritz *et al.* 1990). In 1999, Johannes and Young (1999) released an appraisal of the commercial fishery potential of this krill in Tasmanian waters. They found that *N. australis* is biologically similar to *Euphausia pacifica,* a commercially harvested species from the northern hemisphere. They concluded that biologically *N. australis* has a good potential for commercial exploitation for use in fish feed products. However, they point out that *N. australis* is an important prey of many species, the ecological impacts of a potential fishery would need to be considered, and its availability to a potential fishery in eastern Tasmania is unreliable; *N. australis* almost disappeared from the region in 1989 (Young *et al.* 1993), an event linked to the intrusion of warm, low-nutrient, subtropical waters in the region (Johannes and Young 1999). S. Nicol (pers. comm.) considers that a fishery for krill in the Bonney Upwelling would, similarly, be an unrealistic proposition, because its ecological impacts would likely be unacceptable. *N. australis* was shown to be a vital part of the trophic system for a range of fish and seabird species, such as jack mackerel, tiger flathead and short-tailed shearwater (Johannes and Young 1999).

Key processes

Australian weather patterns between November/December and March/April result in wind induced coastal upwelling that brings cool, nutrient rich waters to the surface along the Bonney Coast (*sensu* Lewis 1981, Schahinger 1987, Gill 2002, Griffin *et al*. 2002 web page) (see Fig. 6). In connection to the cool, nutrient rich waters, an increase of phytoplankton abundance (represented by chlorophyll *a*) can be observed (Griffin *et al*. 2002 web page). This in turn attracts krill to form swarms (*sensu* Colman 2001), which attract among other species feeding Blue Whales (Gill 2002) (Fig. 9).

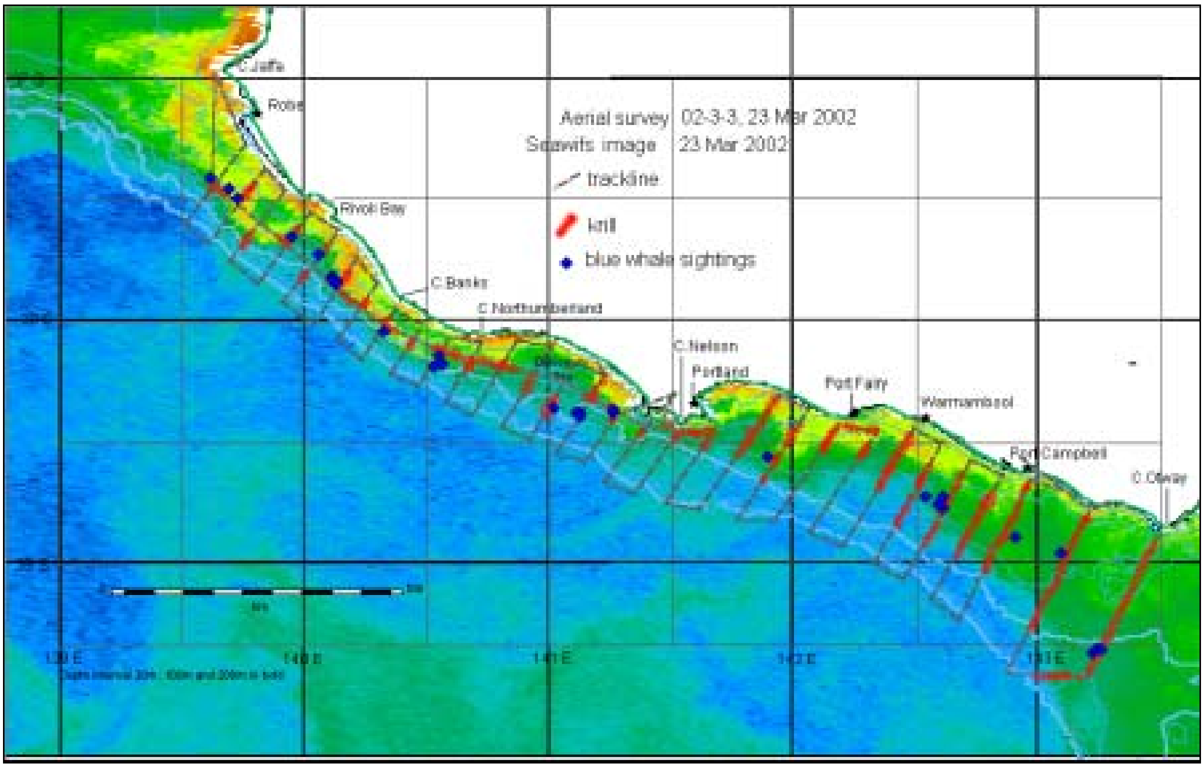


Fig. 9: Tracks of aerial surveys for blue whales in the Bonney Upwelling, March 2002. Sea surface colour indicates the area of enhanced surface chlorophyll. The track line is shown as a dashed line and diamonds indicate sightings of blue whales. Figure courtesy of P. Gill.

Discrete biological units within assessment area

Blue Whales have been sighted from, broadly, Robe to Cape Otway (Gill 2002). However, P. Gill (pers. comm.) points out that the limits of the Blue Whale feeding area along the Bonney Coast are not known because surveys could not be conducted more widely to the northwest and southeast. The upwelling does extend further to the northwest, (Figs. 6 and 9) and probably has a sub-surface expression to the southeast of the area of enhanced surface colour shown in Figure 9. However, none of the aforementioned gives any basis to identify discrete biological units within the assessment area. (Of course, the area is known to be heterogeneous – see sections above on Geomorphology, and Bioregionalisation – but this heterogeneity is not such as to distinguish discrete units within the context of the present Conservation Values Assessment.

Special locations

The comments above apply here; there is no basis for identifying special locations within this area.

MPA identification criteria

Representativeness

This area is considered special, rather than representative in the sense used by the ANZECC TFMPA (1999) in discussing the establishment of a Comprehensive, Adequate and Representative (CAR) system of MPAs for Australia. It was initially selected as an “iconic” area, because Blue Whales aggregate there. As such, although not selected as part of the CAR system, it remains representative of this iconic feature.

Comprehensiveness

This criterion is not applicable for the present assessment.

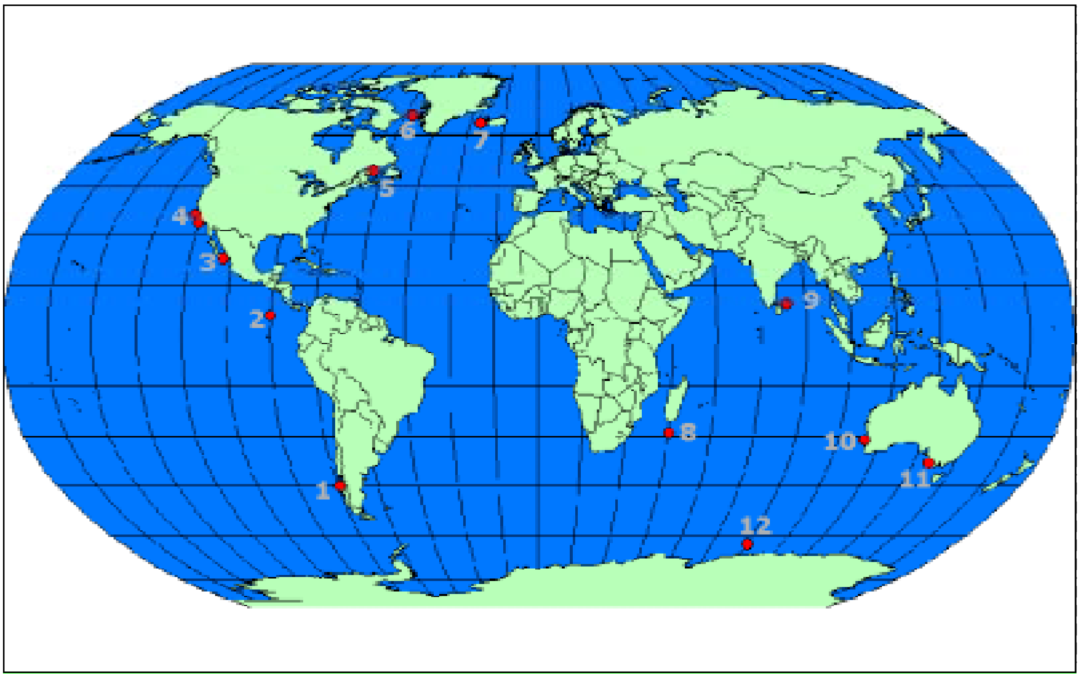
Ecological importance

Blue Whales are listed as an Endangered Species under the *EPBC Act* and are the subject of a forthcoming Recovery Plan under that Act. They are on the IUCN redlist as an endangered species. The Bonney Upwelling region is one of only 12 identified Blue Whale feeding sites that are recognised by whale experts worldwide (P. Gill pers. comm.). Although the region is not listed as ‘critical habitat’ under the *EPBC Act*, it is a recognised feeding ground of an endangered species.

Apart from its importance for Blue Whales, the area is significant as one of the largest and most predictable upwellings in southeastern Australia. This leads to other attributes such as its unique algal diversity (reported by Womersley 1984, Shepherd 1981, and others), and its productivity as a fishery. In addition to whales, many of endangered and listed species frequent the area (Appendix 4), possibly also relying on the abundance of krill that provides a food source to many seabirds and fish. The high productivity of the Bonney Upwelling is also capitalised on by other higher predator species such as little penguins (Collins *et al*. 1999) and Australian fur seals (Phillip Island Research Centre 2002) feeding on baitfish. In short, then, the area has ecological importance because it is a productive upwelling area on a coastline where such sites are relatively rare and mostly of smaller scale. Further details are given in the following section.

International or national importance

There are few identified, and internationally recognised Blue whale aggregation areas worldwide (P. Gill pers. comm., Fig. 10); the Bonney Coast is one of these.



1 – Chilean fjords	5 – St. Lawrence Estuary	9 – E coast Sri Lanka
2 – Costa Rica Dome	6 – Davies Strait, Greenland	10 – Swan Canyon
3 – Baja California	7 – SW Iceland	11 – Bonney Coast Upwelling
4 – California	8 – S of Madagascar	12 – Davis Sea, Antarctica

Fig. 10: Internationally recognised Blue Whale aggregation areas throughout the world. Figure courtesy of P. Gill.

Uniqueness

The upwelling on the Bonney Coast is a rare feature in the Great Australian Bight, which is generally characterised as a nutrient-poor region fed by the warm water of the Leeuwin Current (e.g. Hertzfeld 1997, Gill 2002). However, it is not the only area in southeast Australia where cool, deep waters well up near the coast. As mentioned above, Figure 6 shows cool water upwelling off Eyre Peninsula, Kangaroo Island, northwest Tasmania and Gippsland.

The areas of northwest Tasmania and Gippsland have also been associated with observations of Blue Whales (Mustoe in prep.). In particular, Mustoe (in prep.) noted an area of localised drop in sea surface temperature and increase in SeaWIFs chlorophyll *a* concentration between King Island and Tasmania in January 2002. This event was associated with a number of sightings of Blue Whales in the area of enhanced sea surface chlorophyll, some of which were observed to be feeding. The observers also noted extensive areas of krill between the margin of the continental shelf and the chain of small islands between the Hunter group and King Island. They consider that this represents a previously unknown feeding area for Blue Whales. However, R. McCauley (pers. comm.) comments that, in his experience, Blue Whales are very efficient at locating localised krill swarms. K. Ridgway (pers. comm.) notes that the mechanism for an upwelling at the northwest tip of Tasmania is likely to be similar to that producing the Bonney Coast upwelling, but at present it is not known how frequently or reliably such events occur. It is also possible that upwelling events in northwest Tasmania are directly linked to the Bonney upwelling; preliminary analysis of temperature logger data from the eastern part of the Blue Whale feeding area suggests that sub-surface upwelling connected to the Bonney upwelling may extend in a continuous band to northwest Tasmania (Gill in prep).

Notwithstanding these observations, the Bonney Coast upwelling is clearly a significant and predictable feature. With present data, it is not clear that the other areas of high productivity mentioned above are as predictable annually, or as sustained, as this feature. Its consistency through time is reflected in other observations associated with it, eg, the inter-tidal and shallow sub-tidal algal flora north and west of Cape Jaffa is a warmer-water flora, whereas south and east of Cape Jaffa is a colder-water flora that depends on the low temperatures and high nutrient concentrations present every summer in this area (Shepherd 1981, Womersley 1984). It has also been observed that, south of Cape Jaffa, the invertebrates have a high biomass, presumably due to nutrient enrichment from the upwelling, but relatively lower species diversity, presumably due to lower temperatures, than further north and northwest (K. Gowlett-Holmes pers. comm.). Boreen *et al.* (1993) describe the assemblages of sessile filter feeders such as bryozoans, sponges, and axoozanthellate corals, as rich and abundant particularly at the shelf edge and upper slope. They also mention a widespread proliferation of delicate cyclostome bryozoans on the deep shelf off Portland. Furthermore, the region sustains a rich and diverse fishery; local fishers comment that particularly good fishing is clearly related to the upwelling events.

On present evidence the Bonney Coast upwelling seems to be an especially large, important, and sustained oceanographic feature, which provides a highly productive feeding area for a many species including penguins (Collins *et al*. 1999;) and fur seals (Phillip Island Research Centre 2002). Furthermore, it is the only known and predictable large feeding area for Blue Whales in southeast Australia.

Productivity

The area is, because of the upwelling, one of particularly high productivity compared to surrounding southern Australian waters (see preceding section).

Vulnerability assessment

Due to their relatively small population size, which is a result of overexploitation in the past (Clapham *et al.* 1999), Blue Whales are vulnerable to various natural threats associated with small population sizes (Clapham *et al.* 1999), such as epidemics and disease outbreaks. Unfortunately, not enough is known about the biology or the population dynamics of Blue Whales to make a judgement on their natural vulnerability (Clapham *et al.* 1999). Other species may also be naturally vulnerable but are not the focus of this report and thus are not considered further. Vulnerability of the assessment area and the Blue whales to anthropogenic processes is discussed below.

Biogeographic importance

The Bonney Coast upwelling is the most prominent in southern Australian waters, occurring between November/December and March/April (Lewis 1981, Schahinger 1987). On present evidence, the Bonney Coast upwelling seems to be an especially large, important, and sustained oceanographic feature, which provides the only known large feeding area for Blue Whales in southern Australia, despite the observations of feeding whales in some smaller, less predictable upwellings (eg. Mustoe in prep.). Furthermore, the Bonney Upwelling region is described as part of the Maugean sub-province of the Flindersian province (Womersley and Edmonds 1958, Womersley 1984 and 1990). This sub-province is distinguished by its unique cool-temperate littoral fauna and flora. Thus, the upwelling area is biogeographically unique.

Naturalness

Humans have probably used the Bonney Coast since the arrival of man in southern Australia. Aborigines have inhabited and used the region long before the first contact with white men in the area (approx 1820), believed to have been whalers and sealers from Tasmania. By the mid 1840’s, whaling and sealing in the region had become an organised industry (N. Martin pers. comm.). It can be assumed that, alongside the whaling, commercial fishing was also practiced in the Bonney Upwelling since that time. Nowadays, the area is clearly a multiple-use system. It sustains a variety of fishing operations, as well as oil and gas exploration. Furthermore a major shipping lane intersects the feeding area (Gill 2002). Current human uses of the area are detailed below.

Current and potential uses and existing management regimes

Information on current uses has been obtained from data compiled for the NOO as part of the SE RMP process, in particular from the publication by Larcombe *et al.* (2002) and from current development of data layers for the NOO spatial database. Maps from the latter project have been provided by V. Lyne and his team (pers. comm.), with the approval of the NOO.

Fisheries

With the exception of Portland, the Bonney Cost only has fishing/recreational ports (Fig. 11). The main fishing industries are rock lobster and trawl, followed by squid and dropline fisheries. In Appendix 5, we list the main species caught by the various fisheries. The catch rates of rock lobster are highest between Robe and Portland, dropping off to the south and southeast (Fig. 12). The commonwealth trawl fishery is most intense on the shelf edge, in particular off Portland (Fig. 13). Squid jigging effort on the other hand is most intense off the Warnambool coast (Fig. 14). The dropline and bottom longline fisheries appear to be more localised with intensive effort off Robe, outside Port MacDonnell and on the shelf off Portland (Fig. 15). Gillnetting (Commonwealth fishery) is mainly practiced at the edge of our focus area, that is, north of Robe in Discovery Bay and in Bass Strait (Fig. 16). Finally, the Tasmanian and Victorian Giant Crab fisheries show the highest catch rates in Bass Strait and off the Tasmanian coast, and on the shelf off Portland (Fig. 17). In addition to these Fisheries, an effort of approx 5.4 person days/km^{-2} year^{-1} is invested in the South Australian scalefish fishery, which targets a wide variety of species (Appendix 5) using a variety of gears (Larcombe *et al*. 2002).

The Southern and Eastern scalefish and Shark Fishery (SESSF), which incorporates the south-east trawl, southeast nontrawl, southern shark and Great Australian Bight Fisheries, is currently being strategically assessed under the *EPBC Act*. The assessment will consider, among other things, the impact of the fishery on protected species (including Blue whales) (H Sullivan pers. comm.).

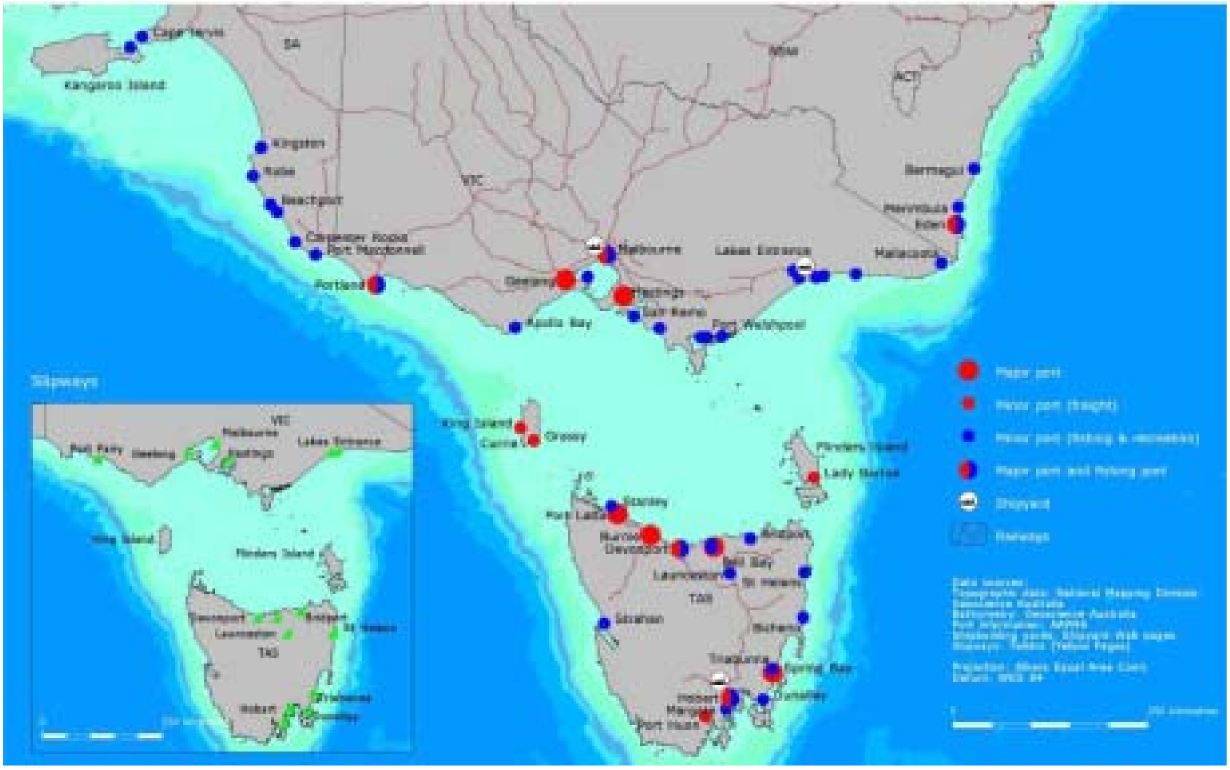


Fig. 11: Major and minor ports, slipways and shipyards in the South-east Marine Region. Reproduction of Map 71 from Larcombe *et al.* (2002).

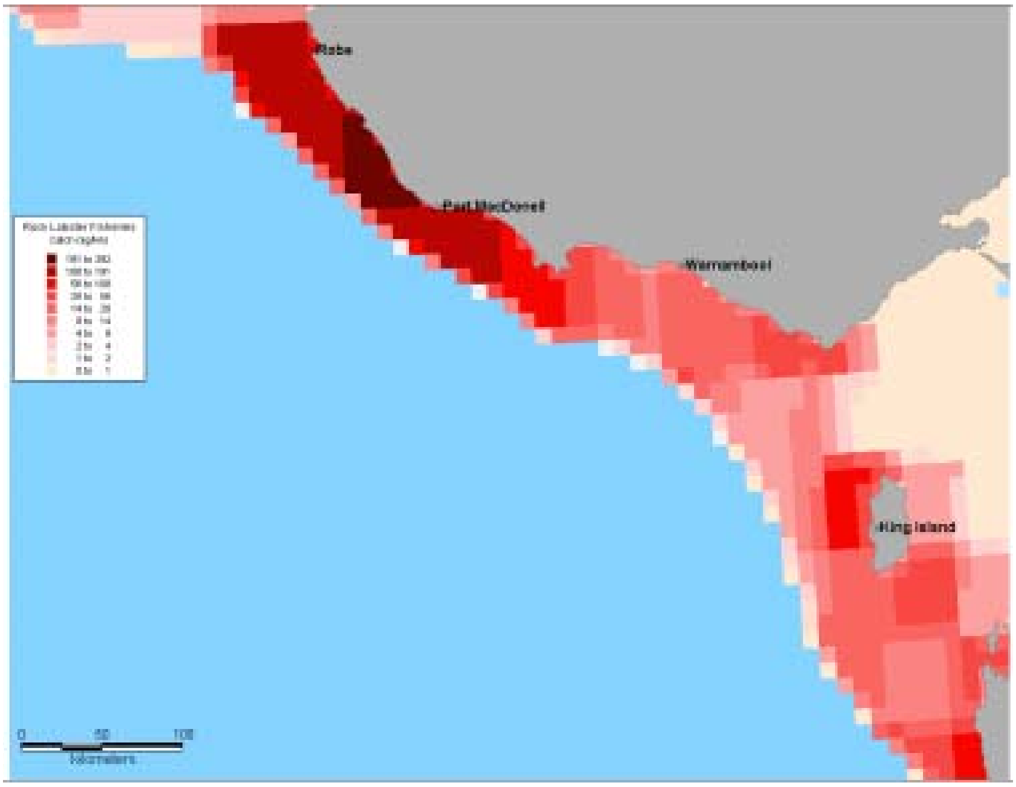


Fig. 12: Catch rate (kg/km) of the combined State Rock Lobster Fisheries in the Bonney Coast, 1995-1999. Cell sizes of reporting: SA: 30-100 km, Vic: 10', Tas: 1°; cells with less than 5 boats from Vic were masked (light grey). Respective State Fisheries data, BRS supplied.

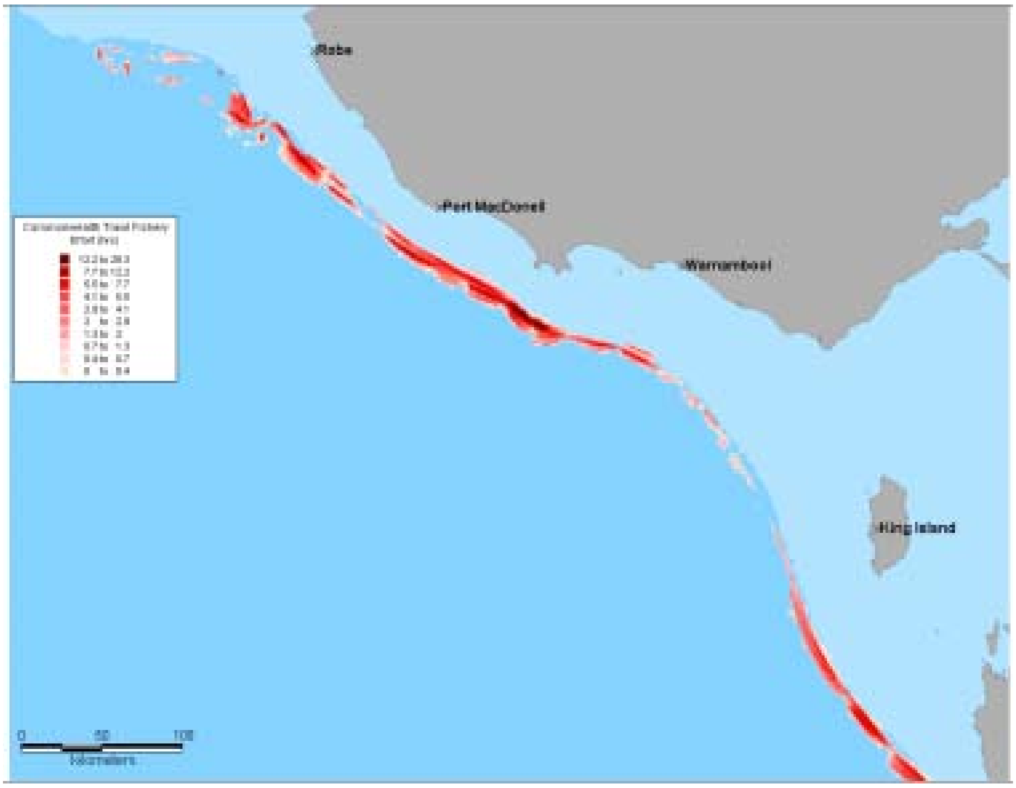


Fig. 13: Fishing effort (hrs) of the South-east Trawl Fishery in the Bonney Coast, 1995-1999. Cell size 1 km, cells with less than 5 boats excluded. AFMA data, BRS supplied.

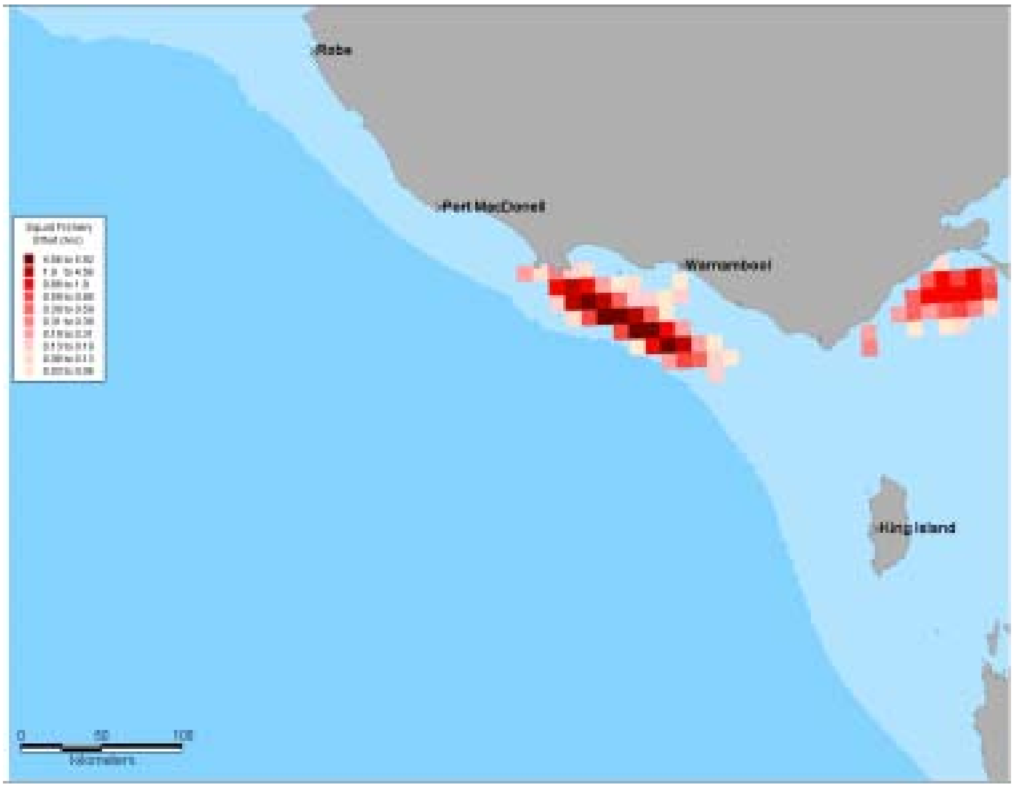


Fig. 14: Effort of the Commonwealth Squid jig Fishery in the Bonney Coast, 1995-1999. Cell size 10 km, cells with less than 5 boats excluded. AFMA data, BRS supplied.

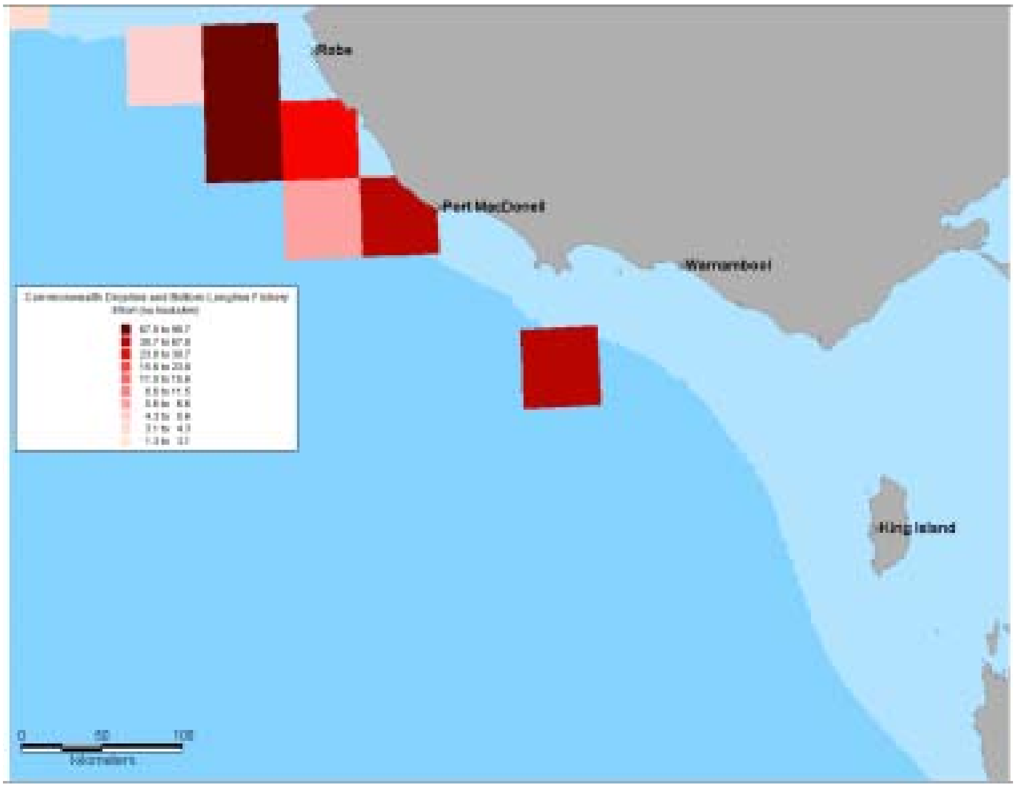


Fig. 15: Fishing effort (number of hooks per km) of the commonwealth dropline and bottom longline fisheries in the Bonney Upwelling, 1997-1999. Cell size 50 km, cells with less than 5 boats excluded. AFMA data, BRS supplied.

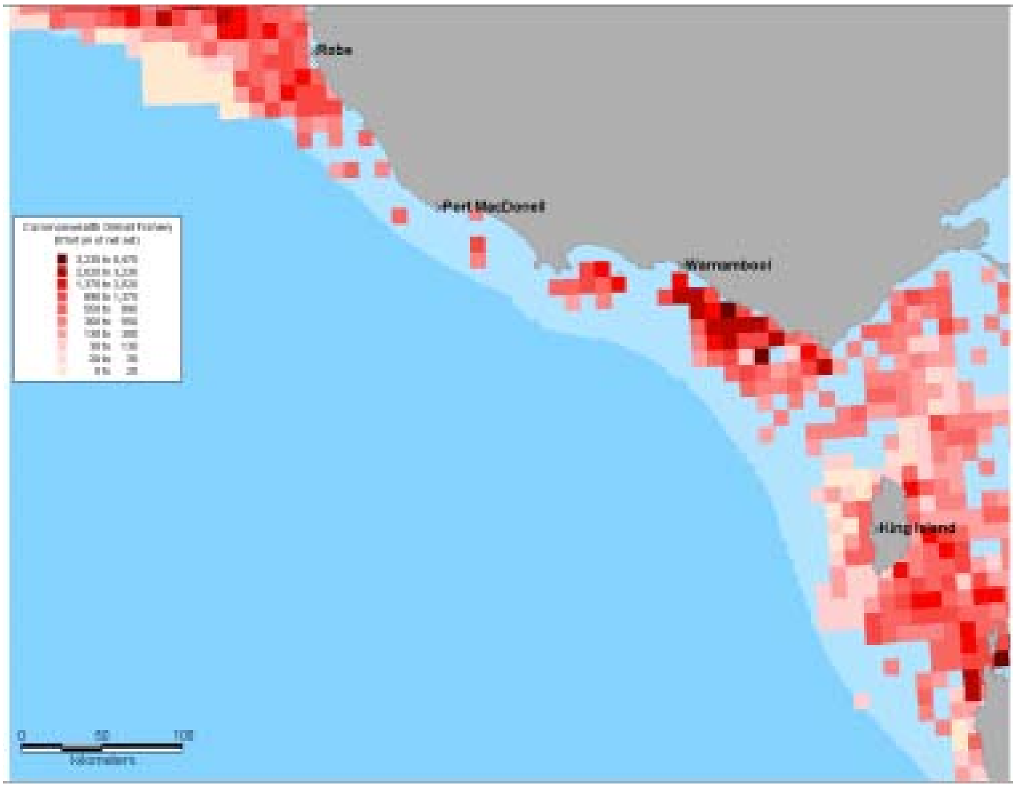


Fig. 16: Fishing effort (m of net set) of the Commonwealth Gillnet Fishery in the Bonney Coast, 1997-1999. Cell size 10 km, cells with less than 5 boats excluded. AFMA data, BRS supplied.

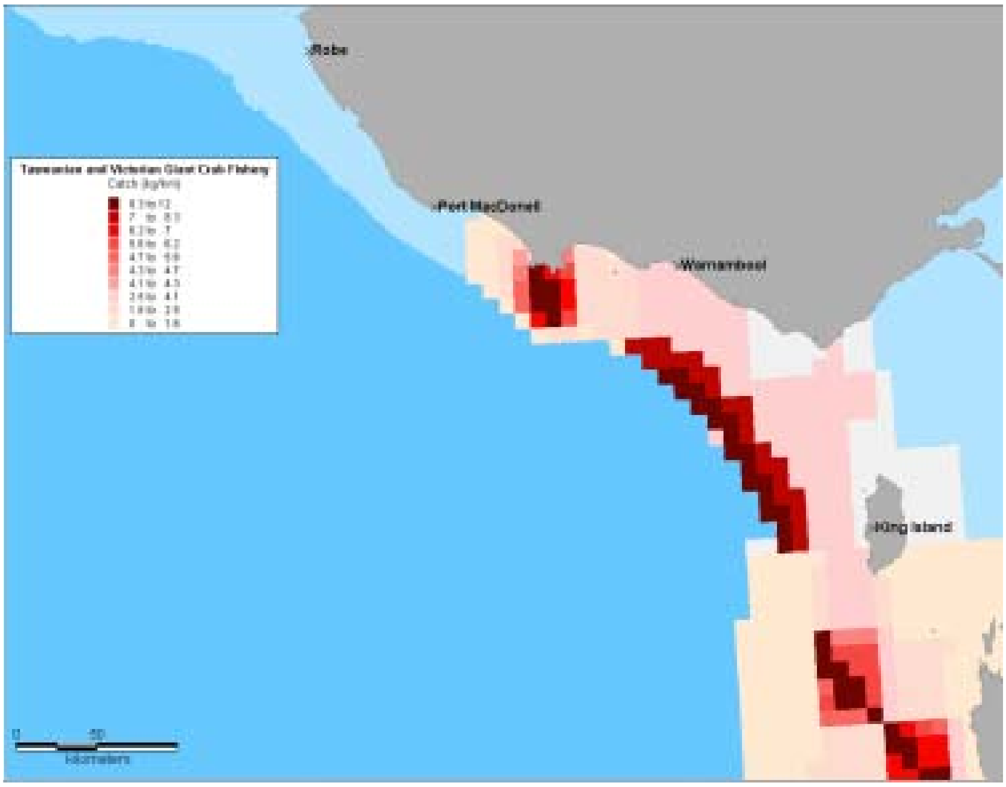


Fig. 17: Catch rate (kg/km) of the Tasmanian and Victorian giant crab fisheries in the Bonney Upwelling, 1995-1999. Cell size 10 km, cells with less than 5 boats in Victoria masked light grey. State Fisheries data, BRS supplied.

Minerals and petroleum

There are significant known gas reserves present in the Bonney Upwelling area, several of which are being assessed for commercial feasibility. Most of the Otway Basin, which coincides with the Bonney Coast, is under acreage release. In particular, some new areas off Portland, overlying the shelf edge have been only recently added to the acreage release (Fig. 18). 2D seismic has been carried out over large portions of the upwelling area (Fig. 18). A CD-ROM released by the Department of Industry, Science and Resources (2002) describes the new acreage releases including the geology and data availability on any wells in the vicinity.
Fig. 19a and b show 30 offshore exploration wells in the northern and central Otway Basin. Of these16 are dry and 14 are identified as gas wells, 7 of which are marked as ‘strong gas show’. Woodside reports combined gas reserves of 0.8 tcf in Thylacine and Geographe, two exploration wells (Fig. 19b); these discoveries were made in 2001 in the offshore Otway Basin (GA 2002). Currently, bids are being received (closing April 2003) for three areas in the western Otway Basin in South Australia, one in Victorian waters adjacent to recent petroleum discoveries at Thylacine and Geographe in the central part of the basin, and two in Tasmanian waters south of these discoveries (GA 2002).

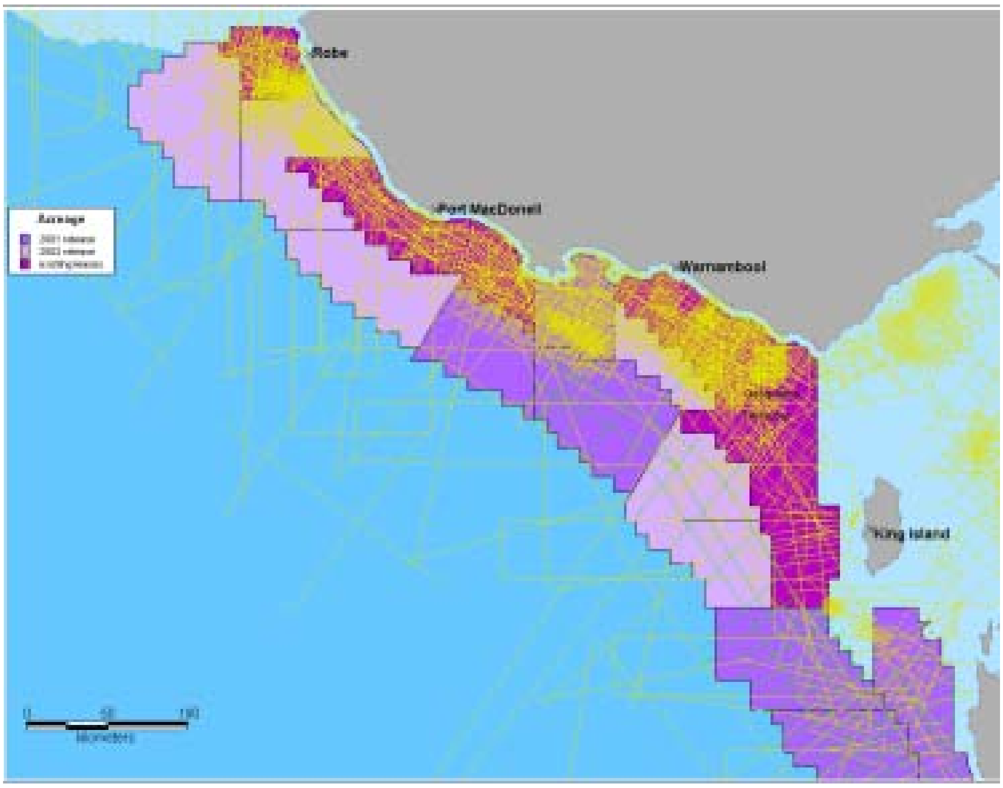


Fig. 18: Seismic surveys conducted in Otway Basin (yellow: 2D, green 3D), overlaying the acreage releases. Data supplied by GA

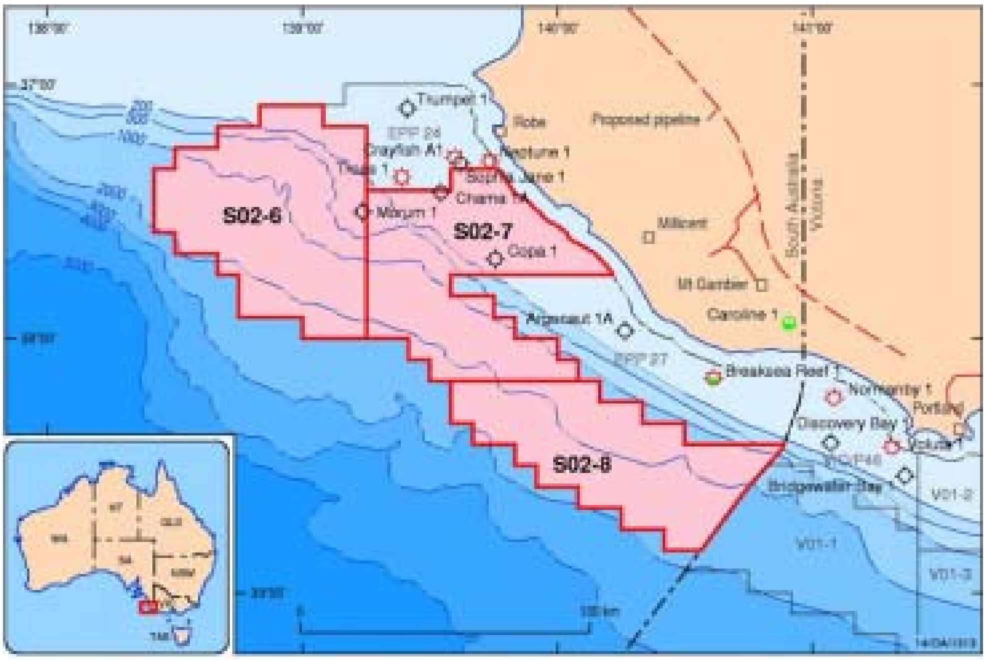


Fig 19a: Exploration wells in the northern Otway Basin identifying the 2002 release areas S02-6 to 8. Well symbols: please refer to the legend in Fig 18b. Reproduction of Figure 1 from ', Otway release areas S02-6 to 8' in Department of Industry Science and Resources (2002)

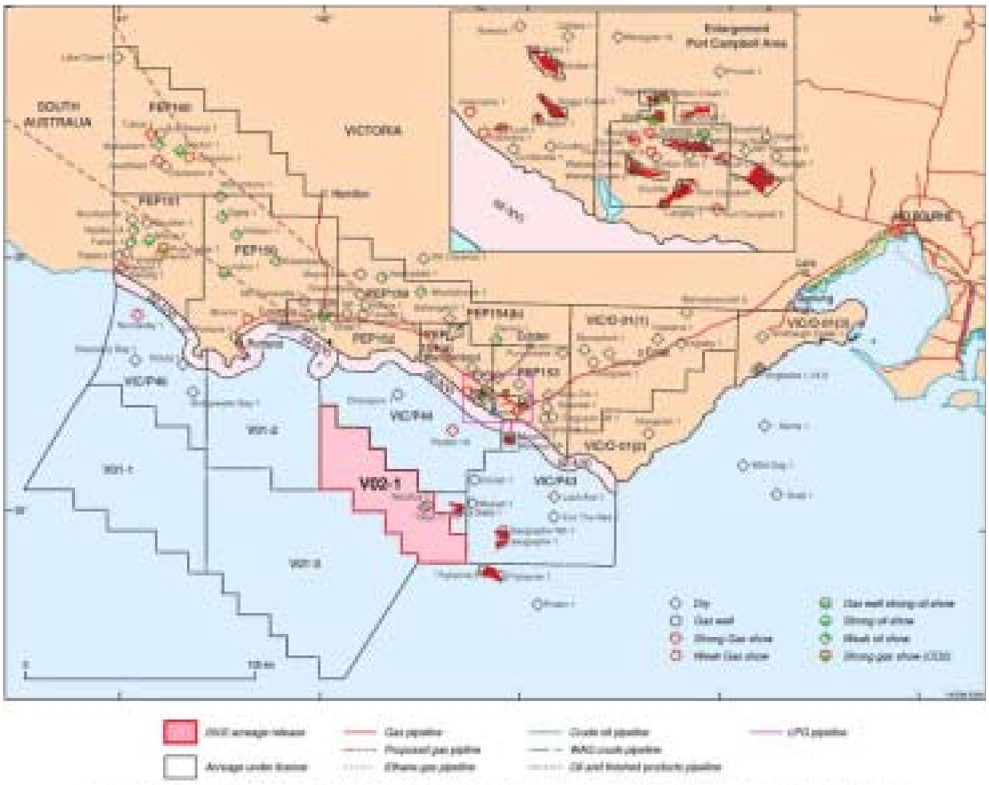


Fig. 19b: Exploration wells in the central Otway Basin identifying the 2002 release area V02-1. Reproduction of Figure 2 from 'Otway release area V02-1, in Department of Industry Science and Resources (2002).

Tourism and recreation

Only few charter operators are currently located on the Bonney Cost. They operate out of Portland, Port Fairy, Warnambool, Port Campbell and Apollo Bay (Larcombe *et al.* 2002).

There are currently no whale watching based tourism activities, however, considering the regularity with which whales visit this coast and the fact that these giants of the sea do come relatively close to shore, there is a potential for whale-watching tours to develop along the Bonney Coast.

The routes of two yacht races, Melbourne to Port Fairy, and Melbourne to Adelaide, lead along the Bonney Coast (Larcombe *et al.* 2002).

Maritime transport

A major shipping lane intersects the Blue Whale feeding area. Figure 20 summarises the traffic volumes passing through the region between 1999 and 2000: 500-1,000 vessels travelled along the coast to/from ports in the gulf of St Vincent, and more than 1,000 vessels travelled off shore (off the shelf) to/from west coast ports and international ports (Larcombe *et al.* 2002).

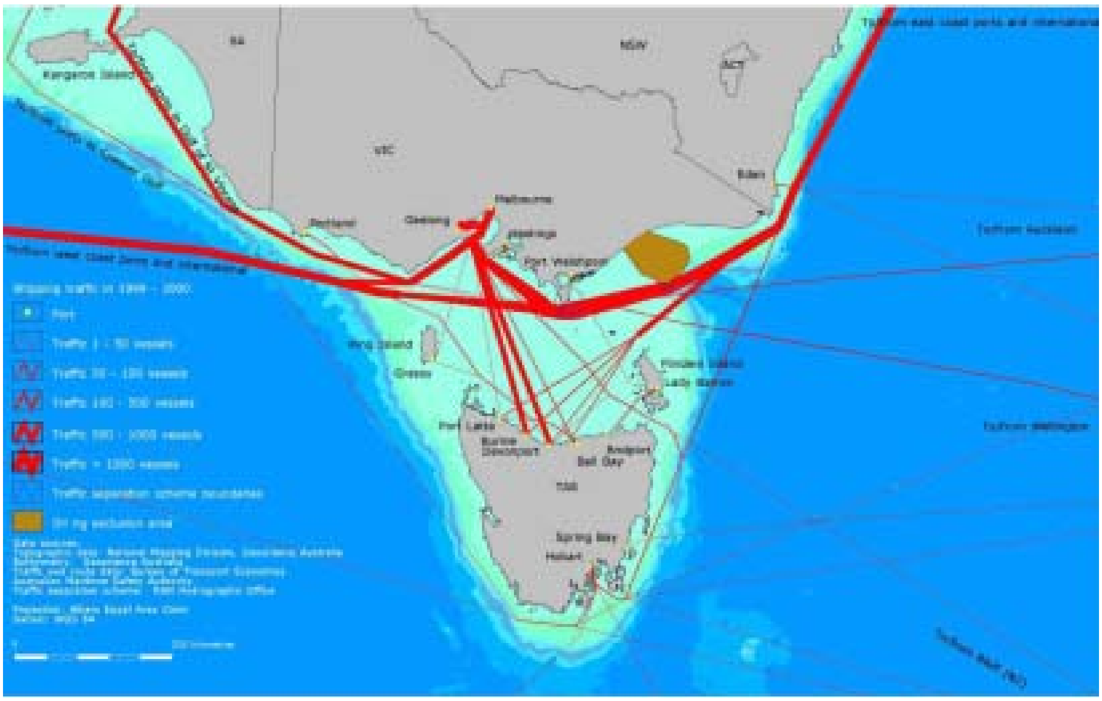


Fig. 20: Shipping routes and traffic volumes (1999-2000) in the South-east Marine Region. Reproduction of Map 69 from Larcombe *et al.* (2002).

Indigenous interests / values

Neil Martin (pers. comm.), indigenous representative at the workshop, reports that there is a close connection of the coastal aboriginal clans with the ocean through stories/dreaming tracks and traditional use. Very little of the stories and tradition of the local aborigines were recorded but, what was recorded of their language, indicates there was a connection to whales. They had a word for whale flesh both fresh and putrid (suggesting they ate whales – either hunted or beached). Description of a massacre in the region over a whale carcass indicates that the indigenous people felt strong ownership of the washed up whale ('Convincing Ground Massacre'). There is an area under application for identification as registered native title extending over the entire shelf from the South Australian border to west of Port Fairy (Larcombe *et al.* 2002), and an area under an indigenous land use agreement near Port Campbell.

Legislation / management arrangements

The Commonwealth legislation that affects how we use and protect our oceans in the South-east Marine Region is described in NOO (2002f). The management framework of our oceans has arisen historically from sectoral planning and is thus characterised by a multiplicity of legislation — more than 100 pieces of Commonwealth legislation apply to ocean use and ecosystem health (NOO 2002f). In their report the NOO (2002f) have subdivided the sectors into 8 chapters titled: overarching legislative framework of marine regulation in Australia; shipping and related activities; indigenous interests; maritime security; environment protection; living marine resources; seabed and subsoil activities; and tourism and recreation.

The focal point for the present assessment is the chapter on legislation regarding environmental protection, in particular, legislation aimed at biodiversity issues. In Commonwealth waters, these are addressed in the *Environment Protection and Biodiversity Conservation Act* 1999 (*EPBC Act* 1999). It makes provisions for environmental impact assessment and strategic environmental assessment. In relation to biodiversity conservation, it provides protection for nationally threatened native species, internationally protected migratory species, cetaceans and other marine species and protected areas. Thus, proposed actions that are likely to have a significant impact upon listed threatened native species or ecological communities are subject to environmental impact assessment and approval processes (NOO 2002f). Although not a legislative instrument, *The Commonwealth Guidelines for the Ecological Sustainable Management of Fisheries* (EA 2001b) play an important role in the assessment of fisheries under the *EPBC Act*. The Blue Whale is an endangered, an internationally protected, listed migratory, and a listed threatened species; thus, the *EPBC Act* controls any action that may significantly affect it or its habitat.

Pollution control — including dumping of waste at sea, and shipping and oil related pollution — does not fall under the *EPBC Act* (1999) but is regulated under various part of the *Protection of the Sea Acts 1981 and 1983* (NOO 2002f).

Detailed legislative provisions related to petroleum exploration activities and fisheries are described in the NOO (2002f) report, under the titles ‘seabed and subsoil activities’ and ‘living marine resources’, respectively.

Fisheries management is divided between the Commonwealth and the States, although some fisheries are managed under joint authority arrangements (NOO 2002f). The management of Commonwealth fisheries is administered by the Australian Fisheries Management Authority (AFMA). The Fisheries branch of AFMA is responsible for the Bass Strait Central Zone Scallop; Southern Squid jig, South-east Trawl; Southern Shark and South East Non-Trawl Fisheries, and others not relevant here. The Rock Lobster, Gillnet and Giant Crab fisheries are administered by the respective state fisheries of South Australia, Victoria and Tasmania.

Australia has played a leading role in the major international forum regulating human impacts on cetaceans – the International Whaling Commission — and is active in conservation initiatives on other relevant bodies (e.g. CITES, CMS and CCAMLR) (Bannister *et al.* 1996). On a national basis, the Whale Protection Act (1980) represented the main legislation concerned with whales; it prohibited killing, injuring, taking, capturing or interfering with cetaceans, and applied to all persons, vessels and aircraft in Australian waters (Bannister *et al.* 1996). It was repealed when the *EPBC Act* gained assent; this Act now contains these provisions.

At the workshop, representatives of the petroleum industry voiced the opinion that the legislation already in place in Australia forms a strong basis for the protection of whales.

Scientific / educational value

As Gill (2002) and others have noted, this area presents a rare opportunity to increase scientific knowledge of Blue Whale biology and ecology and that of their prey, given the relative accessibility of the feeding area coupled with the scarcity of known feeding grounds. The area also has high educational/scientific value for the other biological features mentioned above (eg high diversity, endemicity, and productivity).

Current and potential impacts on natural values

The NOO report titled 'Impacts – identifying disturbances' (NOO 2002e), identifies broad categories of disturbance used to define impacts, as well as broad categories of sources of disturbance to the South-east Marine Region. Due to the focus of the present assessment, we decided to be more specific in the identification of disturbances, concentrating on threats to the Blue Whales, which are the primary reason for the assessment, although the Bonney Upwelling is an area used by many other species, that similarly depend on the nutrient rich, cool upwelling waters and that may be susceptible to different threats.

Bannister *et al.* (1996) point out that none of the cetacean species listed as part of Australia's marine fauna are exclusively Australian. Also, while some threatening processes are localised and generally only affect species which live in, or seasonally visit, a particular region, others are ocean wide, or even global in scale, and have the potential to affect many species, no matter where they occur. The assessment area considered here is a feeding place for Blue Whales, which are listed as an Endangered Species, and are the subject of a forthcoming Recovery Plan under the *EPBC Act*. However, the Bonney Upwelling forms only a small part of the range of these mammals. As mentioned earlier, there are large gaps in our knowledge of the range, migration routes and population structure of these whales. Thus, in this part of the assessment we will only be able to summarise the literature on threats to whales in general and relate these to the current and potentially developing human activities in the Bonney Upwelling.

Threats to large cetaceans are manyfold and range from hunting, to global warming, and climate change. In the action plan for Australian cetaceans, Bannister *et al.* (1996) provide a summary of processes threatening cetaceans. They divide threats to cetaceans into three broad, although not mutually exclusive, categories: direct (direct killing, entanglement and shipping strikes); intermediate (competition from commercial fisheries, oil spills, disturbance and harassment, degradation of habitat and exposure to infectious human disease organisms); and long-term (contamination of the marine environment by chemical pollutants or plastic debris, other contaminations leading to mass mortality, reduced genetic variation in depleted populations, re-start of commercial whaling and global climate change). Simmonds and Hutchinson (1996) provide a comprehensive account of the conservation status of many species of cetaceans, also listing all current threats. More recently, Clapham *et al.* (1999) presented an excellent summary of conservation issues regarding baleen whales. They outline and describe the main threats: entanglement and fisheries issues, ship strikes, whaling, pollution and disease, and habitat degradation. During the workshop held by EA, M. Prideaux from the Whale and Dolphin Conservation Society (WDCS) and R. Brand from the Humane Society International (HIS) identified threats to Blue Whales. With the exception of 'our lack of knowledge', no different sources of threats from the ones described in the literature summarised above were identified. However, some were emphasised as particular concerns relating to the Bonney Upwelling. In particular, Bannister *et al.*'s (1996) threat of disturbance and harassment was clearly separated into noise/acoustic pollution and harassment through whale watching and/or research activities. Considering both the literature and the emphasis implied in the workshop we compiled the following list (ordered alphabetically) of potential, human-induced threats to whales visiting the Bonney Upwelling:

- Chemical pollution (acute) — localised, immediate pollution event (e.g. oil spill)
- Chemical pollution (diffuse) — human induced change in chemical composition and/or introduction of chemical pollutants that are not related to a localised event
- Climate change — habitat degradation (changes to upwelling); reduction/loss of prey
- Collision with vessels
- Commercial whaling — illegal whaling and resuming commercial whaling
- Competition for resources — humans exploiting resources (excluding space) that whales use (e.g. development of a krill fishery)
- Displacement due to large fixed structures
- Gear entanglement — interaction of whales with gear deployed in the marine environment
- Harassment — targeted searching for and following of individual cetaceans
- Marine debris — discarded / lost debris such as plastics, ropes, etc.
- Noise pollution (background) — consistent/continual noise resulting from human activities (e.g. engine noise of shipping)
- Noise pollution (short-term, localised) — noise resulting from human activities that only occur intermittently and that can be regulated in respect to time and to some extent place where they occur (e.g. sub-marine detonations; seismic surveys).

In addition to these threats, direct threats affecting the krill, such as introduced disease or increasing numbers of natural predators, and activities that affect the swarming behaviour of krill, thus reducing the whale's ability to feed efficiently, should be mentioned here as these could indirectly affect the whales.

The human uses of the Bonney Upwelling are described above. It was pointed out at the workshop that many of the threatening processes identified can not be directly associated with activities in the Bonney Upwelling; for example, diffuse pollutants or marine debris may originate in the Bonney region or may be brought into the area with ocean currents. Further, the point was made that, despite the potential occurrence of interactions such as gear entanglement and collisions, none have been reported in the Bonney Upwelling. In the following pages we give a more detailed account of the interactions that potentially threaten Blue Whales, including references.

Chemical pollution

We subdivided this category into acute/localised and diffuse. The obvious example of the former is chemical or oil spills resulting from accidents, and potentially from ruptured pipelines or dumping of chemicals in unsafe containers. We are not aware of any such incidents in the Bonney Upwelling. The Bureau of Transport and Communications Economics (BTCE) estimated the probability of a major spill (>1,370 t) occurring in Australia in 1991 to be 49% in the next 5 years, 84% in the next 20 years. The bureau identified the region between Brisbane and Adelaide as generally high risk, with Bass Strait and the Great Barrier Reef being areas of particular concern (Bannister *et al.* 1996). Thus the specific region of the Bonney Coast was not identified as a high-risk area for a major spill. P Gill (pers. comm.) reports that bilge pumping can also leave oil on the sea-surface, thus potentially causing a threat to feeding whales.

Volkman *et al.* (1994), caution that direct information on oil impacts for marine mammals remains limited. They relate potential effects of oil on marine mammals to direct surface fouling; direct and indirect ingestion with the effects of bioaccumulation; and inhalation of the toxic vapours released from the petroleum hydrocarbons as they evaporate. Geraci (1990) adds irritation of eyes and skin and the abandonment of polluted feeding habitats to that list. Geraci (1990) and Loughlin (1994) both report that although data on effects of oil on cetaceans are inconclusive, large baleen whales appear to be unaffected by oil *per se*. Bannister *et al.* (1996), however, mention that if oil adheres to baleen plates of mysticete whales, it may interfere with feeding. While in some instances cetaceans seem to be able to detect and avoid an oil slick, in others, the animals have been observed swimming through the oil or continuing to feed (Sorensen *et al.* 1984, Bannister *et al.* 1996). The surface feeding habit of Blue Whales in the Bonney Upwelling may result in a particular risk for this species in the event of an oil spill (P. Gill pers. comm.).

Diffuse chemical pollution ranges from routine discharges of oil and other hydrocarbons from shipping, to eutrophication of coastal zones through sewerage, and to persistent ocean contaminants, particularly as organochlorines, including many compounds that originated as pesticides or industrial chemicals (O'Shea *et al.* 1999). The possible effect of hydrocarbons on marine mammals is outlined above. Eutrophication of the coastal zone may lead to increased blooms of toxic algae, which have been known to cause mortalities in cetaceans, and organochlorines have immunosuppressive effects on marine mammals (O'Shea *et al.* (1999). However, O'Shea and Brownell (1994) concluded that there was no evidence for significant contaminant-related problems in baleen whales, due to their relatively low trophic level. Unlike the case for some dolphins and pinnipeds, there have been no recorded epizooics in baleen whales (Clapham *et al.* 1999).

Bannister *et al.* (1996) provide a good summary of the reasons why marine mammals are particularly vulnerable to the long-term toxic effects of chemical pollutants.

Climate change

The trend of increasing levels of greenhouse gases (CO_2, CH_4, and N_2O) in the atmosphere is attributed largely to human activities such as use of fossil fuels, land-use changes, and agriculture (Houghton *et al.* 1995). The resulting global warming and climate change will almost certainly affect marine biota directly and indirectly (Denman *et al.* 1995). However the magnitude and type of effect is uncertain. Global warming could result in lowered carrying capacity of certain environments, which may lead to declines in marine mammal populations (*sensu* Schnell 2000), or alternatively lead to increased phytoplankton growth and fisheries yield (*sensu* Rysgaard 1999).

Findings of unpublished studies by CSIRO Atmospheric Research (K. McInnes pers. comm.) do not give any clear indication of the effects of an increase in atmospheric CO_2 on the Bonney Coast upwelling but they do give sufficient reason to consider that some change in the upwelling, either in its strength or its frequency, is not inconceivable under reasonable climate change scenarios.

Collision with vessels

The problem caused by shipping includes small recreational craft as well as large cargo ships, fishing boats, and potentially fast, highly manoeuvrable, naval vessels (Bannister *et al.* 1996). For large whales, the large, fast commercial-vessels, such as container ships, are a particular threat (Clapham *et al*. 1999). It appears that even fast-moving ships project little noise ahead of them, thus giving relatively little warning to any cetaceans on collision course (P. Gill pers. comm.). Collisions with large vessels are invariably fatal (Clapham *et al.* 1999), either directly killing the animal or inflicting major injuries that eventually lead to death (Bannister *et al*. 1996); smaller crafts are more likely only to injure large whales, although these injuries may cause decreased fitness of the animal or even death. Clapham *et al.* (1999) identify slow species that spend much of their time at the surface as the most vulnerable, particularly if they utilise habitats in the vicinity of major shipping lanes. Although Blue Whales are considered to be among the fastest of the whales, they do spend a considerable amount of time on the surface, particularly when feeding on surface swarms of krill.

In the area of the Bonney Upwelling we could not find any records reporting collisions of ships with Blue Whales, or any other cetaceans, although important transport routes traverse the area (Fig. 20) and there is substantial fishing in the area (see 'current and potential uses'). However, unpublished data from EA (S. Powell pers. comm.) shows that between 1950 and 1989, 82 cetacean strandings were recorded in the general area of Bonney Coast. In 38 cases, the condition of the stranded animal was recorded —12 of these showed lacerations and/or fractures rendering collision as the possible cause of the stranding. It is uncertain when and where these animals were wounded although, in two cases at least, the animals, though dead, were still bleeding. Of all these strandings only two were identified as Blue Whales and neither of those had signs of collisions noted (S. Powell pers. comm.). Nevertheless, in view of anticipated future increases in whale numbers, as the species recovers, as well as potential increases of commercial and other shipping traffic, there will be a need for a risk assessment.

Commercial whaling

The detrimental effects on Blue Whales of any whaling activities is obvious, whether legal or illegal commercial fishery, indigenous customary fishery, or for research. It is unlikely that any legal whaling will resume in Australian waters, but whaling elsewhere within the range of this highly migratory species could negate any good we do for the species by protecting one of its feeding areas.

Competition for resources

If a krill fishery were to develop in the Bonney Upwelling, targeting *N. australis,* humans would directly compete with Blue Whales for this resource. Studies have shown that *N. australis* would be a possible candidate for commercial exploitation, to supply feed for aquaculture (Johannes and Young 1999). The Bonney Upwelling supplies predictable large numbers of coastal krill, in contrast to the unreliability of these krill in eastern Tasmanian waters where the assessment of Johannes and Young (1999) was done. However, S. Nicol (pers. comm.) speculates that it is unlikely that a krill fishery will develop in Australian Commonwealth waters. He proposes that too many bureaucratic hurdles need to be overcome. In other regions proposed krill fisheries found in general great opposition (e.g. ASF 1998; Ellis 2000; PCFFA 2000). Both considerations make the effort involved to establish a krill fishery unprofitable, given that it would, in any case, be a small one by world standards. The fact that the Bonney Upwelling is recognised as a Blue Whale feeding ground would preclude it from even being considered as a krill fishing region; even if that were not the case, competition with other fisheries (whose target species may feed on krill) would be a serious concern.

Displacement due to large structures

It has been suggested that large structures such as oilrigs, or wave power generation plants, may interfere with the usual migration path used by whales. However, it is unlikely that the presence of a stationary structure, truly affects a creature of the dimensions of a Blue Whale unless the structure is extremely extensive or has some other effect (e.g. noise, chemical pollution) considered under other headings below.

Gear entanglement

Entanglement in fishing gear is a major source of non-natural mortality in cetaceans (Clapham *et al.* 1999). Although large whales often manage to drag fishing gear away with them, serious entanglement may reduce the animal's ability to feed (Clapham *et al.* 1999), or it may cause injuries that become infected. Drift and gill nets are the most dangerous to cetaceans (Clapham *et al*. 1999). However, Hofman (1990) and Clapham *et al.* (1999) report that cetaceans appear to be caught incidentally by most, if not all, fisheries that occur in areas where cetaceans occur. There is evidence, for example, of cetaceans being caught and killed in purse-seine, trawl, set-net, drift-net, trap, weir and hook-and-line fisheries. Bannister *et al.* (1996) report that buoy-lines of pots occasionally entangle large species such as Southern Right and Sperm Whales and D. Coughran (P. Gill pers. comm.) noted Humpback Whales as the most common species entangled in pot-lines off Western Australia. Given this, it is feasible that any gear involving buoy-lines deployed from ships may cause a threat to cetaceans.

On the Bonney Coast the main fishing industries are rock lobster and trawl, followed by squid and dropline fisheries. These are low risk fishing practices in regard to whale bycatch (*sensu* Hofman 1990). In fact, gillnetting may be the only fishing method used in the region that is a possible cause for concern. At the workshop, representatives of the fishing industry stated that they had no knowledge of any incidents where Blue Whales were entangled in fishing gears in the Bonney Upwelling region; and they know of no other negative interaction between fishing activities and whales.

Harassment

There is little doubt that large-scale unregulated whale watching, involving numerous boats circling and pursuing a whale, will temporarily disrupt behaviours such as courtship and nursing. The impact of such harassment on the reproductive success of individuals is unknown

(Clapham *et al.* 1999). Whale watching tourism is likely to develop, given the predictability of the Blue Whales in the Bonney Upwelling region, coupled with their coming relatively close inshore. However, Gill (2001) suggests that a whale watching industry using small planes is more likely to develop than a vessel based industry, given the unpredictable, often rough and windy Southern Ocean environment. This would probably be less disturbing for the whales (Gill 2001). Similarly, research into these giants is likely to capitalise on these characteristics of the whale/region interaction. There are guidelines in Australia, regulating the interactions of boats and aircraft with individual whales (EA 2000b). These were designed to minimise the harassment any individual whale is exposed to. As long as these rules are obeyed and enforced, Blue Whales should not become excessively stressed through harassment.

Marine debris

Plastics, rubbish, and lost fishing gear are all included under the title marine debris. While the former may be ingested and cause blockages in the digestive system of cetaceans, the latter is dangerous as it potentially continues fishing indefinitely (Goni 1998), thus posing a threat through entanglement similar to fishing gear in use.

Obviously, lost fishing gear stems from the fisheries; plastics and other rubbish may come from any human activity in, on, or near the water, as well as from stormwater drains.

Noise pollution

Underwater sound is created by many activities worldwide and there is general agreement that man-made noise in the ocean is increasing (McCarthy 2000). Holmes (1997) reports that, as traffic has increased over the past 30 years, background noise levels in the deep ocean have risen significantly in the busier waters of the northern hemisphere. Ocean sounds can be separated into sounds from physical and biological sources, natural to the marine habitat, and introduced, man-made sounds. Natural sources of underwater noise include wind, sea state and swell, rain, as well as fish choruses and whale calls (McCauley and Duncan 2001). Man-made noise may be caused by shipping and small vessel traffic, active drilling rigs, and petroleum seismic-surveys (McCarthy 2000, McCauley and Duncan 2001). Additionally, the use of sonar and other acoustic equipment in naval operations, scientific research, fishing and aquaculture, also contribute to noise levels in the ocean (*sensu* McCarthy 2000). The general rise in anthropogenic sound in the ocean has generated concern that it is affecting marine mammal behaviour and could affect humans as well. Controversy over underwater sound and its effects on marine mammals has generated much discussion within the marine community (McCarthy 2000).

The noise from different human activities effects marine mammals, particularly their behaviour These effects are the subject of many papers and reports (e.g. McCauley 1994, Richardson *et al.* 1995, Holmes 1997, Dolman 1998, Frankel and Clark 1998, Au and Green 2000, Croll *et al.* 2001, McCauley and Duncan 2001, Simmonds 2002), although McCauley and Duncan (2001) point out that there are fewer real studies than reviews, and that the largest base of articles are reviews of reviews, letters and uninformed comments and literature based on both of these. The most comprehensive review of the effects of noise on marine mammals is Richardson *et al.* (1995).

Locally, McCauley and Duncan (2001), commissioned by Ecos Consulting for Woodside Energy, have presented an extensive desktop study on the man-made and natural noise sources, and their possible impacts on blue whales and coastal krill in the region of the Bonney Upwelling. They sub-divided possible direct effects into lethal, sub-lethal/pathological damage, changes in behavioural patterns, masking of signals of interest by temporarily changing animal's hearing response, and no direct effect. McCauley and Duncan (2001) found that "there is no evidence for, and much evidence against, assuming that any of the sound sources likely to be encountered in the Bonney Upwelling may cause lethal effects to blue whales"; and "given blue whales themselves routinely produce intense low frequency signals over sustained periods, resulting in substantially elevated sea noise levels, then it is probable they can tolerate moderate levels of low frequency man-made noise without any sub-lethal effects or shifts in hearing sensitivities". Holmes (1997) compares the noise of a blue whale calf singing next to its mother to Pavarotti bellowing into a soprano's ear during an opera performance. Behavioural responses can range from increased blow rates or changes in movement patterns to changes in vocalisation (Frankel and Clark 1998, McCauley and Duncan 2001, Wiggins *et al.* 2001). The effect of seismic surveys on the marine fauna from invertebrates to whales is treated extensively in McCauley (1994). Richardson (1999) found that feeding bowhead whales avoided seismic activities by a radius of about 20 km. In the specific case of the Bonney Upwelling, seismic airguns may elicit behavioural changes in blue whales in the tens of km, and probably avoidance at 3-20 km (McCauley and Duncan 2001). The noise from shipping may produce localised displacement of whales to several kilometres from the vessel; whale avoidance due to drilling noise was estimated to be negligible while rig tenders were shut down or idle, and to within perhaps 2.25 km when a rig tender was victualling at the rig (McCauley and Duncan 2001). Miller *et al.* (2000) report that male humpback whales lengthen their song patterns significantly when they are exposed to LFA sonar transmissions, presumably to compensate for acoustic interference. While McDonald *et al.* (1995) did not observe changes in Blue Whale movements and calling patterns when they were subjected to air-gun or shipping noise, Wiggins *et al.* (2001) noted that Blue Whales vary the intensity of their sound production level in response to varying ambient noise levels. Behavioural changes may come at an energetic cost that cannot be estimated; thus, it should also be kept in mind that many long-term impacts of noise cannot be assessed within the limits of our current knowledge (S. Dolman pers. comm.).

McCauley and Duncan (2001) concluded in their study that it was considered prudent to evaluate each proposed activity on a case-by-case basis, since the risk factor will vary for different activities at different times and of different scales.

Summary

To summarise the threats (potential impacts) of most concern in the Bonney Upwelling are changes to the upwelling resulting in reduced productivity; changes to the availability of krill due to altered swarming behaviour or reduction in numbers from causes such as climate change, changes in predator numbers, disease, etc.; harassment by potential whale-watching or research operations; collisions with vessels, especially if traffic volumes increase; and the short-term, or largely unknown long-term, effects of noise. Commercial whaling would remain the greatest threat to Blue Whales though we have no evidence that it has occurred recently in this area.

Discussion

Blue Whales (*Balaenoptera musculus*) have been shown to aggregate in relatively large numbers on the continental shelf of Australia between Port Campbell, Victoria and Robe, South Australia — the Bonney Coast —from December to April/May (Gill 2001, 2002). They are known to feed on, and are often seen in association with, coastal krill (*Nyctiphanes australis*), which form in response to increased phytoplankton productivity in cool upwelled water (Colman 2001, Gill 2001, 2002).

The Bonney Coast upwelling is the most prominent and predictable of the wind induced, coastal upwelling events in southeast Australia, where cooler water with elevated chlorophyll *a* concentrations is regularly observed between November/December and March/April (Lewis 1981, Schahinger 1987, Gill 2002). Coastal krill form extensive surface swarms in response to the increased productivity; these in turn attract Blue Whales to the area. This relationship, between the upwelling event and Blue Whales feeding on krill, led to the inclusion of the Bonney Upwelling in the 11 unique marine areas in Commonwealth waters. In fact, the upwelling event is the pivot of the conservation value of the Bonney Coast. Blue Whales range much further than this particular area, and there are large gaps in our knowledge of the range, migration routes and population structure of these whales. However, we know that the productivity from the upwelling draws these animals to the Bonney Coast. Thus, the region provides what may be called 'critical habitat' for Blue Whales (*sensu* Gill 2001).

Blue Whales are listed as endangered. This status in Australia provides for the applicability of management measures provided for under the *EPBC Act*. They are a highly migratory species, which is distributed worldwide in oceanic habitats, but not restricted to deeper waters. The life cycle and pattern of movement of Blue Whales are poorly understood. Only a few Blue Whale aggregation areas have been identified worldwide (Fig. 10). Even though these animals are regularly sighted throughout the southern coast of Australia and three feeding areas have been identified on our shores (Eden, Otway and Rottnest – Fig. 8) (EA 2001a), current knowledge of their distribution is incomplete, and migration routes, such as the one through Bass Strait (Fig. 8), are uncertain (Mustoe in prep.). As mentioned above, in the Bonney Upwelling (aka Otway), Blue Whales are regularly observed in relatively large numbers. Thus, on all the available evidence, the Bonney Upwelling is particularly important as a feeding area in Australian waters.

Nyctiphanes australis is the principal species of krill in southeast Australian and New Zealand shelf waters. They are typically observed in sub-surface swarms, but surface swarms and benthic aggregations are not rare. The biology of this species would allow commercial harvesting (Johannes and Young 1999), but a fishery for *N. australis* would be of concern because of its potential to reduce the food stocks for the whales (and because of other possible ecosystem effects). S. Nicol (pers. comm.) suggests that it is considered unlikely that such a fishery would be developed, due to its potential ecological repercussions.

The southeast Australian region, in general, is an area of high species diversity with a considerable indigenous component (eg Kott 1997, Womersley 1984), and is particularly productive due to the large, predictable, upwelling events. Key species of the region include 22 threatened marine species, as well as 19 species of fish and 7 species of invertebrates that are consistently targeted by commercial fisheries.

The Bonney coast is a multiple-use system that sustains a variety of fishing operations, and oil and gas exploration; in addition, a major shipping lane intersects the whale feeding area. Indigenous people of local clans still feel a close connection with the ocean through stories/dreaming tracks and traditional use, as well as to whales indicated in what is known of their language.

Because there are many gaps in our knowledge of Blue Whales it is difficult to specify threats in the Bonney Coast area. We could only summarise the literature on threats to whales in general and relate these to the current and potentially developing human activities in the Bonney Upwelling. Identified human-induced threats are: chemical pollution (acute and diffuse), climate change, collision with vessels, commercial whaling, competition for resources, displacement due to large fixed structures, gear entanglement, harassment, marine debris, noise pollution. There is little evidence of current impacts; the fisheries in the region mainly use low-risk gears, there is no krill fishery, and there are no current reports of collisions with whales. Noise produced by seismic surveys, an integral part of ongoing offshore oil and gas exploration, may cause concern for the whales. These surveys are assessed and conducted within the guidelines developed by EA in consultation with industry, leading cetacean scientists and NGO's for assessing seismic activities under the EPBC Act; the guidelines are aimed at minimising any potential impact on threatened species. Concern has, however, been expressed by some individuals that the interaction between seismic surveys and blue whales could potentially have a detrimental impact on the species use of the area. EA has advised that preliminary information from the aerial surveys conducted in association with the most recent seismic activity in the area show that in fact no Blue Whales were present in the wider region prior to or during testing. Thus, the threats (potential impacts) that give greatest cause for concern on the Bonney Upwelling, considering its current and potential uses, in alphabetical order, are:

- Changes to krill abundance and/or swarming behaviour
- Changes to the upwelling due to climate change, i.e. if the upwelling was to be altered or stopped, the Bonney Coast may lose its productivity and thus its attraction for Blue Whales.
- Collision with vessels, especially in the light of future increasing traffic volumes and predicted increases in the numbers of whales
- Noise pollution, where the key area of uncertainty is our lack of knowledge of both short and long-term effects of increased noise on whales.

The potential impacts of developing/potential industries such as whale watching or krill fisheries, as well as the potential construction of permanent structures, such as wave power plants or petroleum production platforms, in the upwelling will have to be considered on a case-by-case basis.

The term “Conservation Values”, of course, implies a value judgement which should not be attempted by us alone; it is for the whole community to decide what is to be valued. However, as scientists, we can comment on the biology, geology and oceanography of the area and on aspects we think might reasonably be considered valuable. This present assessment shows that the area has a number of unique features, notably, but not confined to, the fact that it is the largest and most predictable Blue Whale feeding area in southern Australia. However, we must acknowledge the limitations of considering a specific area such as the Bonney Upwelling when the conservation values to be protected include highly migratory species. We are restricting our discussion here to the values of the Bonney Upwelling – they include the contribution that this area makes to the ecology of Blue Whales and this is a value worth protecting. This is *not*, however, the same as an effective recovery plan for Blue Whales, which is not the subject of this report.

Conclusion

The main question of the present assessment is: "Does the Bonney Upwelling possess biodiversity values worthy of protection?" Recent studies have shown beyond any reasonable doubt that the Bonney Upwelling provides a substantial food resource for Blue Whales, a species that is endangered largely due to human exploitation, and to which the predominant view in Australia at present gives high value. It has been suggested that the Bonney Upwelling be classed a 'critical habitat' of Blue Whales (Gill 2001), although it has not yet been formally listed as such under the *EPBC Act*. The Bonney upwelling may not be strictly unique – there are other upwelling events in southern Australia – but it is uniquely large and predictable, although there is spatial and temporal variability both in the upwelling and in the biodiversity associated with it (the krill swarms and the presence and numbers of Blue Whales). The term 'biodiversity' refers to the whole variety of life at all scales, and to processes. In that context, we note that the Bonney Coast has high productivity because of the upwelling, which explains its importance in fisheries and its known high coastal biodiversity and endemism, and which makes it likely that there is high diversity in parts of the ecosystem not yet well studied (benthic organisms, plankton). With respect to those aspects that have been studied, it is already known that, whilst perhaps not unique, the system is rich. Thus, we believe that the area does have biodiversity values worthy of protection, and that it has these values primarily as a result of the Bonney upwelling.

Regarding threats to this biodiversity, a number of possibilities are listed above but the key concerns are (1) any processes that may affect the upwelling system itself, and (2) processes that may directly affect the whales.

We have noted the possibility that climate change may influence the upwelling, though it does not appear to be a serious concern. Blue Whales appear not to be significantly impacted by the current use – the main fishing methods are low risk; there are no recorded incidents with Blue Whales in the area; and petroleum exploration is conducted within the guidelines of the *EPBC Act*. However, in the light of increasing population sizes as the Blue Whales recover from exploitation, increases in traffic volume and potential new uses of the region, the risks need to be monitored and assessed on a case-by-case basis, considering their short and long-term impact on the whales.

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Appendix 1

FROM: ***Guidelines for establishing the National Representative System of Marine Protected Areas.*** **(ANZECC TFMPA 1998). Criteria to be used as a basis for the identification and selection of MPAs**

IDENTIFICATION

Representativeness

Will the area:

- represent one or more ecosystems within an IMCRA bioregion, and to what degree;
- add to the representativeness of the NRSMPA, and to what degree.

Comprehensiveness

Does the area:

- add to the coverage of the full range of ecosystems recognised at an appropriate scale and within and across each bioregion;
- add to the comprehensiveness of the NRSMPA.

Ecological importance

Does the area:

- contribute to the maintenance of essential ecological processes of life-support systems;
- contain habitat for rare or endangered species;
- preserve genetic diversity, i.e. is diverse or abundant in species;
- contain areas on which species or other systems are dependent, e.g. contain nursery or juvenile areas or feeding, breeding or resting areas for migratory species;
- contain one or more areas which are a biologically functional, self-sustaining ecological unit.

International or national importance

- is the area rated, or have the potential to be listed, on the world or a national heritage list or declared as a Biosphere Reserve or subject to an international or national conservation agreement.

Uniqueness

Does the area:

- contain unique species, populations, communities or ecosystems;
- contain unusual or unique geographical features.

Productivity

- Do the species, populations, or communities of the area have a natural biological productivity.

Vulnerability assessment

- Are the ecosystems and/or communities vulnerable to natural processes.

Biogeographic importance

- Does the area capture important biogeographic qualities.

Naturalness

- How much has the area been protected from, or not been subjected to, human induced change.

Appendix 2

Information to be compiled for each area.

Note, all of this information is to be assembled / interpreted ***to the extent possible***. In some cases, there may be no relevant information.

1. A Description of the Physical Environment

a. Bathymetry – To a resolution required to identify biophysical values
b. Geomorphology
c. Oceanography
d. Distinct sub-regions within the assessment area

2. A Description of the Biological Environment

a. Comprehensive list of taxa to lowest practical taxonomic rank.
b. Full list of species that are of known ecological, commercial, cultural or recreational importance (to be referred to below as key species, where the term key simply means species of interest or special concern).
c. Abundances and distributions of key species
d. Behaviour and life history of known key species, e.g. breeding, feeding, migratory paths, etc. as they relate to the area.
e. Key processes such as trophic relationships and species interdependence including any known functional linkage with other communities/systems or areas outside the assessment area
f. Definition of discrete biological units (ecosystems / habitats / communities / assemblages / systems) within assessment area
g. If specific locations are found within the general area studied for the conservation values assessment as having particularly high biophysical values or other features of specific interest these locations should be identified and described.

3. **Address to the extent possible each MPA Identification Criterion** (see Appendix 1)

a. Representativeness
b. Comprehensiveness
c. Uniqueness;
d. Naturalness;

e. Ecological importance;
f. Biogeographic importance;
g. International or national importance;
h. Productivity; and
i. Vulnerability.

4. Current and Potential Uses and Existing Management Regimes

Provide information, to the extent possible, on the following

a. Fisheries – Complete information on commercial, charter, amateur and traditional fisheries including:
   - catch composition and distribution of fisheries
   - catch quantities including bycatch of non-commercial species;
   - main fishing methods and boat types;
   - number of non-commercial and commercial operators using the area;
b. Minerals and petroleum –exploitable minerals present, potential petroleum and mineral reserves, any exploration leases granted, seismic activity, location of any wells etc
c. Tourism and recreation (non fishing) - types of use/activity, visitation rates, seasonal use patterns, number of commercial operators
d. Maritime transport – locations of shipping lanes and volumes of traffic
e. Indigenous interests/values.
f. Describe the legislation and management arrangements (both domestic and international) relevant to each of the uses above and or to the assessment area generally.
g. Scientific and education values – such as ongoing projects, exploration, and relevance for future local and regional users.

5. Current and Potential Impacts on Natural Values

The report should identify natural processes and anthropogenic *processes* that may impact on the biophysical values of the assessment area. For example, the report should identify/list any existing and potential pressures from human impacts such as physical, chemical and or biological processes that impact on biophysical values such as the disturbance of seagrass habitat, heavy metal contamination and predation by introduced pests. Similarly the risk and associated impact of storm events, global warming and natural predators, etc., should be described.

Appendix 3:

Sources for data and/or expert opinions

A Stakeholder Reference Group (SRG) has been established by EA for the Commonwealth MPA process. The CSIRO team made presentations to this group, and specifically invited provision of data, anecdotal information and comments. The membership of the SRG is listed in Table A3.1. For this particular assessment area, EA arranged a workshop to facilitate access to information, whether formal data or informal observations; participants in this workshop were invited to provide any information they thought we should know about. A number of them provided references, copies of reports and publications, or verbally told us their own observations. Attendees at the workshop are listed in Table A3.2. CSIRO specifically contacted the organisations and individuals listed in Table A3.3

Table A3.1 Membership of the Commonwealth MPAs Stakeholder Reference Group

Organisation	Contact Name
Aboriginal & Torres Strait Islander Commission	Rodney Dillon
Aboriginal & Torres Strait Islander Commission	Wieslaw Lichacz
Association of Australian Ports & Marine Authorities Inc.	Jane Reynolds
Association of Australian Ports & Marine Authorities Inc.	John Hirst
Austral Fisheries	Martin Exel
Australian Fisheries Management Authority	Joanna Fisher
Australian Fisheries Management Authority	Paul Murphy
Australian Marine Conservation Society	Kate Davey
Australian Maritime Safety Authority	Annaliese Caston
Australian Maritime Safety Authority	John Gillies
Australian Petroleum Production & Exploration Association Limited	Mark McCallum
Australian Seafood Industry Council	Russ Neal
Australian Seafood Industry Council	Terry Moran
Australian Shipowners Association	Jennifer Taylor
CSIRO	Alan Butler
Department of Defence	Lauren Gray
Department of Defence	Colin Trinder
Dept of Agriculture -- Fisheries and Forestry - Australia	Matt Gleeson
Dept of Agriculture -- Fisheries and Forestry - Australia	Louise Galli
Dept of Agriculture -- Fisheries and Forestry - Australia	Glenn Hurry
Dept of Education -- Science & Training	Philip Diprose
Dept of Education -- Science & Training	Patrick Davoren
Dept of Industry -- Tourism & Resources	Chris Lloyd
Dept of Transport and Regional Services	Katrina Preski
Dept of Transport & Regional Services	Karenn Singer
Marine & Coastal Community Network	Tim Allen
Marine & Coastal Community Network	Di Tarte
Minerals Council of Australia	Michael Bissell
National Oceans Advisory Group	Russell Reichelt
National Oceans Office	David Johnson
National Oceans Office	Bernadette O'Neil
Recfish Australia	Graeme Creed
Recfish Australia	Ross Monash
SERMP Steering Committee	Diane James
Tourism Task Force	Stephen Albin
Whale & Dolphin Conservation Society	Margi Prideaux
Woodside Petroleum	Greg Oliver
World Wide Fund for Nature Australia	Margaret Moore

Table A 3.2 Attendees at the Blue Whale Workshop, Melbourne, Monday 3 June 2002

Sector	Name	Organisation
Research	Peter Gill	Deakin University
	Margi Morrice	Deakin University
	Simon Jarman	Australian. Antarctic Division
Gas and Petroleum	David Gordon	Woodside
	Joanna Knight	APPEA
	Ed Pinceratto	BHP Billton
	Catriona McTaggart	SANTOS
	Simon Mustoe	ESSO
Indigenous	Neil Martin	Framlingham Aboriginal Trust
	Lionel Harradine	Framlingham Aboriginal Trust
Conservation	Margi Prideaux	Whale and Dolphin Conservation Society
	Pam Eiser	Project Jonah
	Carole de Fraga	Project Jonah - Victoria
	Sarah Dolman	Whale and Dolphin Conservation Society
	Rebecca Brand	Humane Society International
Fishing Industry	Alan Campbell	
	Andrew Levings	Victorian Seafood Industry Council
	Terry Moran	Australian Seafood Industry Council
	Ian Knuckey	
	Bert Tober	
CSIRO	Alan Butler	CSIRO
	Franzis Althaus	CSIRO
Government	Meredith Hall	National Oceans Office
	Colin Trinder	Defence
	Angela Rymer	Marine Species Section
	Leanne Wilks	MPA Section
	Margaret Tailby	MPA Section
	Peter Taylor	MPA Section
	Matt Carr	MPA Section
	Karl Heiden	Mining and Industrial Section

Table A3.3 Organisations/people contacted for data and/or expert opinions

Organisation	Contact Name	Reason for contacting
NOO - National Oceans Office	M. Hall	Marine matters report (BRS) and other SE MRP data
GA – Geoscience Australia	P. Harrison / R. Smith	Geomorphology maps
Australian Antarctic Division	S. Nicol	Opinion on possibility of a krill fishery
Tasmanian Scallop Fishery	H. Revill	Scallop fishery (Bass Strait)
South Australia Museum	C. Kemper	Whale sightings / strandings
Museum Victoria	T. O'Hara / G. Poore	Museum Surveys; expert opinion on sponge and other invertebrate abundance/distribution (W Bass Strait)
Curtin University	R. McCauley	Whale distribution
Deakin University	P. Gill	Blue whales in Bonney Coast region
EA – Environment Australia	K. Heiden	*EPBC Act*
EA – Environment Australia	J. Tranter	Threatened and endangered species
Consultant for ESSO	S. Mustoe	Recent surveys recording Blue Whales off northwest Tas
Woodside Energy	D. Gordon	Surveys/studies on exploration activities and whale interactions
BHP Billiton	E. Pinceratto	Surveys/studies on exploration activities and whale interactions
Consulting Environmental Engineers	S. Chidgey	Any surveys ?
Maunsell Australia Pty Ltd	B. Ridgeway	Any surveys ?
EA – Environment Australia	A. Rymer	Whale collision / stranding data
WDCS – Whale and Dolphin Conservation Society	S. Dolman / M. Prideaux	Whale conservation issues / threats
Defence	C. Trinder	Whale research sponsored by Defence
Navy	S. Cole/C. Shaw	Whale research sponsored by Defence; distribution/abundance from listening stations
Indigenous groups	N. Martin / L. Harradine	Aboriginal connection to whales
Deakin University	A. Levings	Giant crab fishery
CSIRO (NOO Data management/spatial analysis)	V. Lyne and M. Martin	SE RMP data
CSIRO (Oceanography)	K. Ridgway / S. Condie	Oceanographic data
CSIRO (Climate Program)	D. Griffin	SST and SeaWifs pictures
CSIRO (Invertebrate Collection)	K. Gowlett-Holmes	Expert opinion on invertebrate distribution
CSIRO (Atmospheric Research)	K. McInnes	Possible effects of climate change on Bonney Upwelling

Appendix 4:

Marine species occurring in the Bonney Upwelling that are listed under the marine protection and marine migratory provisions of the *EPCB Act*. Also including species listed as threatened and their status. CR: critically endangered, EN: endangered, VU: vulnerable, N/a not on threatened species list. 'Presence code' refers to the type of presence in the area: 1 Species or species habitat likely to occur within area; 2 Foraging recorded within area; 3 Breeding recorded within area; -a Derived from a general distribution map > 1 degree

Class	Scientific Name	Common Name	Listed threatened species status	Listed marine migratory species	Listed marine species	Presence code
Aves	*Arenaria interpres*	Ruddy Turnstone	N/a	N/a	Listed	1
Aves	*Calidris acuminata*	Sharp-tailed Sandpiper	N/a	N/a	Listed	1
Aves	*Calidris alba*	Sanderling	N/a	N/a	Listed	1
Aves	*Catharacta skua*	Great Skua	N/a	N/a	Listed	1-a
Aves	*Diomedea amsterdamensis*	Amsterdam Albatross	EN	Listed	Listed	1-a
Aves	*Diomedea dabbenena*	Tristan Albatross	EN	Listed	Listed	2-a
Aves	*Diomedea epomophora*	Southern Royal Albatross	VU	Listed	Listed	1-a
Aves	*Diomedea exulans*	Wandering Albatross	VU	Listed	Listed	1-a
Aves	*Diomedea gibsoni*	Gibson's Albatross	VU	Listed	Listed	1-a
Aves	*Diomedea sanfordi*	Northern Royal Albatross	EN	Listed	Listed	1-a
Aves	*Eudyptula minor*	Little Penguin	N/a	N/a	Listed	3
Aves	*Haliaeetus leucogaster*	White-bellied SeaEagle	N/a	N/a	Listed	1
Aves	*Halobaena caerulea*	Blue Petrel	EN	N/a	Listed	1-a
Aves	*Larus novaehollandiae*	Silver Gull	N/a	N/a	Listed	3
Aves	*Larus pacificus*	Pacific Gull	N/a	N/a	Listed	3
Aves	*Macronectes giganteus*	Southern Giant-Petrel	EN	Listed	Listed	1-a
Aves	*Macronectes halli*	Northern Giant-Petrel	VU	Listed	Listed	1-a
Aves	*Morus capensis*	Cape Gannet	N/a	N/a	Listed	3
Aves	*Morus serrator*	Australasian Gannet	N/a	N/a	Listed	3

Class	Scientific Name	Common Name	Listed threatened species status	Listed marine migratory species	Listed marine species	Presence code
Aves	*Numenius madagascariensis*	Eastern Curlew	N/a	N/a	Listed	1
Aves	*Pelagodroma marina*	White-faced Storm-Petrel	N/a	N/a	Listed	3
Aves	*Pelecanoides urinatrix*	Common Diving-Petrel	N/a	N/a	Listed	3
Aves	*Phalacrocorax fuscescens*	Black-faced Cormorant	N/a	N/a	Listed	3
Aves	*Phoebetria fusca*	Sooty Albatross	VU	Listed	Listed	1-a
Aves	*Pluvialis fulva*	Pacific Golden Plover	N/a	N/a	Listed	1
Aves	*Pterodroma mollis*	Soft-plumaged Petrel	VU	N/a	Listed	1-a
Aves	*Puffinus tenuirostris*	Short-tailed Shearwater	N/a	Listed	Listed	3
Aves	*Sterna anaethetus*	Bridled Tern	N/a	Listed	Listed	3
Aves	*Sterna bergii*	Crested Tern	N/a	N/a	Listed	3
Aves	*Sterna caspia*	Caspian Tern	N/a	Listed	Listed	3
Aves	*Thalassarche bulleri*	Buller's Albatross	VU	Listed	Listed	1-a
Aves	*Thalassarche cauta*	Shy Albatross	VU	Listed	Listed	1-a
Aves	*Thalassarche chlororhynchos*	Yellow-nosed Albatross	N/a	N/a	Listed	1-a
Aves	*Thalassarche chrysostoma*	Grey-headed Albatross	VU	Listed	Listed	1-a
Aves	*Thalassarche impavida*	Campbell Albatross	VU	Listed	Listed	1-a
Aves	*Thalassarche melanophris*	Black-browed Albatross	N/a	Listed	Listed	1-a
Aves	*Thalassarche salvini*	Salvin's Albatross	VU	Listed	Listed	1-a
Chondrichthyes	*Carcharias taurus (east coast population)*	Grey Nurse Shark (east coast population)	CE	N/a	N/a	1-a
Chondrichthyes	*Carcharodon carcharias*	Great White Shark	VU	N/a	N/a	1-a
Mammalia	*Arctocephalus pusillus*	Australian Fur-seal	N/a	N/a	Listed	1
Mammalia	*Balaenoptera borealis*	Sei Whale	VU	N/a	N/a	1-a

Class	Scientific Name	Common Name	Listed threatened species status	Listed marine migratory species	Listed marine species	Presence code
Mammalia	*Balaenoptera musculus*	Blue Whale	EN	Listed	N/a	1-a
Mammalia	*Balaenoptera physalus*	Fin Whale	VU	N/a	N/a	1-a
Mammalia	*Eubalaena australis*	Southern Right Whale	EN	Listed	N/a	1-a
Mammalia	*Megaptera novaeangliae*	Humpback Whale	VU	Listed	N/a	1-a
Osteichthyes	*Acentronura australe*	Southern Pygmy Pipehorse	N/a	N/a	Listed	1-a
Osteichthyes	*Campichthys tryoni*	Tryon's Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Heraldia nocturna*	Upside-down Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Hippocampus abdominalis*	Eastern Potbelly Seahorse	N/a	N/a	Listed	1-a
Osteichthyes	*Hippocampus breviceps*	Short-head Seahorse	N/a	N/a	Listed	1-a
Osteichthyes	*Hippocampus minotaur*	Bullneck Seahorse	N/a	N/a	Listed	1-a
Osteichthyes	*Histiogamphelus briggsii*	Briggs' Crested Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Histiogamphelus cristatus*	Rhino Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Hypselognathus rostratus*	Knife-snouted Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Kaupus costatus*	Deep-bodied Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Kimblaeus bassensis*	Trawl Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Leptoichthys fistularius*	Brushtail Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Lissocampus caudalis*	Australian Smooth Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Lissocampus runa*	Javelin Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Maroubra perserrata*	Sawtooth Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Mitotichthys mollisoni*	Mollison's Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Mitotichthys semistriatus*	Half-banded Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Mitotichthys tuckeri*	Tucker's Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Notiocampus ruber*	Red Pipefish	N/a	N/a	Listed	1-a

Class	Scientific Name	Common Name	Listed threatened species status	Listed marine migratory species	Listed marine species	Presence code
Osteichthyes	*Phycodurus eques*	Leafy Seadragon	N/a	N/a	Listed	1-a
Osteichthyes	*Phyllopteryx taeniolatus*	Weedy Seadragon	N/a	N/a	Listed	1-a
Osteichthyes	*Prototroctes maraena*	Australian Grayling	VU	N/a	N/a	1
Osteichthyes	*Pugnaso curtirostris*	Pug-nosed Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Solegnathus robustus*	Robust Spiny Pipehorse	N/a	N/a	Listed	1-a
Osteichthyes	*Solegnathus spinosissimus*	Spiny Pipehorse	N/a	N/a	Listed	1-a
Osteichthyes	*Stigmatopora argus*	Spotted Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Stigmatopora nigra*	Wide-bodied Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Stipecampus cristatus*	Ring-backed Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Urocampus carinirostris*	Hairy Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Vanacampus margaritifer*	Mother-of-pearl Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Vanacampus phillipi*	Port Phillip Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Vanacampus poecilolaemus*	Australian Long-snout Pipefish	N/a	N/a	Listed	1-a
Osteichthyes	*Vanacampus vercoi*	Verco's Pipefish	N/a	N/a	Listed	1-a

Appendix 5:

Commercially fished species in the SE Australia (Larcombe *et al.*2002)

Common Name	Scientific Name	Fishery/ies
Blue-eye trevalla	*Hyperoglyphe antarctica*	Trawl, gillnet, dropline & bottom longline
Blue grenadier	*Macruronus novaezelandiae*	Trawl
Blue warehou	*Seriolella brama*	Trawl & gillnet
Flathead	*Neoplatycephalus spp.* & *Platycephalus spp.*	Trawl
Western Gemfish	*Rexea solandri*	Trawl
Jackass morwong	*Nemadactylus marcopterus*	Trawl
Ling	*Genypterus blacodes*	Trawl, gillnet, dropline & bottom longline
Mirror dory	*Zenopsis nebulosus*	Trawl
Ocean perch	*Helicolenus spp.*	Trawl
Orange roughy	*Hoplostethus atlanticus*	Trawl
Silver trevally	*Pseudocaranx dentex*	Trawl
Spotted warehou	*Seriolella puncata*	Trawl & gillnet
Oreo dories	*Oreosomatidae*	Trawl
Gummy shark	*Mustelus antarcticus*	Gillnet, dropline & bottom longline
School shark	*Galeorhinus galeus*	Gillnet, dropline & bottom longline
Hapuku	*Polyprion oxygeneios*	Gillnet, dropline & bottom longline
Elephant fish	*Callorhinchus milii*	Gillnet
Saw shark	*Pristiophorus spp.*	Gillnet
Whiskery shark	*Furgalaeus macki*	Gillnet
Arrow squid	*Nototodarus gouldi*	Squidjig
Southern rocklobster	*Jasus edwardsii*	Rocklobster (SE states)
Eastern rocklobster	*Jasus verreauxi*	Rocklobster (SE states)
Blacklip abalone	*Haliotis rubra*	Abalone (SE states)
Greenlip abalone	*Haliotis laevigata*	Abalone (SE states)
Southern scallop	*Pecten fumatus*	Scallop (SE states & Commonwealth)
Giant crab	*Pseudocarcinus gigas*	Giant crab (Tas & Vic)
King George Whiting	*Sillaginoides punctata*	SA marine scale fisheries
Snapper	*Pagrus auratus*	SA marine scale fisheries Vic general ocean fisheries
Tommy ruff	*Arripis georgianus*	SA marine scale fisheries
Pilchard	*Sardinops neoplicharus*	SA marine scale fisheries
Australian salmon	*Arripis trutta* and *A.truttaceus*	SA marine scale fisheries Vic general ocean fisheries
Garfish	*Hyporhamphus spp.*	SA marine scale fisheries
Calamary	*Sepioteutis australis*	SA marine scale fisheries
Cuttlefish	*Sepia spp.*	SA marine scale fisheries
Mud cockle	*Katelysia spp*	SA marine scale fisheries
Sand crab	*Ovalipes australiensis*	SA marine scale fisheries
Octopus	*Octopus spp.*	Vic general ocean fisheries