Department for Environment and Heritage

Towards a System of Ecologically Representative Marine Protected Areas in South Australian Marine Bioregions

Technical Report, December 2004

Government of South Australia

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About this Report

This report contains an overview of the framework and background related to the development of an ecologically-representative system of marine protected areas (MPAs) in South Australian marine bioregions, based upon the CAR principles (comprehensiveness, adequacy, representativeness) advocated by the Commonwealth for the future development of MPAs in Australian States and Territories. The report discusses the approach that was undertaken during the early 2000s, to (i) develop the scientific principles underlying a bioregional, ecologically-representative system of marine protected areas, and (ii) identify and document a list of areas and their attributes that would make a substantial contribution to that system.

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Foreword

We South Australians are very lucky indeed. We have a deeply indented coastline of approximately 4,000 km long, with a large variety of gulfs, bays and islands, which together provide an astonishing diversity of habitats and marine life.

The long east-west coastline of southern Australia, and climatic stability for 65 million years have together led to the evolution of the world's richest temperate marine flora and flora. One of the greatest wonders of the planet lies in our shallow temperate seas in the form of an intricate tapestry of tens of thousands of interwoven species!

Human activities threaten this astonishing diversity of life in different ways. "Fishing down the food web" has seen the reduction in numbers of top predators, while trawling has changed bottom habitats in Gulf St Vincent and Investigator Strait (Tanner, 2003). Nutrient enrichment, shoreline reconstruction and pollution have all taken their toll, especially in estuaries and near urban/town centres, while introduced exotic species threaten to outcompete native species and degrade ecosystems. Many of the changes that have occurred have gone unnoticed, and the "shifting baseline" syndrome tends to make each generation accept the existing state as the norm.

While South Australia's coastal waters have immense value as a source of food and recreation, the partnership between humankind and this relatively fragile marine ecosystem is clearly an uneasy one. It was once thought that human-caused extinction of marine species was a rarity, compared with terrestrial species. However, as shown by the recent study of Edgar et al. (2004), that was a biased view based on ignorance. Species' extinction and fragmentation of species' ranges or habitats are matters that need serious and urgent attention. Hence the pressing need to set aside an adequate system of reserves (with "no go" and "no take" marine protected areas) to conserve the rich ecosystems for which we are all trustees for the future. South Australia made a pioneering start in 1971, when it led marine conservation in Australia by setting aside a series of small reserves. Now is the time to build on that beginning, by increasing the number and size of reserves to an appropriate level.

Since 1971, science and management have made many advances, and much information, diffusely spread in research and popular articles, has accumulated about South Australia's coastal waters. In addition, the pressures on coastal waters have increased manyfold over the same period. This information now needs to be brought together in order to enable managers and policy makers to make sound decisions about the management of this complex region. The author has undertaken this formidable task, and the present work is a tour de force, bringing together into coherent form a vast reference store of knowledge about the coastal waters of the State, and its flora and fauna. The source of every datum is meticulously referenced. Everywhere throughout the work the author's dedication to the gigantic task is apparent.

This work will undoubtedly become the most valuable source of information available for every part of the State's waters, and the challenge is now for marine managers to put this knowledge to best use for the no less formidable task of conserving this rich heritage that is ours for the common benefit of all.

Scoresby A. Shepherd

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Executive Summary

The Government of South Australia recognises the ecological importance of South Australia's diverse, productive marine environment, and its many values to society and economy. The Government is committed to protecting the long-term ecological functioning of the marine environment; to conserving its biodiversity; and to the responsible wide use and enjoyment of South Australia's marine and estuarine habitats.

This report, and its recommendations, forms one of a number of government projects that have been undertaken in South Australia since 1992, as part of this State's commitment to developing a comprehensive, adequate and ecologically representative (CAR) system of Marine Protected Areas (MPAs) in State waters. The development of a CAR system of MPAs is also South Australia's contribution to the *National Representative System of Marine Protected Areas* (NRSMPA), directed by the *Commonwealth's Strategic Plan of Action* (ANZECC, 1999), and its predecessor, the *Ocean Rescue 2000* program.

Suitably located and well-managed MPAs are now widely considered to be one of the key methods for protecting marine environments and their component biodiversity, sustaining productivity of some marine resources, and managing multiple uses in coastal marine environments. As a party to the international *Convention on Biological Diversity*, the Australian Government accepts that *the fundamental requirement for the conservation of biological diversity is the in situ conservation of ecosystems and natural habitats, and the maintenance and recovery of viable populations of species in their natural surroundings.* MPAs are one important way of achieving this aim. South Australia is signatory to the process of conserving biodiversity according to national agreements and policies, which also advocate the development of ecologically representative systems of MPAs in Australian States and Territories. Also, the South Australian Representative System of Marine Protected Areas (SARSMPA) is being developed in accordance with this State's marine policies, such as the *South Australian Marine and Estuarine Strategy* (1998), *Marine Protected Areas: A Shared Vision* (2002), later released as *Blueprint for the South Australian Representative System of Marine Protected Areas* (2004) and the *Living Coast Strategy* (2004).

This report describes the scientific and technical aspects of work undertaken between 2000 – 2002, towards identifying a CAR system of MPAs for the SARSMPA, a project of the (then) Office for Coast and Marine, Department for Environment and Heritage. The report describes the background and recommended framework for the project; the ecological principles of the SARSMPA; and the criteria, methods and data, used to identify a number of potential MPA locations within South Australia's marine bioregions. Internationally and nationally recognised criteria have been used to identify locations (released by the South Australian Government in 2001) that, if chosen as MPAs, will form the basis of the SARSMPA, will be major contributors to a CAR system for protecting biodiversity, and may confer many other ecological, social and economic benefits. Over time, additional locations may be identified as better knowledge becomes available. This report describes in detail the ecological attributes of 19 locations, and provides an overview of their many socio-economic values and uses. It also contributes as background to the S.A. Government's phase of community consultation and participation for developing the CAR system; and the Marine Planning Program, in which all locations of specific environmental, social and economic values in S.A. will be highlighted, as part of a participatory zoning process for marine uses and activities. Public participation will also be sought in the development of management and monitoring plans for each MPA, to ensure that they function effectively over time, for the long-term benefit of the marine environment, and the generations of South Australians who use and enjoy that environment.

1 Marine Protected Areas

1.1 Definition and Purpose

A marine protected area is defined as: *Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment* (IUCN, 1988, cited by Zann, 1995; Kelleher, 1999).

Another definition from IUCN (1994), emphasised the biodiversity conservation function of protected areas: *An area of (land and/or) sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.*

The Australian government has adopted IUCN's (1994) definition of MPAs (see Department for Environment and Heritage: http://www.deh.gov.au/coasts/mpa/about/index.html).

The term 'MPA' generally encompasses a broad spectrum of areas which are afforded different levels of protection (see Ivanovici, 1984; Baker, 2000). A major role of highly protected MPAs is the safeguarding of ecosystem function and biodiversity, and the protection of marine habitats. In the case of multiple-use or limited-use MPAs, additional important roles include managing resources for sustainable use, and/or providing a framework for supporting resource use and the use of marine space, with a minimum of conflict (Eichbaum *et al.,* 1996; Kenchington et al., 2003).

MPAs can be designated for one or many *overlapping and related* purposes of conservation and management, including:

Biodiversity Conservation purposes: such as:
- protecting examples of bioregionally 'representative' habitats and the biota within them;
- protecting 'unique' habitat types;
- protecting areas that contain a high diversity of habitat types;
- conserving biodiversity 'hotspots', that are rich in marine taxa (e.g. species, families and/or phyla);
- protecting areas of high significance for the breeding/spawning, feeding, aggregation and/or development of major marine groups, and for specific taxa of special conservation significance;
- maintaining genetic diversity;
- maintaining biological productivity; and
- protecting habitat for recognised rare or threatened species, among other reasons.

Social and Economic purposes: such as:
- provision of reserves which function to replenish particular fish stocks with habitat attachment phases;
- protecting examples of the habitats that are of key significance to the life stages of commercially and recreationally valued fish species;
- providing 'control' sites for research, and monitoring of biological, ecological and physical impacts (i.e. 'ecological benchmarks' against which the effects of natural and human-induced impacts / disturbances in other less protected areas can be assessed), thereby assisting in the development of 'feedback loops' between science and policy;

- conserving and managing areas that are important for marine recreation and tourism;
- providing important opportunities in marine education and training, in a number of fields;
- protecting aesthetic and spiritual values, including pristine areas of 'wilderness' value.

Cultural purposes: such as:
- protecting sites for traditional Aboriginal use;
- conserving historic shipwreck sites and other cultural features.

Other purposes: such as:
- assisting the restoration of degraded habitats; and
- the intrinsic value of maintaining undamaged marine ecosystems, and conserving marine environments for the future (i.e. existence value, and bequest value, the latter relating to inter-generational equity).

Any one MPA may serve a variety of functions depending upon its location, size, and zoning of activities. For example, one MPA may contribute to biodiversity conservation; fish stock protection and restoration of abundance; protection of habitat and associated features of value for diving and other passive recreation and tourism; and protection of culturally significant features, such as historic shipwrecks.

It is recognised that principles of marine conservation and ecologically sustainable use must extend beyond the bounds of marine protected areas, to the marine environment as a whole, and all of its component ecosystems (IUCN, 1991, cited by Kenchington, 1993, and see discussion of this topic in Baker, 2000). The complex nature of the marine environment, coupled with the many demands we place on it, makes it impossible for a single mechanism to provide a complete solution for marine conservation, and it is therefore necessary to integrate a number of different management approaches. As part of that suite of approaches, marine protected areas are essential for protecting marine ecosystems and ensuring ecologically sustainable use of areas and resources.

1.2 International Context

Since the 1970s, most MPAs have been declared by individual countries on a case-by-case basis. However, several different international organisations and initiatives have also been used to establish MPAs. These include the World Conservation Union (IUCN); UNEP's Regional Seas Program; UNESCO's Man and the Biosphere Program; UNESCO's Marine Science Program; the South Pacific Regional Environment Program, and initiatives of the Food and Agriculture Organisation (FAO) of the United Nations, the International Maritime Organisation, and the International Whaling Commission (Kelleher and Kenchington, 1991, cited by Baker, 2000).

The development of MPAs has become an increasingly important international issue, particularly during the past two decades, as marine resources worldwide have continued to decline, and marine habitats and ecosystems have continued to be degraded.

The International Group of Experts on Marine Protected Areas (IGEMPA, cited by Crosby *et al.,* 1997) agreed that MPAs:

- have a critical role in the management for long term conservation and sustainable use of marine and coastal biological diversity;

- function as focal points for development of governance for coastal and ocean systems; and
- provide for local community education and training in the importance of conserving coastal and marine biodiversity.

During the two decades, the focus for marine protected areas has shifted from an "ad-hoc" approach, to a more systematic approach, in which ecologically representative networks of marine protected areas are established, with protection of ecosystem processes and biodiversity conservation as primary goals (e.g. see Ballantine, 1994 and 1999b; Brunckhorst and Bridgewater,1996; ANZECC Task Force on Marine Protected Areas, 1998, 1999a,1999b; Baker, 2000; EEC, 2000). The National Research Council of the United States, in its presidential submission and guidelines for MPA establishment (USNRC, 2000), recommended that *biodiversity protection and ecosystem functioning should be the top priorities for MPA establishment.* This recommendation has been echoed in a number of recent reports and papers on the benefits of marine protected areas (e.g. Kenchington et al., 2003).

Recently, one of the key outcome agreements of the World Sustainable Development Summit held in Johannesburg in 2002, was:

….*the establishment of marine protected areas consistent with international law, and based on scientific information, including representative networks by 2012*.

(United Nations DESA, 2002)

Some of the main international treaties, conventions and agreements that relate to marine environmental protection and management, are discussed below. Establishing marine protected areas is one of the major goals of a number of these agreements, to which Australia and South Australia are party.

Convention on Biological Diversity

Establishing a representative system of MPAs in Australian waters, as part of a global system of MPAs, has been on the agenda since 1992, when Australia became signatory to the international Convention on Biological Diversity and its associated Jakarta Mandate. This convention is an international legal instrument for the conservation and sustainable use of biodiversity, and was signed by nations in agreement at the United Nations Conference on Environment and Development (the Rio Earth Summit) in June 1992. The Rio document contained no specific article on marine and coastal biodiversity. In consequence, the 1995 Conference of the Parties dealt with these issues in two decisions. One (II10) was a policy decision – now known as the Jakarta Mandate on the Conservation and Sustainable Use of Marine and Coastal Biological Diversity – containing basic principles and thematic areas. These provisions were to be implemented through a multi-year program of work described in the second decision (IV5). The United Nations Environment Program's Regional Seas Conventions and Action Plans are considered to have a major role to play in the promotion of the Jakarta Mandate at the regional level. The regional programs also relate to guidelines on integrated marine and coastal area management, criteria for marine and coastal protected area establishment, and management and guidelines for ecosystem evaluation, including indicators.

The development of representative systems of MPAs in each country is related to the international *Convention on Biological Diversity* and the Jakarta Mandate, in the sense that contracting nations agreed that:

the fundamental requirement for the conservation of biological diversity is the in situ conservation of ecosystems and natural habitats, and the maintenance and recovery of viable populations of species in their natural surroundings.

The convention also recognises the need to respect the dependence of local communities and indigenous people on biological resources.

World Conservation Union (IUCN)

An important goal of the World Conservation Union (IUCN) is the development and implementation of a global, representative system of marine protected areas, recognising that such a system will be part of a broader integrated marine ecosystem management framework.

Australia is under no legal obligation to create MPAs under international law. Nevertheless, a modified form of the international guidelines of the IUCN, regarding MPA policy, planning, objectives, and site identification and selection criteria, has formed the basis of the Commonwealth's *National Representative System of Marine Protected Areas* program, since the early 1990s.

The IUCN Program on Protected Areas (PPA) is related to IUCN World Commission on Protected Areas (WCPA), and has the same mission and vision as WCPA:

To promote the establishment and effective management of a worldwide, representative network of terrestrial and marine protected areas as an integral contribution to the IUCN mission.

The IUCN Protected Areas Program is designed to:
- assist in the planning of protected areas and their integration into all sectors by providing strategic advice to policy makers;
- strengthen capacity and effectiveness of protected area managers through the provision of guidance, tools and information, and as a vehicle for networking; and
- increase investment in protected areas by persuading public and corporate donors, as well as governments, of their value.

The IUCN has developed 7 management categories for protected area classification, some of which are relevant to marine protected areas. The categories are defined according to the primary conservation and management objectives of each type of protected area, ranging from small, highly protected Strict Nature Reserves, to large, multiple-use Managed Resource Protected Areas.

Other Treaties and Conventions

There are numerous other International Treaties and Conventions to which Australia is a party. These cover a variety of marine issues that are relevant, or potentially relevant, to marine protection in South Australia, such as:

- national sovereignty over marine resources lying within coastal waters (The *United Nations Convention on the Law of the Sea (LOSC) 1982*), which came into force on 16

November 1994. Although LOCS exercises the greatest rights within 12 miles of the coast, lesser controls apply to waters of the 200-mile exclusive economic zone (EEZ). By establishing property rights that apply to the species and habitats found within coastal waters, the treaty provides countries with some incentive to better manage these resources. It obligates parties to protect and preserve the marine environment by cooperating regionally and globally, and to adopt laws and regulations to deal with land-based sources of marine pollution. It also provides a framework for establishing maritime zones and for regulating fishing and marine scientific research.

- *International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978* (MARPOL), and other International Maritime Organisation conventions and agreements on marine pollution and ocean dumping;

- the *Convention on Conservation of Migratory Species of Wild Animals 1979* (Bonn Convention, which came into force globally in 1983, and in Australia, in 1991).

- the *Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar) 1971* for the conservation and wise use of wetlands and their resources. This convention has resulted in the periodically updated *Ramsar List of Wetlands of International Importance.*

- JAMBA – the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment (Tokyo, 6 February 1974) and CAMBA – the Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (Canberra, 20 October, 1986).

Some other treaties and conventions of relevance include those covering the regulation of whaling in Australian waters, and the conservation of endangered species of wild flora and fauna.

1.3 National and State Strategies, Policies and Agreements

South Australia is signatory to the process of developing a representative system of MPAs, according to the *Intergovernmental Agreement on the Environment* (1992), and the Commonwealth's Strategic Plan of Action and Guidelines for the National Representative System of Marine Protected Areas (NRSMPA) (ANZECC, 1999a) (**Appendix 1**). The NRSMPA initiative developed from the Commonwealth's *Ocean Rescue 2000* program, instigated in 1991.

A key contribution from South Australia to the NRSMPA is the development of the *South Australian Representative System of Marine Protected Areas* (SARSMPA). State policies and strategies of relevance to the identification of candidate areas for the SARSMPA are the South Australian *Marine and Estuarine Strategy* (South Australian Government, 1998), and the draft *Marine Protected Areas: A Shared Vision* (South Australian Government, 2002), later released as *Blueprint for the South Australian Representative System of Marine Protected Areas* (Department for Environment and Heritage, 2004).

In light of the various international, national and State obligations, the Government of South Australia recognises the ecological importance of South Australia's diverse, productive marine environment, and its high social and economical values. It also recognises the need to commit to protecting the long-term ecological functioning of the marine environment; to conserving its biodiversity; and to the responsible wide use and enjoyment of South Australia's marine and estuarine habitats (*Living Coast Strategy*, South Australian Government, 2004).

The State Government acknowledges that in order to achieve long-term ecosystem functioning and conserve biodiversity, suitably located and well-managed MPAs are now widely considered, both internationally and nationally, to be one of the most effective methods for protecting marine environments and their component biodiversity. Furthermore, MPAs are a tool that can be used to sustain productivity of some marine resources, and manage multiple uses in coastal marine environments (Ballantine, 1991b and 1999a; Ray and McCormick-Ray, 1992; Thackway, 1996b and 1996c; ANZECC, 1999a; Murray *et al.*, 1999; USNRC, 2000; Baker, 2000; Kenchington *et al.*, 2003).

2 The Role of South Australian Government Strategies in the Development of the South Australia Representative System of Marine Protected Areas

"Greater representation of coastal and marine habitats and species in areas protected and managed for biodiversity conservation is required. South Australia now lags behind in the implementation of the national Representative System of Marine Protected Areas (NRSMPA). There is a need to protect coastal and marine habitats, species assemblages, individual species and genetic resources".

(South Australian Government, 2004).

"A foundation for any comprehensive marine and estuarine strategy is the protection of marine habitat, species assemblages, individual species and their genetic origins. Our marine conservation system should protect both cultural heritage and the biodiversity fundamental to long term sustainable use of marine and estuarine resources. It should also accommodate the national and international dimensions of biodiversity conservation and the associated responsibilities for South Australia".

(South Australian Government, 1998).

Four main documents relevant to the development of a representative system of marine protected areas in South Australia are:

- *Our Seas and Coasts: A Marine and Estuarine Strategy for South Australia* (South Australian Government, 1998);

- *Marine Protected Areas: A Shared Vision* (South Australian Government, 2002), a draft policy document to guide the development of the SARSMPA. A final draft of the *Marine Protected Areas* policy was released in November 2004, as *Blueprint for the South Australian Representative System of Marine Protected Areas* (Department for Environment and Heritage, 2004) ;

- *The State Strategic Plan* (South Australian Government, 2004), with a target of establishing 19 large, multiple-use Marine Protected Areas by 2010; and

- The *Living Coast Strategy* (South Australian Government, 2004), which builds on *Our Seas and Coasts: A Marine and Estuarine Strategy for South Australia.*

Also of relevance to the development of the SARSMPA and its objectives, is the South Australia Government's *Planning Strategy for Country South Australia* (1996). Apart from economic development goals, three of the other major goals in that strategy were:

- Protection and enhancement of biodiversity.
- Protection of areas of conservation significance.
- Protection of areas of conservation and cultural significance such as reserves, the coast, rivers, streams, lakes, marine resources and heritage.

The *Living Coast Strategy* (2004), sets out the State Government's environmental policy directions for sustainable management of South Australia's coastal, estuarine and marine environments, including a stated action of protecting representative areas of ecological significance as MPAs, under the SARSMPA program. The *Living Coast Strategy* recognises that the integrity of South Australia's coastal, estuarine and marine environments are under significant pressure from development and use, pollution and the introduction of pest species.

The foundations for the *Marine and Estuarine Strategy* and the *Living Coast Strategy* are statewide recognition of the multiple values of marine and estuarine areas, and the need for those areas to be well managed. As part of this recognition, uses must be demonstrated to be ecologically sustainable, and respect both biodiversity conservation values and cultural heritage. The strategy's foundation also recognises the importance of coastal and marine resources to South Australia's economy, and that common property rights for marine resources require both responsible community involvement, and an impartial government.

The development of a Marine Protected Areas system in South Australia is compatible with the following objectives of the *Living Coast Strategy*:

- To conserve and safeguard the natural and cultural heritage of our coastal, estuarine and marine environments;
- To control pollution of our coastal, estuarine and marine environments;
- To protect our coastal, estuarine and marine environmental assets;
- To improve understanding of our coastal, estuarine and marine environments; and
- To develop and maintain partnerships between State and local Governments, community and industry.

With the national development of a bioregional approach to the conservation and management of the marine environment, the State Government recognised that the previous *ad hoc* approach to marine protected area placement in S.A. needs to be improved. Therefore, the South Australian Government endorsed use of the Commonwealth's Interim Marine and Coastal Regionalisation of Australia (IMCRA) *bioregional framework* for developing a representative system of MPAs in S.A. The IMCRA framework, and the rationale for developing a bioregionally representative system, is discussed in **Chapter 4.**

Developing the SARSMPA has the potential to be a key step forward for marine conservation in South Australia. It is a long term process that requires clear goals from the outset. Consequently, the South Australian Government released *Marine Protected Areas: A Shared Vision* (South Australian Government, 2002), a Vision and Policy document to guide the development of the SARSMPA. It proposed goals, objectives and general principles that underpin the development and implementation of a representative system of MPAs.

Many of the principles espoused in the Vision document were drawn or adapted from those described in the *Guidelines for the Establishment of the NRSMPA* (ANZECC, 1998), and reproduced in **Appendix 1.**

The **Goal of the SARSMPA** was consistent with the primary goal of the NRSMPA:

> *to maintain the long term ecological viability and processes of marine and estuarine systems, to protect biodiversity, and contribute to ecologically sustainable development.*

According to *Marine Protected Areas: A Shared Vision (2002),* the Government's summary objectives for development of the SARSMPA were to:

- "protect comprehensive, adequate and representative examples of ecosystems, habitats, species and populations";
- protect areas of high conservation value, including those containing high species diversity, natural refugia for flora and fauna and habitats unique to southern Australia;
- protect species that are rare, threatened, depleted or "special", and their associated habitats;
- provide a framework for managing a broad spectrum of human activities compatible with the goal, including economic, cultural/indigenous and social resource use.

That policy document also recognises that additional benefits are likely to be realised from the establishment of the SARSMPA. These include:

- opportunities for eco-tourism, recreation, education and research;
- protection of cultural sites and aesthetic values
- benefits for fisheries

It is noted that the Australian Marine Science Association (AMSA, 2002), also recognises these additional benefits

3 The Bioregional Approach

The *Interim Marine and Coastal Regionalisation for Australia* (IMCRA) process classified Australia's coastal and marine environments (IMCRA Technical Group, 1998) into 60 different marine biogeographical regions, or bioregions, each of which contains a distinct combination of physical and biological features. Eight bioregions have been defined by the IMCRA for waters that occur either completely or partially within South Australia's marine jurisdiction (Figure 1).

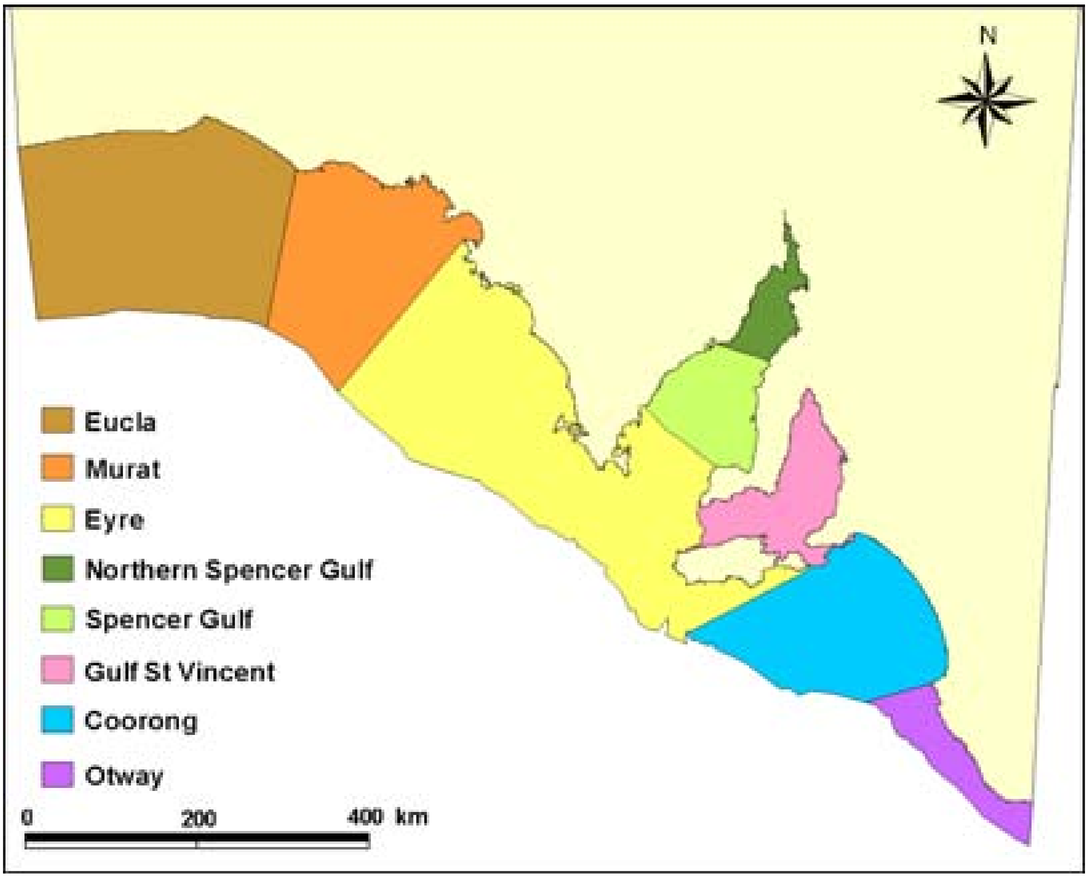

Figure 1: South Australian Marine Bioregions

Representing biogeographic regions and their component ecosystems / habitats has been recognised internationally (e.g. Ray, 1976; Atwood *et al.*, 1997; Starr and Johnson, 1997; Ballantine, 1999a); nationally (Muldoon, 1995; Thackway, 1996c; Thackway and Cresswell 1996; ANZECC 1999a) and at the State level (e.g. Environment Conservation Council, 2000; Marine and Marine Industries Council, 2000) as the preferred design framework to ensure that an MPA system functions to protect ecosystems and their component biodiversity.

A bioregional approach provides a systematic basis for recognising and understanding broad scale biophysical and ecosystem patterns, and a consistent framework for developing regional conservation and management strategies. The bioregional approach assists in the classification of areas that are regionally representative, so that the chosen protected areas may therefore contribute significantly to the MPA system at both national and state levels. Because marine biogeographical regions have major differences in their biota, the conservation benefits of a MPA system can only be optimised by representing all bioregions in the system.

IMCRA regions and boundaries were developed using mainly Geographical Information System (GIS)-based physical and oceanographic data sets as ‘surrogates’, supplemented by various biological data sets, in the absence of more detailed ecological and habitat data (see IMCRA Technical Group, 1998). IMCRA uses both:

- a qualitative approach in which experts for each jurisdiction provided marine physical and biological data for inclusion in the IMCRA classification; and
- quantitative, analytical methods of biophysical classification.

The marine bioregions (see **Appendix 2** for descriptions) provide a framework for ecosystem management through the South Australian Government’s Marine Planning Process, and also through the development of the South Australian Representative System of Marine Protected Areas (SARSMPA), which is discussed below.

4 Rationale for the South Australian Representative System of Marine Protected Areas

Marine biodiversity within South Australia's jurisdictional marine environment, encompasses dozens of habitat types, thousands of species, and millions of individual plants and animals. Limiting marine conservation efforts to single species and habitat types serves only to protect a small number of taxa, and a small number of areas, hence the need to focus on protecting systems at a variety of scales, from assemblages and communities at smaller scales, through to larger scales such as broadly defined 'habitat types' / 'ecosystem types' within bioregions (Ray and McCormick-Ray, 1992; Edyvane and Baker, 1995; Baker, 2000; Ponder *et al.*, 2002).

The preferred approach is to have a network or system of MPAs that contains, as *one* of its primary features, samples all of the major habitat types in each biogeographic region, thus protecting whole suites of taxa by protecting their habitats.

The South Australian Marine and Estuarine Strategy recognised that:

- *the present MPA system does not represent and conserve the State's marine biodiversity;* and
- *an essential component of any marine and estuarine strategy is the protection of marine habitat, species assemblages, individual species and genetic resources.*

(South Australian Government, 1998, page 24).

With the exception of the Great Australian Bight Marine Park, most of the existing MPAs in South Australia, listed in **Appendix 3,** were established with specific objectives, such as protection of nursery areas for economically important species such as scalefish, prawns or Rock Lobsters; protection of reef sites of high social value for diving; protection of habitat for pinnipeds such as the Australian Sea Lion, or to provide sites for research (see Neverauskas and Edyvane, 1993; Baker, 2000, and **Appendix 3** this report, for a more detailed overview of existing MPAs and the reasons for their designation). There is now a shift in emphasis from this *ad hoc* approach, towards a bioregionally and ecologically representative system of MPAs, which can serve a larger number of conservation objectives, and therefore contribute in a substantial way to biodiversity conservation across the state. Although some of the existing MPAs may ultimately contribute to the SARSMPA, they do not collectively provide a comprehensive, adequate and representative system in that:

- most bioregions are under-represented.
- many habitats / ecosystem 'types' are under-represented.
- most MPAs are too small to be effective (irrespective of their level of protection).
- most MPAs are relatively isolated from each other.
- most MPAs are not managed or assessed.

South Australia has an important opportunity to avoid some of the historical deficiencies in the terrestrial protected area system which, although accounting for almost 23% of the land, fails to represent all habitat types. As components of the marine environment are basically 'intact', there is opportunity to develop a system of MPAs that can more effectively conserve marine biodiversity than is occurring at present. Although there is no percentage target for the amount for area to establish as MPAs, **Table 1** gives an indication of the poor representation of most bioregions within MPAs, and lists some of the basic habitat types that are not yet well represented.

Table 1: Percentage of South Australia's Marine Bioregions currently protected

Bioregion	**% Bioregion (SA portion) within MPA**	**Broadly defined habitats that are under-represented or not represented**
Eucla	> 80	*(Eucla Bioregion is not being considered by State Government at this stage of the development of the SARSMPA)*
Murat	0.0	mangroves, seagrass, sand, reefs of various types
Eyre	0.1	sand, seagrass, reefs of various types
Spencer Gulf	< 0.1	mangroves, seagrass, sand, reefs of various types
Northern Spencer Gulf	1.6	sand, biogenic and other patch reefs, benthic mud habitats, seagrass
Gulf St Vincent	0.6	seagrass, reefs of various types, sand, benthic mud habitats, invertebrate-dominated habitats
Coorong	5.6	reefs, seagrass, sand
Otway	1.1	reefs of various types, sand, minor areas of seagrass

(adapted from Edyvane, 1999a)

N.B. The Eucla Bioregion, which contains the Commonwealth and State components of the Great Australian Bight Marine Park, is not being considered by State government at this stage of the development of the SARSMPA.

The following chapters provide some detail about the diversity of South Australia's coastal marine habitats and biota, and how that diversity can be better protected through the development of the SARSMPA.

5 South Australia's Marine Biodiversity

Ecosystem: a dynamic complex of plants, animals and micro-organisms and their non-living environment, interacting as a functional unit.

(International Convention on Biological Diversity)

Overview of Biodiversity

The simplest definition of marine biodiversity is the variety of life in estuaries, seas and oceans, from the small scale of genes up to the large scale of ecosystems. Biodiversity is expressed in:

- the genetic variability within a species (such as separate populations of the same species, which may have different rates of growth or reproduction, for example);
- the number of different species (e.g. more than 1200 species of marine macroalgae in southern Australia) and higher taxa (e.g. genera, families, phyla etc);
- the variety of definable habitat types, assemblages / communities and their component biota (such as the major differences in plant and animal assemblages that occur with increasing water depth and/or differences in wave exposure);
- the variety of ecosystem types and processes in the marine environment, related to all of the above, and the interactions that occur within and between ecosystems.

Contrary to popular belief, marine biodiversity is not just about the number of different species and the variation within them, but also about the different functions that marine organisms provide for each other in forming ecosystems. Ecosystems are complex because they are formed by a variety of interactions between species. Food webs are one important type of interaction, but species can provide a base for attachment, can alter current or light patterns, provide camouflage or other forms of shelter, or compete for space with other species - there are many other examples.

The term 'ecosystem' has been applied to interactions over a range of scales, from the local to the global. In the same way that a variety of species and processes interact to form ecosystems, smaller ecosystems interact and provide functions for larger ecosystems. For example, the fish species of a gulf ecosystem might be dependent on deeper-water ecosystems (for spawning adults) and mangrove ecosystems (for juvenile growth). Ecosystems provide functions beyond the sum of the parts, commonly described by scientists as 'emergent properties'. Each component plays a role in maintaining ecosystem function. Plankton, worms and lice can be just as important as whales, whiting and seadragons. Ecosystems are dynamic because of constantly changing physical conditions such as tides, storms, seasonal currents and other natural processes that cause shifts in the balance of component species.

Marine ecosystems are continually changing over periods of hours and seasons, but also adapt over decades and centuries to meet changing conditions. Genetic diversity (the 'building blocks' of life) allows species to evolve, and diversity of species ecological processes allows ecosystems to evolve. There are many functions of marine ecosystems and their component biota that humans are not yet even aware of, and more is being discovered every year. The proper functioning of the marine environment is dependant on its ecological integrity, which means that all ecosystem components are present and ecologically viable - for example, sufficiently numerous and undisturbed, so they may play their ecological role.

There are many direct and indirect benefits that humans derive from the biodiversity contained in marine ecosystems. These include:

- so-called 'ecological services': marine biodiversity is a carbon sink and has an important role in climate regulation; prevention of coastal and seabed erosion; breakdown and absorption of pollutants; maintenance of water quality; storage and recycling of nutrients/food sources for marine plants and animals, and even production of some kinds of sands and rocks;
- highly valued social and economic benefits, such as fisheries and other marine foods; marine industrial and medical products; opportunities for tourism, recreation, education and research; and intrinsic values.

(HORSERA, 1993; Commonwealth of Australia, 1996; Baker, 2000)

Biodiversity levels can provide a sensitive indicator to environmental change. Also, resource use and ecosystem function increase in areas where high biological diversity exists and is maintained (McGrady-Steed *et al.,* 1997; Emmerson *et al.,* 2001). Experimental work has shown that areas of high biodiversity may also be more resistant to invasion by exotic species (Stachowicz *et al.*, 1999).

We do not know exactly how diverse our southern Australian marine ecosystems are at species and genetic levels, nor all of the important ecological and biological functions of biodiversity. Nevertheless, we have a responsibility as marine users to be precautionary; to ensure that uses and developments in the marine environment are sustainable and well managed; and to guard against the depletion of marine biodiversity, so that marine ecosystems and their component biodiversity can thrive long into the future.

South Australia's marine environment is unique in both its physical and biotic diversity, which are strongly inter-related. The following sections provide a brief overview of some of the reasons for this diversity, and how it can be protected.

Physical Diversity in South Australia's Marine Environment

South Australia has been subject to many different evolutionary processes that have determined the present varied physical make up and oceanography of the middle part of the southern Australian coast. Physical factors have also contributed to the development of what is recognised as a unique and diverse marine biota in southern Australia, and South Australia in particular. Some of the physical factors that have shaped southern Australia's marine biodiversity include:

- the large continental shelf
- the long east-west, ice-free extent of the southern coastline (the longest stretch of south facing coastline in the Southern Hemisphere)
- the characteristic low nutrient status of Australia's coastal waters (low nutrient regimes can promote biodiversity)
- a period of geological isolation for over 65 million years, which has led to high levels of speciation and *endemism* (see below).

(Poore, 1995, Edyvane, 1999a)

South Australia has a long, varied marine and coastal environment, spanning a large latitudinal and longitudinal range (over 3500 km coastal length). South Australia's coastal marine environment encompasses a wide range of:

- coastal landforms and types (e.g. steep cliffs, intertidal platform reefs, shallow bays and estuaries, and sandy beaches);
- average sea surface temperatures (from 12°C to 25°C, with even higher temperatures during summer, in the 'inverse estuaries' that form the upper gulfs);
- depth gradients in coastal waters (ranging from broad shallow bays, such as those of the far west coast, to steep nearshore gradients and deep coastal waters, such as those of western Kangaroo Island, parts of southern Eyre Peninsula, and the offshore islands of the mid west coast);
- wave exposures (from coastal marine environments exposed to the full force of the Southern Ocean, to sheltered gulfs, and semi-enclosed bays);
- currents (from the fast tidal races of Backstairs Passage to 'quiet water' estuarine environments);
- salinities (ranging from the highly saline shallow waters of the far north of the gulfs, to normal oceanic salinities in many coastal marine areas exposed to the Southern Ocean);
- rock and sediment types and forms (e.g. limestone, granite, metamorphic rocks; mud, sand, rock rubble and shell).

The different physical environments are dominated by different plants and animals, forming a variety of ecosystem types and habitats.

South Australia's Marine Biodiversity

South Australia is positioned in the centre of a large biogeographical region known as the Flindersian Province (Womersley, 1990), and contains marine flora and fauna that are typical of that province, as well as biota that are characteristic of both the cold temperate marine areas of lower south-eastern Australia (i.e. the Maugean Sub-Province in Victoria and Tasmania), and the warm to cool temperate areas of south-western Australia.

Due to the evolutionary and biogeographic factors cited above that helped to shape the southern Australian marine environment (Womersley, 1990; Poore, 1995), as well as the great variation in the present geology, geomorphology and oceanography of South Australia, the marine and estuarine waters of this State (and indeed, all of southern Australia), contain some of the most unique biota and most biologically diverse groups found in the world (Edyvane, 1996c; Edyvane, 1999a).

Ecosystem/Habitat Diversity

South Australian waters contain some of the largest areas of highly productive temperate saltmarsh, mangrove, and seagrass habitats in existence (see Edyvane, 1996c), as well as many thousands of square kilometres of highly diverse macroalgae-dominated and invertebrate-dominated rocky reefs. Other marine habitats also occur in parts of South Australia, including 'gardens' of sponges and/or other sessile invertebrates; bryozoan-dominated beds, calcrete 'barrens', sandbanks and sand flats, and shell-dominated mud habitats, amongst others, in addition to many 'mixed habitats' composed of patches of seagrass and/or macroalgae and/or attached invertebrates. Each habitat type in South

Australia, as well as the gradationary areas between them, plays important ecological roles. There is a common misconception that areas of high benthic *species* diversity are more productive than other habitats, but this is disputable. For example, research in the southern hemisphere has shown that marine habitats that could be classed as ‘barren’ rocky flats are highly biologically productive, with rapid nutrient recycling, and are often feeding grounds for many species of small fish.

Many factors can influence the form and composition of marine habitats, and thus determine the types of organisms found in those habitats. The significant environmental variables have been discussed in **5.2**. Some of the main coastal marine habitat types known in S.A. include the following, some of which inter-grade:

- Estuaries / wetlands: which are of particular importance because South Australia is a dry State with little rainfall, and consequently there are very few estuarine areas with significant freshwater influences, compared with other States of Australia (see Edyvane, 1996c);
- Freshwater outputs to sea, such as river mouths (overlaps with estuaries / wetlands category, in many but not all cases), and groundwater discharges;
- Tidal flats with no freshwater influence (sandy, muddy and/or shelly in composition) – overlaps with estuaries/ wetlands category;
- Beaches of various compositions and exposures;
- Saltmarsh / samphire flats;
- Mangroves;
- Seagrass meadows, of various types, as pure stands or mixed beds, ranging from small, fine seagrasses such as *Zostera* (also sub-genus *Heterozostera*) and *Halophila*, to larger robust taxa such as species of *Posidonia* and *Amphibolis*
- Reefs. This is a very broad category, comprising reefs of various forms, compositions, exposures and/or covers. Reefs forms include intertidal and subtidal platforms, ledges, blocks, boulders, and cobble/rubble reefs. Reef in various parts of South Australia is composed of granite, metamorphic rocks, calcareous (e.g. limestone) rocks or biogenic materials. Shallow subtidal reefs are often dominated by one or more species of large brown macroalgae (some of many examples in various parts of S.A. include *Ecklonia radiata*, *Scytothalia dorycarpa*, *Macrocystis angustifolia*, *Acrocarpia paniculata*, species of *Cystophora* and species of *Sargassum*, and *Scaberia agardhii*) and/or mixed red, brown and/or green macroalgae of various sizes and forms. Some reefs are covered mainly with calcareous red algae. Deeper reefs are often dominated by invertebrates and red macroalgae where light still penetrates, and larger sessile invertebrates in deeper, darker-water areas. Coastal reefs in areas of fast current flow and/or with steep depth gradients can contain assemblages that are similar to those on reefs usually found in much deeper water;
- Benthic sand-dominated habitats (in some areas, without visible benthic cover, and in other areas, supporting sessile invertebrate cover, including various assemblages of ascidians, soft corals and gorgonian corals, bryozoa, sponges, and/or large molluscs such as Razorfish or Hammer Oysters);
- Both shallow- and deep-water sponge-dominated ‘gardens’;
- Benthic mud habitats, some with bivalve shells as the visually dominant fauna;
- Island habitats, of various sizes, forms and compositions. Island habitats contain a number of special features not found in other parts of the SA marine environment. For example, reefs around offshore islands provide a distinct type of habitat due to the often steep depth gradients, which therefore permit a variety of depth-related assemblages to exist in a relatively small area;
- Mixed habitats (e.g. granite boulders, interspersed with seagrass patches and sand).

The ecological significance of some marine habitat types is often cited, particularly seagrass beds and stands of macroalgae, and numerous examples are provided in some of the tables in section **9** of this document. Specific details of the ecological significance of seagrass beds and macroalgae will not be recounted here (for more detail, see Baker, 2000, Appendix 2, and references cited therein). In general, like terrestrial plant assemblages, stands of macroalgae and seagrass meadows are important for maintaining the biodiversity of all biota with which they are associated, as well as maintaining the 'health' of the nearshore marine environment. For example, amongst other ecological functions, these habitat types provide (i) both direct and indirect food sources for a large variety of commercial and non-commercial fish and invertebrates; (ii) shelter for fish and invertebrates from currents and storms; (iii) protection of marine biota from predators; (iv) sites for courting, mating and egg-laying; (v) larval "sinks", in which the structure of the vegetation assists settlement; (vi) nursery areas for many species of juvenile fish and invertebrates; (vii) substrate and "micro-habitat" for attached animals and epiphytes (which are also important food sources for larger fauna); (viii) protection of coasts from excess wave energy and erosion; (ix) nutrient sources for mineral-poor marine waters, following break-down and recycling of marine plant matter; (x) feeding areas for coastal birds and other fauna (e.g. invertebrates and insects in the beachwrack); (xi) protective rafts for larvae and small fish (which hide in detached floating macroalgae); (xii) water purification (i.e. algae and seagrass take up nutrients), (xiii) water clarifiers (e.g. rhizomes trap sediments and prevent their release into nearshore waters), and (xiv) sediment sources (for example, dead coralline algae that is epiphytic on seagrass blades, forms sand in some areas).

It is important to note that *all* marine habitat types have important ecological functions, even if the particulars of those functions require more investigation. For example, the ecological importance of "bare sand" habitat is often overlooked in environmental impact assessment, and in marine planning. Consequently, bare sand is a favoured habitat type for the siting of coastal / nearshore marine developments (such as boat harbours and canal estates, and aquaculture leases), and is also overlooked in determination of coastal impacts from dredging, trawling and other processes that damage benthic environments. Unjustifiably, "bare sand" habitats are sometimes considered to have "low conservation value" in environmental impact assessments (e.g. Fairhead et al., 2002; Cheshire et al., 2002), whereas vegetated reefs and beds of slow-growing seagrass species are accorded the highest conservation value, because some benthic impacts may prevent such plant species from re-establishing readily. Such reasoning ignores the potential impacts of damaging benthic undertakings (e.g. trawling, dredging, aquaculture lease siting) on a multitude of sand-dwelling invertebrates and site-associated bony and cartilaginous fish, for example. A brief overview of the ecological significance of sand habitat follows.

Generally, sand and other soft substrates provide habitat for some of the most basic life forms, such as amoebas, foraminifera, and large ciliates (an important food source for some invertebrates). Sand beds trap organic particles, which are also a food source for small crustaceans and many other invertebrates. In the ecosystem associated with sand-dominated habitat, numerous species of minute gastropod shells, mostly less than 5mm long, play important roles in food supply and nutrient recycling. A full list of marine biota that utilise marine and estuarine sand habitats in South Australia would be very large, but examples are provided in the following table. The species diversity of some groups, such as the bivalves, is rich in sand habitats. Bivalve shells are important secondary producers, particularly in sand and sand-gravel habitats. Some of the numerous small, sand-dwelling invertebrates ("meiofauna"), such as foraminifera, polychaete worms, small molluscs, and copepods and other small crustaceans, are an important food source for sand-dwelling fish species (e.g. Whiting species; Small-toothed Flounder, and numerous others), and also for macroinvertebrate species, with a notable example being Western King Prawn (Carrick, pers. obs., cited by PIRSA, 2003). Different sand habitats, which may appear superficially similar (and thus be categorised as “the same type” on a benthic habitat map), support different invertebrate assemblages, depending upon numerous factors, such as biogeography (e.g. warmer gulf water locations versus cooler south-eastern locations); sediment type (shelly rubble, coarse sand, fine sand etc); organic content; wave exposure level; and depth, amongst others.

Furthermore, there are numerous micro-habitats in sandy areas. For example, both living and dead shells of sand-dwelling molluscs are used as substrate by various species of macroalgae (e.g. the tropical species *Acetabularia calyculus*, which is also found in Gulf St Vincent), and by stalked and sessile invertebrates that require hard substrate for attachment. Some species of macroalgae that are found in sand habitats (e.g. *Caulerpa trifaria* and *Caulerpa cactoides*) bind the sand with their ramuli, and thus help to prevent erosion. Fine-scale oceanographic processes, for example the eddies that occur in many coastal sand beds, help to trap decomposing macroalgae and seagrass in areas of “bare” sand, and these clumps of decomposing vegetation provide feeding areas for invertebrates (such as small shrimps), and for juveniles of some fish species, which are also protected from predators in this “mobile micro-habitat”. Coastal sand habitats also provide feeding, breeding and/or sheltering areas for numerous fish and invertebrate species, and examples of such taxa are shown in **Table 2**.

Table 2: Examples of coastal / marine species that inhabit Intertidal and/or Subtidal Sand Habitats in South Australia

Worms **(various phyla)**	◆ various nemertean worms ◆ nematodes ◆ oligochaete worms ◆ various families of polychaete worms (e.g. onuphid, eunicid, opheliid, sabellid and pectinariid worms)
Crustaceans	◆ harpacticoid copepods (which are an important food source for juvenile fish); ◆ seed shrimps (ostracods); ◆ nebaliaceans; ◆ mantis shrimps (stomatopods); ◆ cumaceans; ◆ some amphipod species ◆ some isopod species ◆ Western King Prawn, and several other smaller temperate prawn species ◆ Wollongong Bug / Slipper Lobster ◆ Ghost Shrimp ◆ Galatheids (squat lobsters or “craylets”) ◆ Sand Crab ◆ Blue Swimmer Crab ◆ Various species of pebble crab
Molluscs	◆ Southern Calamari ◆ Lined Dumpling Squid / Striped Pyjama Squid (*Sepioloidea lineolata*) ◆ Southern Dumpling Squid (*Euprymna tasmanica*) ◆ Pale Octopus (*Octopus pallidus*) ◆ Sand Octopus (*Octopus kaurna*) ◆ Southern Keeled Octopus (*Octopus berrima*) ◆ the white mollusc *Philine angasi* (which has a thin, internal shell) ◆ the sand-dwelling Nudibranch *Armina cygnea* (which feeds on sea pens) ◆ the opisthobranch mollusc *Bulla quoyii* (Botany Bay Bubble Shell). ◆ Moon Shells (Sand Snails), such as *Natica sertata* and *N. subcostata*, *Sinum zonale*, *Polinices conicus*, *P. sordidus* and *P. incei*, *Eunaticina albosutura, and E. umbilicata*.

- Helmet Shells (*Cassis fimbriata, Semicassis pyrum*, *S. adcocki*, *S. semigranosum* and the rare species *S. sinuosum*)
- New Holland Spindle Shell *Fusinus novaehollandiae*
- Tun Shell *Tonna variegata*
- The Carrier Shell *Xenophora flindersi*, that attaches small shells and pebbles to its own shell, as a form of camouflage.
- Volute shells, such as the Desirable Volute or Much-Desired Volute *Amoria exoptanda* and the Wavy Volute *Amoria undulata*; Lightning Volute *Ericusa fulgetra*; Sowerby's Volute *Ericusa sowerbyi*, Marbled or Papillose Volute *Ericusa papillosa*; Cotton's Volute *Livonia nodiplicata*; False Melon Volute *Livonia mammilla;* Roadnight's Volute *Livonia roadnightae*; Kreusler's Volute *Notovoluta kreuslerae* and Verco's Volute *Notovoluta verconis*; Gunther's Volute *Nannamoria guntheri*, and the rare transparent volute *Notopeplum translucidum.*
- Dove Shells, such as *Anachis atkinsoni, A. beachportensis, A. cominelliformis*, *A. dolicha*, *A. fulgida*, *A. atkinsoni*, *A. remoensis* and the two endemic species *Anachis dolicha* and *A. fenestrata; Exomilopsis spica, Mitrella acuminata, M. austrina, M. axiaerata, M. dictua*, *M. lincolnensis* and *M. vincta; Zella beddomei; Retizafra plexa* and *R. calva.*
- Auger Shells, such as *Terebra jacksoniana*, *T. assecla*, *T. tristis*, *T. albida*; *Hastula brazieri*, *Duplicaria fictilis* and the endemic *Terebra scalariformis*.
- Wentletrap Shells, a group of turretted, strongly whorled shells that live in sand. Species in S.A. include *Cirsotrema* (*Propescala*) *translucidum* and the closely relaed *C*. (*P*). *valida*, *Epitonium delicatulum*, *E. acanthopleura, E. platypleura, E. godfreyi, E. jukesianum*, *Opalia granosa*, *Nodiscala subcrassa* (which is possibly the same species as *Opalia apostolorum*), *Problitora globula*, *Cirsotrema* (*Propescala*) *valida ,* and *Narvaliscala flindersi.*
- Typhine shells, such as *Siphonochelus syringianus*; *Typhina yatesi*, *Typhis philippensis*, and the endemic *Monstrotyphis bivaricata*.
- A number of Trophine Shells, mainly from deeper water (e.g. several species in the genera *Anatrophon*, *Apixystus*, and *Litozamia*).
- Turrid shells, such as *Austrodrillia saxea*, and the three endemic species *Austrodrillia agrestis*, *A. dimidiata* (= *achatina*), and *A. sublicata*; also *Splendrillia woodsi*, *Epidirona flindersi, E. quoyi*, and the endemic species *Epidirona beachportensis*, *E. jaffaensis* and *E. perksi.*
- Costellate Mitre shells, such as *Vexillum apicitinctum*, *V. australe, V. lincolnense, V. pellucidum* and *V. corallinum.*
- Volutomitrid shells, such as *Peculator bacatus*, *P. porphyria*, and the endemic *Microvoluta stadialis*.
- Some species of Olive Shell, such as *Alocospira petterdi*, *A. edithae*, and the endemic *A. beachportensis;*
- Numerous Marginellid shell species, such as *Alaginella borda* and *A. vercoi*; *Austroginella johnstoni* and *A. muscaria*; *Cystiscus alternana*, *C. angasi, C. connectans*, C*. cratericula, C. cymbalum, C. flindersi, C. freycineti, C. halli, C. incerta, C. minutissima, C. obesula, C. problematica, C. subauriculata,* and *C. thouinensis*; *Dentimargo allporti, D. jaffa, D. kemblensis, D. lodderae,* and *D. mayii; Gibberula diplostreptus* and *G. subbulbosa; Granulina elliottae; Mesoginella caducocincta*, *M. consobrina, M. gabrieli, M. olivella, M. schoutanica, M. strangei,* and *M. turbinata*; *Ovaginella ovulum, O. tenisoni* and *O. whani*; *Pillarginella columnaria*, *P. tridentata,* and *P. vincentiana; Volvarina haswelli* and *V. mustelina*.
- A number of Screw Shell species, such as *Gazameda iredalei* and *G. tasmanica*; *Turritellopsis neptunensis* and the endemic *T. kimberli*.
- The Kelp Shell *Bankivia fasciata* (which lives in sand habitat, but also in kelp beds), and the related species *Leiopyrga octona*, *Ethminolia vitiliginea* and *Talopena gloriola*.
- Nutmeg Shells (*Cancellaria spirata, C. granosa, C. lactea* and *C. purpuriformis*).
- Most species of Buccinid Whelks in S.A. (*Cominella torri, C. tasmanica,* and *C. eburnea*; *Dolicholatirus spiceri; Fax grandior; Fusinus australis; F. novaehollandiae* and *F. undulatus; Latirus pulleinei; Microcolus dunkeri; Penion mandarinus; Tasmeuthria clarkei*) and Dog Whelks (e.g. *Fusus bednalli*, *F. reticulatus*, *Nassarius ephamillus*, N. *jonasii, N. mobilis, N. nigellus, N. pauperus, N. pauperatus* and *N. pyrrhus*).
- Numerous species of minute gastropods in the families Cingulopsidae, Eatoniellidae, Rastodentidae, Barleeidae, Caecidae, Epigridae, Iravadiidae, Tornidae, Truncatellidae

and Vitrinellidae.

- A number of Oyster Drill shells and their relatives (e.g. *Bedeva paivae* and *Phyllocoma eburnea*)
- Nut Shells and Beaked Nut Shells. Examples of species in S.A. include *Nucula australiensis, N. pusilla*, *N. covra* and *N. beachportensis*; *Rumptuncula vincentiana*; *Leionucula dilecta flindersi* and *L. obliqua*; *Sarepta tellinaeformis*; *Nuculana crassa, Nuculana* (*Ledella*) *miliacea, N.*(*L.*) *curtior,* and the endemic *N.*(*L.*) *remensa; Nuculana* (*Poroleda*) *spathula; Nuculana* (*Propeleda*) *ensicula* and the endemic *Nuculana* (*Propeleda*) *typica*; *Nuculana* (*Scaeoleda*) *crassa*; and the endemic species *Nuculana* (*Scaeoleda*) *verconis* and *N*.(*S*.) *comita*
- The small, deeper water bivalve *Pseudoglomus verconis*
- The dark brown, elongate bivalve *Solemya* (*Solemya*) *australis*
- Limopsid shells, namely *Limopsis* (*Limopsis*) *penelevis and L. (L.) vixornata*, *Limopsis* (*Pectunculina*) *tenuiradiata, L.* (*P.*) *tenisoni*, *L.* (*P.*) *eucosmus, Lissarca rhomboidalis* and the endemic species *Limopsis* (*Pectunculina*) *forteradiata*
- The Manzanellid bivalves *Huxleyia concentrica* and *Nucinella hedleyi*.
- The Philobryid shells *Cosa pectinata*, *C. tatei*, *C. bordaensis*, *C. fimbriata* and the endemic species *C. tartiradiata* and *C. celsa*; *Notomyrtilus rubra*, and the endemic *Notomyrtilus robensis*; *Cratis cuboides*; *Micromyrtilus crenatulifera* and the endemic *M. francisensis*.
- Dog Cockles (*Glycymeris radians, G. striatularis, Tucetona flabellata, T. sordida* and several other species)
- *Amygdalum beddomei* (a sand mussel)
- Hammer Oyster *Malleus meridianus.*
- “Razorfish” (*Pinna bicolor* and *Atrina tasmanica*).
- Razor Shell *Solen vaginoides.*
- King Scallops *Pecten* spp.
- Queen Scallop *Equichlamys bifrons.*
- the Doughboy Scallops *Mimachlamys asperrima* and *M. famigerator.*
- the endemic scallop *Notochlamys hallae.*
- the small scallops *Mesopeplum anguineum* and *M. tasmanicum.*
- Native Oyster *Ostrea angasi.*
- the oyster-like shell *Monia zelandica.*
- Brooch Shells (*Neotrigonia margaritacea* and *N. bednalli*).
- Lucinid shells, such as *Callucina* (*Pseudolucinisca*) *lacteola*; *Codakia rugifera* and *C. perobliqua*; *Cardiolucina crassilirata*; *Myrtea mayi*; *Monitilora adelaideana* and the endemic *M. paupera*; *Divalucina cumingi*; and *Anodontia* (*Cavatidens*) *perplexa*.
- Galeommatid bivalves, such as *Kellia yorkensis*; *Mysella donaciformis* and *M. angasiana*; *Marikellia solida*; the small bivalves *Cyamiomactra mactroides* and *C. communis*; the endemic bivalve *Montacuta meridionalis* and the parasitic bivalve *M. semiradiata*; *Lepton* species, such as *L. ovatum*, and *L. subrostratum*; *Myllita* (*Myllita*) *tasmanica*, *M*.(*M*). *deshayesi*, the endemic *Myllita* (*Myllita*) *bethicola*; *M*. (*M*). *gemmata*, and the endemic bivalves *Ephippodonta* (*Ephippodonta*) *lunata* and *Ephippodonta* (*Ephippodontoana*) *macdougalli*, the latter three of which live in burrows made by a small species of prawn.
- Neoleptonid bivalves, such as the small bivalves *Austrocardiella isosceles*, *Condylocardia notoaustralis, C. limaeformis*, *C. pectinata*, *C. rectangularis*, *Diplodonta subrotunda*, *Hamacuna hamata*, *Ovacuna atkinsoni*, *Propecuna obliquissima* and *P*. *subovata, Warrana comma, W. edentata,* and *W. sessens,*; *Cunanax crassidentata* and *C. subradiata*.
- The Sportellid bivalve *Anisodonta subalata.*
- The Corbulid bivalves *Corbula* (*Notocorbula*) *stolata* and *Corbula* (*Serracorbula*) *coxi* and *C*. (*S*). *verconis*
- Cardita Shells, such as 3 species of “*Verenicardia*”; *Carditella* (*Carditella*) *subtrigona*, *C*. (*C*.) *valida* and *C*. (*C*.). *vincentensis*; *Cardita excavata; Cyclocardia* (*Vimentum) dilectum, C.* (*V*)*. delicatum, C.* (*V.*) *jaffaensis, C.* (*V.*) *calva* and *C.* (*V.) excelsior.*
- Crassatella Shells, such as *Eucrassatella kingicola* and *E. donacina*; *Salaputium micra*, *S. producta*, and *S. probleenmum*; and the endemic crassatellids *Talabrica angustior* and *T. carnea*
- true Cockles, such as *Fulvia tenuicostata*, *Acrosterigma cygnorum,* and *Nemocardium* (*Pratulum*) *thetidis*
- Trough Shells, such as *Mactra (Electomactra) antecedens*; *Mactra (Nannomactra) jacksonensis*; *Mactra* (*Austromactra*) *contraria*; *Mactra (Mactra) pura* and *M.* (*M.*)

	australis; Spisula (*Notospisula) trigonella; Lutraria* (*Psammophila) rhynchaena*, and the endemic *Raeta meridionalis*. ◆ Wedge Shells, such as *Paphies* (*Amesodesma*) *elongata* and *P*.(*A*.) *cuneata*; *Anapella cycladea* and *A. amygdala* ◆ the File Shell *Limatula* (*Stabilima) jeffreysiana iredalei* and the endemic File Shell *Limea* (*Gemellina*) *austrina* ◆ Tellin Shells, such as *Tellina albinella*; *Tellina* (*Macomona*) *deltoidalis, T.*(*M.*) *margaritina,* and *T*.(*M.*) *imbellis; Tellina* (*Abranda*) *modestina, Tellina* (*Semelangulus*) *tenuilirata* and *T*.(*S*.) *semitorta, Tellina* (*Cyclotellina*) *umbonella, Tellina* (*Pseudarcopagia*) *victoriae*; ◆ Goolwa Cockle / Pippi, *Donax* (*Plebidonax*) *deltoides,* and other pippi species, namely *Donax (Deltachion) electilis* and the endemic *D. (Tentidonax) francisensis* ◆ other Pippi species, such as *Donax* (*Deltachion*) *electilis* and *Donax* (*Tentidonax*) *veruinus* ◆ Sunset Shells, such as *Soletellina biradiata* and *S. alba*; *Gari* (*Psammobiai*) *kenyoniana*, *G*.(*P*.) *livida* and *G*. (*Gari*) *modesta.*; ◆ Semelid shells, such as *Abra* (*Syndosyma*) *exigua*, *Semele monilis* and the endemic *Semele ada.* ◆ The unusual shells in the Clavagellidae family, members of which have valves that are fused to, or partially concealed by, a bulbous, calcareous tube. Examples from S.A. include *Humphreyia strangei*; *Clavagella* (*Clavagella*) *multangularis* (also occurring as an Eocene fossil in S.A.), *Brechites* (*Brechites*) *vaginiferus australis* and *Brechites* (*Foegia*) *veitchi*. ◆ Burrowing / sand-boring bivalves in the Gastrochaenidae, such as *Gastrochaena* (*Gastrochaena*) *cuneiformis* and *G.* (*G*.) *tasmanica*; and *Panopea australis.* ◆ Thraciid bivalves, such as *Thracia* (*Thracia*) *speciosa*, *T*. (*T.*) *myodoroides*, *T*. (*T*.) *lincolnensis* and the endemic *Thracia* (*Thracia*) *concentrica*; *Phragmorisma watsoni*; *Thraciopsis peroniana*, *T. subrecta* and *T. flindersi.* ◆ Laternulid bivalves, such as *Laternula* (*Laternula*) *laterna*, *L*. (*L.*) *creccina*, and *L*. (*L.*) *rostrata.* ◆ the southern Australian bivalve *Parilimya tasmanicia,* which has sand grains embedded in the shell surface. ◆ Bivalves with a broad depth range, such as *Verticordia bordaensis*, *Spinosipella ericia*, and the endemic *Haliris* (*Haliris*) *jaffaensis.* ◆ the widely distributed Periplomatid bivalve *Periploma* (*Offadesma*) *angasi* and the widely distributed Poromyid bivalve *Poromya (Poromya) illevis*. ◆ Species of *Myadora* bivalve, such as *M. brevis*, *M. complexa*, *M. rotunda*, *M. elongata*, *M. albida*, *M. antipodium*, *M. pervalida*, and the endemic *M. delicata*, which also occurs in deep waters. ◆ Cuspidariid bivalves, such as *Pseudoneaera trigonalis*, *Cuspidaria* (*Cuspidaria*) *exarata*, *C*. (*C*.) *halei* and the endemic *C*. (*C*.) *occidua; Cuspidaria (Rhinoclama) alta*, *C*. (*R*.) *dorsirecta* and the endemic *C*.(*R*.) *simulans*, and the deep water species *Halonympha ros* and *Cardiomya (Cardiomya) pinna*. ◆ Venus Shells (a large family, with many sediment-dwelling species, such as *Bassina* (*Bassina*) *pachyphylla* and *Bassina dijecta* (Frilled Venus Shell); the Mud “Cockles” *Katelysia scalarina*, *K. peronii* and *K. rhytiphora*; and numerous other venus shell species such as *Antigona* (*Periglypta*) *puerpera, Callista* (*Notocallista*) *kingii* and *C.*(*N.*) *diemenensis*; *Circe* (*Circe*) *rivularis*; *Dosinia victoriae*, *D. crocea*, *D. circinaria*, and the endemic species *Dosinia diana*; *Eumarcia fumigata*; the endemic *Gouldia* (*Gouldiopa*) *francisensis*; *Gomphina undulosa*; *Irus carditoides* and *Irus* (*Notopaphia*) *griseus*; *Placamen placidum* and *P. flindersi*; *Sunetta vaginalis*; *Timoclea* (*Chioneryx*) *cardioides*; *Tawera spissa*, *T. gallinula* and *T. lagopus*; *Venerupis anomala* and *V. galactites.*
Echinoderms	◆ Southern Sand Star *Luidia australiae* ◆ *Anthaster valvulatus* ◆ *Astropecten preissi* ◆ *Astropecten vappa* ◆ *Bollonaster pectinatus* ◆ Eleven-armed Sea Star *Coscinasterias muricata* ◆ the Brittle Star *Ophiura kinbergi* ◆ the Hat Urchin *Peronella peronii* ◆ the Heart Urchins *Echinocardium cordatum* and *Moira lethe* and *Brissus agassizii*

Ascidians	◆ Bagpipe Ascidian *Polycarpa viridis* ◆ The solitary ascidian *Ascidia sydneiensis* ◆ The stalked ascidian *Sycozoa pulchra*
Bony Fish	◆ Sand (School) Whiting ◆ Yellow-eye Mullet ◆ Sea Mullet ◆ Congolli ◆ Sand Flathead ◆ Yank Flathead and other flathead species ◆ most species of flounder (e.g. Small-toothed, Long-snouted, Spotted, Elongate, Greenback, and other flounders) ◆ Southern Sole ◆ Southern Tongue Sole ◆ Silverbelly ◆ Silverbiddy ◆ Blue-spotted Goatfish ◆ Common Stinkfish ◆ Smooth Toadfish ◆ Prickly Toadfish ◆ Orange-barred Pufferfish ◆ various species of Hardyhead ◆ Warty Handfish ◆ Common Stargazer ◆ Sculptured Seamoth ◆ Little Scorpionfish ◆ several species of Gurnard ◆ many of the Goby species (e.g. Marine Goby, Bridled Goby, Fray-finned Goby, Long-finned Goby, Groove-cheek Goby) ◆ Beaked Salmon (a burrowing fish) ◆ Serpent Eels (burrowing fish) ◆ Worm-eels (burrowing fish)
Cartilaginous Fish	◆ Angel Shark ◆ Tasmanian Numbfish ◆ Fiddler Ray ◆ Shovelnose Ray ◆ Eagle Ray ◆ Smooth Stingray ◆ Black Stingray ◆ various species of Skate (e.g. Thornback Skate; Pygmy Thornback Skate; Whitley's Skate; Melbourne Skate; Peacock Skate; Southern Round Skate; White-spotted Skate) ◆ various species of Stingaree (e.g. Western Stingaree; Banded Stingaree; Sparsely-spotted Stingaree; Bight Stingaree; Wide Stingaree).
Other	◆ Numerous taxa in the phylum Foraminifera ◆ some species of Oribatid and Halacarid mites ◆ the anemone *Epiactis australiensis* (e.g. found in shallow sand habitats in central and eastern South Australia) ◆ the Sea Pen *Sarcoptilus grandis* ◆ Phoronid Worms ◆ Some species of Acorn Worm (phylum Hemichordata)

(compiled from: Shepherd and Thomas, 1989; Ludbrook and Gowlett-Holmes, 1989; Lamprell and Whitehead, 1992; Wilson et al, 1993; Wilson et al., 1994; Gomon et al., 1994; Lamprell and Healy, 1998; Edgar, 2000; Australian Government Department of the Environment and Heritage, 2003b, and references therein).

Species Diversity, and Endemism

***Biological diversity**: the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.*

(International Convention on Biological Diversity, and the National Strategy for the Conservation of Australia's Biological Diversity)

There are high levels of species diversity in southern Australia's marine environment, including South Australian waters. For example, of the thousands of invertebrate species in our State waters, some groups are particularly rich in species, including the bryozoa (lace 'corals'), ascidians ('sea squirts'), echinoderms (sea stars, urchins, brittle stars, feather stars, and sea cucumbers), sponges, and some of the molluscs (e.g. sea slugs; and bivalves and gastropod shells, including rare shells, and some with tropical affinities). Lesser known groups of high diversity in S.A. include brachiopods (ancient 'lamp shells'), pycnogonids (sea spiders), soft corals, hydroids (small stalked animals, in the same phylum as corals, anemones and jellyfish), and a variety of marine worm groups.

In South Australia's coast and marine jurisdictional waters, some examples of the diversity within marine groups include the following (N.B. see Appendix 4 for more details about the species diversity of marine mammals, bony and cartilaginous fish, and invertebrates in South Australian waters):

- Most of the 1200+ species of red, brown and green macroalgae that occur within the southern Australian Flindersian Province, including uncommon tropical and sub-tropical species of greens and browns that occur in very limited parts of South Australia, as well as cold temperate species (mainly red, and some brown species) shared with Tasmania. Some of the larger species of macroalgae are often the dominant cover on reefs in South Australia, providing habitat for a variety of fish, invertebrate fauna, epifauna, and microbiota.
- Around 17 species of marine and estuarine seagrasses, of which species in the marine genus *Posidonia* are particularly well represented;
- Most of the 220+ species of ascidians ('sea squirts') that are found in southern Australia, including around 45 species that are considered to be endemic within South Australian waters;
- More than 250 species of marine bivalve molluscs, at least 30 of which appear to endemic to South Australia, based on currently known distributions;
- More than 470 species of gastropod molluscs, including at least 30 species which appear to be endemic to S.A., based on currently known distributions. This figure does not include the minute gastropods of 5mm or less, hence the species diversity may be higher than 500 if such species were included;
- More than 150 species of marine sponge;
- Hundreds of recorded species of bryozoa ('lace corals'). Bryozoa contribute significantly to sea floor sediment production, and are also a food source for some marine animals, and provide an area of attachment ('micro-habitat') for others;
- Many dozens of nudibranch (colourful 'sea slug') species;
- More than 720 species of fish (South Australian Museum, 2002), including a number of species endemic to southern Australia; various migratory and 'vagrant' species from other parts of Australia or overseas; and a number of deep water species. In South Australia, at least 457 species of fish occur within the range from shore to 200m deep, and these are detailed in Appendix 4;
- Over 70 species of seabirds, including migratory species;

- 5 species of marine mammal (breeding in S.A.), plus another 32 marine mammal species which visit S.A. waters, most very irregularly but some seasonally.

The figures above are present estimates, however more species in southern Australian waters are being discovered all the time. For example, two new cephalopod species have been recently described, one known only from south-eastern Australia (the Southern White-Spot Octopus *O. bunurong*), and the other, the Lace Bottletail Squid (*Sepiadarium* sp.), recorded only in the shallow areas of South Australia's two gulfs (Norman and Reid, 2000). A recent scientific investigation of St Francis Isles and surrounds as part of *Encounter 2002*, documented abundant new species of jelly fish (L. Best, DEH, pers. comm., 2002; Gershwin and Zeidler, 2003).

Many unique life forms have evolved in southern Australian waters (including some known only from South Australia) - these species are not found anywhere else in the world, and are thus classified as *endemic*. Studies of the endemism in marine fauna (Wilson and Allen 1987, cited by Poore, 1995, cited by Edyvane, 1996e) and flora (Womersley, 1990; Poiner and Peterken, 1995) in southern Australia have shown that 75% of red macroalgae, 85% of fish, 90% of echinoderms, 95% of known molluscs (although some have yet to be described) and almost all of the seagrasses, are endemic to southern Australian waters. This contrasts with around 10% -15% of tropical species from the same marine faunal group being endemic to northern Australian waters (Wilson and Allen 1987, cited by Poore, 1995 and Edyvane, 1999a).

South Australian waters are also home to a large variety of species fished by commercial and recreational fishers, such as scalefish (e.g. Snapper, King George Whiting, Yellow-fin Whiting, School Whiting, Yellow-eye Mullet, Tommy Ruff, Southern Sea Garfish, West Australian Salmon, Flathead and flounder species, and many others), and invertebrates such as Southern Rock Lobster, Blue Swimmer Crabs and Sand Crabs, Greenlip and Blacklip Abalone, Mud Cockles and Goolwa Cockles, Razorfish, Southern Calamari, and Scallops, amongst other marine invertebrates. 'Popular' species with high 'public profiles' for eco-tourism are also found in most parts of South Australia, such as Leafy and Weedy Seadragons, Fairy Penguins, Giant Cuttlefish, Western Blue Groper, Great White Sharks, New Zealand Fur Seals and Australian Sea Lions, Bottlenose Dolphins, and Southern Right Whales.

Appendix 4 lists the marine mammals, sharks and related fauna, bony fish, coastal and marine birds, and marine reptile species that are found in the continental shelf waters of South Australia, and outlines their conservation status, according to IUCN listings, and Commonwealth and/or State legislation. A number of invertebrate groups are also included in Appendix 4, illustrating the species diversity of the sponges, molluscs, brachiopods, echinoderms and ascidians in South Australian waters. Many of the species in Appendix 4 are mentioned in the tables of this report, in relation to the ecological attributes of the recommended areas.

6 Identification of a Set of Representative Areas

Whilst the first requirement for developing the SARSMPA is to establish a Statewide strategy with clear goals (see South Australian Government, 1998 and South Australian Government, 2002), the next step is to develop a framework and set of criteria to guide MPA selection, planning and management. Identifying potential MPAs for a representative system involves compiling and evaluating available scientific information to identify biogeographically and ecologically representative locations, and applying some basic principles for identification and selection.

In 2000, the then Department for Environment, Heritage and Aboriginal Affairs, in partnership with Primary Industries and Resources South Australia, commenced work on a project that provides a technical assessment of the known values of a number of marine locations across South Australia, in terms of their contribution to a bioregional-based, ecologically representative system of MPAs. The project was initially funded by the Commonwealth's Coasts and Clean Seas, as part of South Australia's contribution to the National Representative System of Marine Protected Areas, with the objective of meeting the South Australian Marine and Estuarine Strategy's key requirement for protecting marine habitats and their biodiversity:

Use interim guidelines for establishing the national system of MPAs, the IMCRA methodology and existing marine habitat maps, to identify and recommend areas of South Australian waters to be part of a system of MPAs.

This report discusses the results of this project.

6.1 Background

In the past decade, there has been considerable progress towards the identification of potential locations for a South Australian Representative System of MPAs (SARSMPA), initially through the Commonwealth Government's 10-year *Ocean Rescue 2000* program. Three key components of the *Ocean Rescue* program in South Australia entailed:

(i) the production of a draft Green Paper on Marine Protected Areas during 1991-1993, which provided a detailed summary of marine protected areas in South Australia; documented the physical, ecological, social and economic values of locations in each coastal geo-morphological province across South Australia, including the nearshore marine area; and highlighted gaps in the knowledge of habitat distribution, required to be filled prior to the development of the SARSMPA (Edyvane and Nias, unpublished report chapters, and Edyvane, 1999b);

(ii) a series of benthic surveys undertaken across South Australia between 1992 and 1997, to document nearshore benthic habitats, as part of the Commonwealth's *Ocean Rescue 2000* program (Edyvane and Baker, 1995, 1996a, 1996b, 1996c, 1998a, 1998b, 1999a, 1999b, 1999c);

(iii) the formation, in 1991, of a 30-member scientific South Australian Marine Protected Areas Working Group (SAMPAWG) of scientists, to nominate areas of high conservation value for potential protection as MPAs. Recommendations from members of that working group were supplemented by a limited period of public submission to government, recommending areas of high environmental and/or social value. All of the 'forementioned processes culminated in the report *Conserving South Australia's Marine Biodiversity*, SARDI Research Report Series Numbers 38 and 39 (Edyvane, 1999a and 1999b).

Within the eight South Australian IMCRA bioregions, the SARDI report (Edyvane, 1999b) developed a more detailed classification level, termed 'biounits' (devised by Ortiz, 1992; see also Ortiz and Pollard, 1995), and based upon the concept of hierarchically-scaled ecosystem patterns. For South Australia, the biounit classification was based largely upon existing biophysical information gathered as part of South Australia's contribution to the Commonwealth IMCRA planning process, complemented by: (i) information provided by the SAMPAWG; and (ii) data collected from the State-wide Benthic Survey Program. To some extent, the biounit classification reflects the variety of geological, geomorphological, oceanographic and major ecological features within each bioregion, and divides the coastal marine waters into sections, based on practical boundaries. Thirty-five biounits were classified for areas within S.A. waters (Edyvane, 1999b).

A preliminary list of potential MPAs was prepared in South Australia (SARDI Research Report Series No. 39, Edyvane, 1999b), using a 'Delphic' (group expert) approach, drawing upon information supplied by members of the SAMPAWG during the early 1990s. Ninety-six potential MPAs were identified as part of this process, representing all bioregions and portions of all 'biounits' (see section Error! Reference source not found.). Within each biounit, a set of ecological, cultural and socio-economic criteria advocated by Kelleher and Kenchington (1992) was applied to summarise the 96 potential locations. A preliminary IUCN classification, implying a specified level of protection and management, was applied to each of the nominated areas (see Edyvane, 1999b). **Appendix 5** describes the IUCN Protected Area Management Categories.

The SARDI Report 39 described above also provided a detailed overview of many of the major biogeographical features, ecological and social values of substantial portions of the South Australian marine environment, and provided a useful technical starting point for identifying potential MPAs for an ecologically representative system.

6.2 The Current Approach

The South Australian Government has adopted a bioregional framework for identifying areas for the SARSMPA. The IMCRA bioregion framework, and generally defined biounits within bioregions, is a practical way for identifying the 'broad-scale' components of a representative system of MPAs. However, further work has been undertaken to determine the distribution of finer scale habitat types and key biota within each bioregion, in order to satisfy the principles of both the NRSMPA (**Appendix 1**) and the SARSMPA (see below), and to make use of many other available and appropriate data sources.

The designation of a large number of small MPAs (some of which were previously identified during the early 1990s primarily due to a single ecological or biological feature / conservation value) is considered to be imprudent in terms of both designing and managing MPAs for the representative system. Additionally, and in keeping with the requirements of the Commonwealth's NRSMPA, the use of many socio-economic and pragmatic criteria is considered by the S.A. Government to be inappropriate at the initial stage of identifying areas for a bioregionally representative system, as is the assignment of potential IUCN Protected Areas categories. Application of such criteria is more pertinent to the final selection and zoning of MPAs through comprehensive community consultation.

In light of this, the previous approach to identifying candidate areas (see SARDI Research Report Series No 39), has been reviewed. A number of areas within larger regions are now recommended, in order to:

- propose larger, zoned areas for the system, to protect larger scale ecological processes, and to bring uses and impacts within those areas under an integrated management regime.
- focus on ecological criteria at this stage, in order to ensure a more complete representation of biodiversity values within the recommended areas. This will set the scene for a thorough, participatory application of socio-economic criteria as part of each MPA proposal, and the subsequent management planning process. Similarly, no IUCN classifications are being recommended at this stage, as the management objectives of an area will not be determined until the specific proposal and management planning phases are undertaken for each focus area;
- develop a suitable and valid set of criteria to apply the ecological principles of the NRSMPA;
- use a large number of additional and appropriate data sets and information sources to document coastal marine habitat types and biota within bioregions, which will assist in the development of an ecologically representative system.

The South Australian Scientific Advisory Group on Marine Protected Areas (SAG) was established in 2000 to assist with process of identifying areas for the SARSMPA, and consisted of representatives from SARDI Aquatic Sciences, University of Adelaide and Flinders University, and the South Australian Museum. Collectively, this group had expertise in the fields of marine ecology and biology, marine geology, commercial and recreational fisheries research, and marine invertebrate research. In providing advise on the design of potential MPAs, this group accepted the model that an MPA would be a multiple-use area, with ***"core" highly-protected areas***, surrounded in some cases by buffer areas to provide additional protection for the "core" areas. It is noted that Australian Marine Science Association (AMSA, 2002) also specified the need for "core" highly protected areas within the National Representative System

6.3 Key Ecological Principles for the SARSMPA

A number of key ecological principles underpin the development of the NRSMPA, and these principles were applied to the development of a bioregional, ecosystems-based South Australian Representative System of MPAs. They are as follows:

6.3.1 Bioregional Framework

The MPA system in South Australia should be developed within the framework of marine bioregions. MPAs forming part of the network in South Australia should primarily represent the variability of major ecosystems/habitat types within and between each bioregion; and all bioregions should be represented in the system. The rationale for developing a bioregional system is discussed in **Chapter 3**.

6.3.2 Representativeness

ANZECC (1999b) defined representativeness as the need for: *those marine areas that are selected as MPAs to reasonably reflect the biotic diversity of the marine ecosystems from which they derive*. In the absence of more complete knowledge of the biodiversity of marine ecosystems, representativeness can be interpreted as: the extent that sites identified for protection reflect known biological diversity, biophysical and ecological patterns, processes, and (related) features, at various scales (Brunckhorst, 1993).

Those areas to be selected for declaration as MPAs in South Australia should reasonably reflect the known biotic diversity of the larger ecosystems that they 'represent', with provision for modifications and additions to the system in light of further knowledge.

Areas chosen for the system should collectively encompass the broadest practicable range of variation in: depth; wave exposure levels; current strengths; sea surface temperature; substrate type; benthic topography and known habitat types. Although this may be achieved over a number of areas, it is efficient to include areas that do contain a high diversity of habitat types, which is one surrogate for finer scale biodiversity protection. Similarly, areas that contain a high diversity of species or higher level taxa (e.g. phyla) will improve the both the *representativeness* and *comprehensiveness* (see below) of the SARSMPA.

An effective system of MPAs that serves to protect ecosystems and the biodiversity within and between them, cannot be limited only to representing examples of simplified, mappable habitat types that are 'typical' of a specified area, such as a bioregion. There are many other requirements of an ecologically representative system, and these are discussed in the following section, under *Comprehensiveness*.

Limitations of the Representativeness Principle:
Representativeness is commonly perceived to mean that the network of MPAs should comprise areas containing habitat type(s) that are 'typical' of those that occur at a defined scale (e.g. biogeographic region, or at a finer scale within a bioregion). Representative habitats usually cover a large area, and support major ecological functions within a biogeographic region. However, according to the Commonwealth's definition, a representative system also includes 'atypical' (unique) habitat types; rare and threatened habitat types; habitat for rare and threatened species, and areas of known special importance (spawning/breeding areas, nurseries). Ideally, the development of a representative system requires a good quality ecosystem/habitat classification based on physical and biological data, which to date has not been developed in South Australia.

In theory, developing a truly 'representative' system of MPAs also requires knowledge of the distribution, diversity, abundance, habitat linkages, population dynamics and conservation status (e.g. rarity, and degree of threat) of major groups of marine flora and fauna in each bioregion, as well as 'keystone' and 'special' species within those groups. This is clearly a major data requirement, and, similar to the case in other states and territories, there are still major gaps in marine knowledge/data in South Australia. Despite these limitations, marine research has amassed a significant quantity of relevant data/information during the past three decades, and such data are being used in the development of a representative system.

It is recognised that representing mappable habitat types is insufficient in developing an ecologically representative system of effective MPAs, and that the system must include additional sites of outstanding conservation value(s) that have been identified using other established biogeographic, biophysical, ecological, and other identification criteria, in addition to 'representativeness'.

The representativeness of a protected area system in South Australia is expected to improve over time, as better marine knowledge develops.

6.3.3 Comprehensiveness

According to the Commonwealth's (ANZECC TFMPA 1999a) definition, *comprehensiveness* refers to the system containing, if possible, (samples of) *the full range of ecosystems recognised at an appropriate scale, within and across each biogeographic region*.

ANZECC considers "ecosystems" to be represented by definable (preferably mappable) habitat types, although it is recognised that ecosystem function and the maintenance of ecosystem "integrity" transcend the boundaries of definable habitats, at all scales.

Within each bioregion, this should include samples of 'typical' habitat types (*representativeness*) as well as 'unique' and 'rare' areas that are irreplaceable[1], due to their biogeographic, biophysical, ecological and/or biological attributes not being represented in any other known area.

A comprehensive system would protect habitats and species that are not only 'typical' of a bioregion, but also those that are biogeographically significant (as discussed in **Section 6.4**), rare, threatened, depleted or special[2]. Also important are areas of high significance for breeding/spawning, feeding, aggregation and/or development of major marine groups and/or specific taxa of special conservation significance. A comprehensive system would also include areas of known high biological productivity, areas with a high diversity of habitat types, and areas containing high taxonomic diversity. Many of the important ecological criteria that should be considered in developing a CAR system, are discussed in section **6.4**.

Limitations of the Comprehensiveness Principle

Comprehensiveness is a principle with a variety of interpretations. According to Brunckhorst (1993), comprehensiveness refers to *the degree to which the protected area system encompasses the entire variety of biological species and communities, ecological attributes, and physical features, on a nationwide basis, as evaluated against national criteria*. The Commonwealth Task Force on Marine Protected Areas (ANZECC, 1999a) recommended that the 'full range of ecosystems' be represented, defining ecosystems as *mappable units encompassing a community of associated organisms and their surrounding environment*s. ANZECC (1999b) recommended that the type, extent and location of marine ecosystems be defined and mapped in each state, and that an example of each ecosystem, habitat and community (i.e. a comprehensive set) be included in the NRSMPA.

There are practical limitations to implementing this principle in any state or territory, including South Australia. It is desirable that a systematic, scientifically defensible and ecologically relevant marine ecosystem type / habitat classification be developed in South Australia. However, it is recognised that this may not occur within the time frame required for the initial development of the South Australian system of MPAs. In the event that an ecosystem / habitat classification is developed, it is unlikely that the Commonwealth's goal of representing

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[1] Note: Irreplaceability also relates to the level of both 'natural' and human-induced impacts / threats to which existing and potential new MPAs are subjected. Assessment of impacts and threats (both regional and local) is therefore required for each region in which existing and potential MPAs are established.

[2] For example, in the case of species, this includes those with complex habitat requirements or mobile or migratory species, or species vulnerable to disturbance (ANZECC, 1999a,1999b).

examples of ‘each ecosystem, habitat and community’ could be met, because simplified ecosystem classifications do not consider:

- the variety of community types that occur at finer scales within those major ecosystem/habitat categories; and
- the fact that mappable habitat types are expedient simplifications for comparing areas which, in many cases, are not equivalent in ecological composition or function.

Furthermore, there are many socio-economic and practical limitations against selecting examples of each ‘ecosystem, habitat and community’ in any State, for the protected area system. For example, particular examples of some ‘types’ may not be available for reservation, for a number of reasons - the location and nature of the areas may make them impractical for priority protection and management; the only examples of some habitats types may be highly degraded; and/or particular habitat examples may not be publicly accepted for inclusion in the protected area network for numerous economic and/or social reasons.

6.3.4 Adequacy

The system of MPAs in South Australia should, over the long term, contain areas which are of a size and level of protection to ensures that, collectively, they contribute as far as possible to *maintaining the ecological viability and integrity of communities, species and populations* (ANZECC, 1999a, 1999b). It is important to recognise that it may not currently be possible to develop a truly adequate system, using existing information. Developing an adequate system is an incremental process over time, based on MPA performance and the activities and impacts that occur within MPAs and surrounding areas over the longer term.

An adequate system of MPAs has regard to:

- the size of individual MPAs;
- the management of human impacts within and outside their boundaries;
- the needs of rare, threatened, depleted or ‘special’ species (e.g. having regard to their genetic diversity, population dynamics and habitat requirements) and rare and/or threatened habitat types;
- the number of examples of each ecosystem type needed to insure against natural or human-induced impacts (i.e. replication);
- the connectivity between the component MPAs, for example, in terms of oceanographic features such as currents, which are important in the transport of some migratory species, larvae and food sources, as well as pollutants.

Monitoring of Core Areas, as part of the Adequacy Principle

Adequacy in the system can be assisted if MPAs are also used as ‘control’ sites for monitoring biological, ecological and physical impacts. Monitoring is an important requirement in the management of highly protected areas, because it:

- helps in determining the effectiveness of the core, in terms of contributing to the Primary Goal of the MPA network and the stated objectives of establishing highly protected areas;

- may also provide valuable information regarding the functioning of marine ecosystems and the dynamics of specific biota that form part of those ecosystems;

- enables ‘core’ protected areas within large, multiple-use MPAs to function as ‘reference’ or ‘control’ sites, which may provide valuable information about the impacts of activities that occur outside the core, in equivalent habits, and/or upon equivalent taxa that are not ‘protected’ to the same extent as those in the core area. In other words, ‘core’ portions of MPAs can serve as ‘ecological benchmarks’ against which the effects of natural and human-induced impacts / disturbances can be assessed in less protected areas of similar types, where they exist.

Limitations of the Adequacy Principle
Adequacy refers to the capacity of the system to maintain the viability of natural processes, communities, and ecosystems (ANZECC, 1999a). In addressing adequacy, it is recommended by the Commonwealth’s Task Force on Marine Protected Areas (TFMPA) that states and territories will:
- ensure that MPA design criteria (size, shape, number, proportion of ecosystem types / habitats reserved etc) are relevant to ‘maintaining ecosystem integrity and viability’;
- compile data on natural and human-induced threats/disturbances/impacts over time, both locally and regionally;
- compile relevant data that assist species-specific conservation objectives, including population dynamics data (overlaps with the *Representativeness* and *Comprehensiveness* criteria);
- ensure that the chosen ecosystem types/habitats are replicated in the system where possible, to guard against ‘loss of the natural values of a protected areas’, particularly due to human-induced impacts;
- ensure that MPAs are designed in a practical way, so that management within and outside of the MPA can be complimentary, and to minimise threats to MPA viability.

It should be recognised that some of these commitments (i) will require long term data collection efforts and/or (ii) can only be met following MPA establishment, and consequent long term management and monitoring. It is therefore usually difficult to ensure that a MPA system is adequate at the outset (i.e. at the stage of site identification).

Adequacy is related to *comprehensiveness* and *representativeness*, because a system of MPAs cannot be adequate if it is not representative, and the system is more likely to be adequate if the ecosystem types/habitats that are represented form a comprehensive set. Adequacy also depends upon the variety of processes operating in region. In the long term, it is desirable that indicators be developed to assess: perturbations / impacts occurring over space and time (both natural and human-induced); the viability of populations and communities; whether size (and other design features) of MPAs is appropriate for meeting the desired MPA performance goals; the level of replication and redundancy in the system, and the ability of the MPA network to maintain ‘ecosystem services’ at a quality that meets the present and future needs of marine biota and habitats, and the needs of humans who rely upon them. Of particular importance is the need to assess regional and local scale threatening processes within and between all MPAs.

6.3.5 Precautionary Principle

The absence of scientific certainty should not be used as a reason to postpone measures to establish MPAs to protect South Australia’s marine ecosystems and their component biodiversity. Even if an activity is assessed as having a low risk of causing serious or irreversible adverse effects, or if there is insufficient information with which to assess fully and with certainty the magnitude and nature of impacts, decision-making should (nevertheless) proceed in a cautious manner.

According to the IUCN, it is a mistake to postpone action because ecological data are incomplete, and there is usually sufficient information to indicate whether MPAs are justifiable ecologically, and to set reasonable boundaries (see ECC, 2000). Under ANZECC's Principles of Developing the NRSMPA (ANZECC, 1999a), scientific uncertainty (regarding the 'best' locations for MPAs, and the most appropriate design - size, shape, number, amongst other factors) should not be used to postpone measures to establish representative systems of MPAs, because information will almost always be incomplete. The precautionary principle extends to the assessment and management of impacts. Thus, the precautionary approach emphasises the prevention of ecological damage when a negative environmental effect is deemed likely, even when the scientific evidence is inconclusive. Rather than requiring proof that a proposed activity will cause harm, it requires convincing evidence that a proposed, potentially damaging, activity will not cause environmental harm.

6.3.6 Replication

Replication should be considered in the South Australian system where possible, despite gaps in the knowledge of spatial position and boundaries of even the major habitats that can be mapped and classified as 'types'. However, it is also recognised that, in the short term, there are significant practical limitations and a general lack of public acceptance regarding declaration of two MPAs of the same 'type', particularly given that some major ecosystems/habitats in South Australia have not even been represented at all to date.

Scientific Rationale for Replication
ANZECC (1999a) has specified that replication of 'ecosystem types' within bioregions is also desirable in the MPA network, as a precautionary management measure. In theory, replication of ecosystem types/habitat types in separate MPAs improves the adequacy of the system for maintaining 'viable' ecosystems and their component communities and species populations. Replication also ensures that if a MPA is vulnerable to negative impacts (e.g. pollution events), then another example of its type is also present in the system. Apart from ensuring that a MPA system is adequate for maintaining viable ecosystems, replication provides opportunity for less biased monitoring of MPA performance. Replication of similar areas in the system, where possible, permits comparative tests of management options, and the application of adaptive management measures between those 'replicate areas'.

Ballantine (1999a, 1999b) and US National Research Council (2000) summarised some of the main reasons for replication:

- more than one example of the same habitat 'type' is required to demonstrate that the category does exist. It is difficult to determine whether a portion of habitat chosen as a MPA is 'representative' if there are no other examples in the category (i.e. no other areas for comparison);
- replication permits examination of the ecological and biological variability between habitat examples that belong to the same category (which can also assist MPA site prioritisation, management and performance monitoring);
- the purely statistical need for replication - to provide a measure of precision when features of a habitat are being measured. For example, if an example of a specific habitat type is used for monitoring natural baselines, one example of that type may not be sufficient (for a number of other practical reasons in addition to the statistical reason);
- replicating habitat and species protection over space is a useful design for study of the responses of marine systems to predicted climate change, catastrophic events and human-induced impacts.

The application of the ‘replication’ principle to ‘ecosystem types’ or ‘habitat types’ depends upon they way those ecosystems/habitats have been classified. Superficially, replication may be possible at the scale of areas within bioregions. In practice, true replication does not apply over such large scales (e.g. within bioregions), and certainly not between bioregions, in the sense of two separate MPAs having exactly the same set of ecological functions and attributes.

For example, although a mappable ‘ecosystem type’ in two different bioregions may be described as the same type (e.g. ‘*Posidonia*-dominated seagrass meadow’), it is unlikely that a seagrass meadow in the warm sheltered waters of the west coast will contain the same assemblages of fauna, or have the exactly the same set of ecological functions, or even be of a similar size in terms of ‘viability’, as a *Posidonia* meadow in the colder waters of the south-east. Similarly, two habitats within the same bioregion that could both broadly be classified as ‘seagrass’ (e.g. one *Amphibolis*-dominated and one *Heterozostera*-dominated) may support quite different biota, and not be equivalent in ecological function. They are therefore not true ecological replicates, even though they can be presented as such in terms of simplistic ecological classification.

6.3.7 Assessment of Impacts and Threats

This relates to the preceding three criteria. The development of a representative MPA system in South Australia should consider existing impacts and potential threats within and surrounding potential MPAs, from bioregional to local scales. Such information is pertinent to MPA site selection, priorities for establishment, zoning, management and monitoring.

To date, detailed descriptive information regarding threats and impacts (see **Chapter 9** for overview of types being considered) has been compiled for each bioregion, and areas within bioregions. There is a need to develop a method of quantifying and ranking threats and impacts, to assist MPA site prioritisation, management planning and zoning.

Scientific Rationale for Assessing Impacts and Threats
Apart from biophysical and ecological criteria, ‘threats’ (i.e. risk assessment or vulnerability assessment) criteria are of equal importance in identifying areas for a CAR system, in any state and territory of Australia (see references by Thackway, 1996). Vulnerability assessment relating to impacts and threats (both within and adjacent to candidate MPAs, is required to ensure that areas chosen as MPAs provide an adequate level of reservation to ensure the ‘ecological viability and integrity’ of populations, species and communities (i.e. the *Adequacy* principle).

Many of the existing and potential human-induced physical, chemical, biotic and combined impacts are being assessed at both regional and local scales prior to new MPA establishment in South Australia. Inclusion of data on impacts and threats will assist in determining:

- which habitats and their component biota are most vulnerable to degradation/depletion in both the short and long term;
- suitable sizes and levels of ‘core’ areas (and limited use ‘buffer’ zones) within the larger recommended areas, that have been identified using combined biogeographic, biophysical and ecological criteria; and
- the performance of MPAs in the network over space and time, in terms of protecting (or, in some cases, restoring) biodiversity and ecological functioning.

Given the apparent irreversibility of some human-induced threats (such as water pollution, physical damage and chemical pollution of marine habitat, and proliferation of marine pests), it is important to identify areas which:

- have been insulated from such impacts, i.e. have a high degree of 'naturalness', and that will continue to be insulated (i.e. are not 'vulnerable');
- have potential to be significantly damaged acutely and/or chronically, by current and potential threats;
- are currently polluted, or face other threats to ecosystem structure and/or function, but which have a high degree of 'restorability' of designated as an MPA.

6.3.8 'Optional' MPAs for the System

Where possible, 'options' within each bioregion should be incorporated into the MPA network.

Rationale for Optional Areas

Within each bioregion, several different 'combinations' of sites may be available to collectively contribute to a representative (and adequate) protected area network (Brunckhorst, 1993). Similarly, more than one area within a bioregion may contain a similar set of recognised biogeographic and ecological attributes, that seemingly contribute in a equivalent way towards satisfying the principles of the protected area system, and therefore may be considered as 'options' in the MPA network. There are also practical, social and economic advantages to incorporating into the system such spatial flexibility in area choices.

6.3.9 Provision for 'Restoration'

The MPA system in South Australia should also provide for restoring, in areas demonstrated to have suffered significant impact, what is known of that area's ecosystem 'function' (that is, the natural physical and biological interactions that occur in any given marine area, which can be significantly altered through human-induced impacts). Under this principle, some areas that are demonstrated to be degraded could be included in the network, and the level of MPA management provisions and activities within those areas should be directed towards rehabilitation of those habitats.

6.3.10 Long Term Flexibility in the South Australian Representative System of MPAs

The establishment of the SARSMPA should be flexible enough to accommodate improvements in scientific knowledge and unforeseen necessary changes. For example, there may be provision for additional areas and / or modifications to existing MPAs, as better information regarding bioregions, habitat types and distribution, ecosystem functioning and environmental impacts, becomes available in the ensuing decades.

6.4 Criteria used to Identify Areas for the SARSMPA

Due to the primary goal of new MPA declarations under the guidelines of the NRSMPA (ANZECC TFMPA 1999) being to establish and manage a system of marine protected areas that contributes to *maintaining the long term ecological 'viability' of marine and estuarine systems, protecting biodiversity at all possible levels, and ensuring that ecological processes are not compromised by human activities*, it follows that the primary criteria for identifying a representative system of MPAs should be ecological.

In keeping with the Commonwealth's guidelines for the NRSMPA, and within the bioregional framework of the SARSMPA, biogeographical, biophysical, ecological and biological criteria were primarily used for the identification process.

Thackway's (1996a) criteria and guidelines for identification and selection of representative MPAs in Australia concluded that the application of biophysical and ecological criteria is of primary importance in identifying areas for a CAR system, since the Primary Goal is based upon ecosystem representation and biodiversity conservation. Despite the fact that each state and territory in Australia uses a different methodology and set of specific criteria for identifying suitable sites, all of these have a biophysical and ecological emphasis.

The criteria that are being used in South Australia to assess the contribution of areas to a representative system, are adapted from Thackway (1996), Nilsson (1997), WA Dept of CALM (1994 & 1998), ANZECC (1999), Porter (1999), Environment Conservation Council (2000), and Marine & Marine Industries Council (2000). Porter's (1999) list was compiled from criteria described by Ray (1976), Rooney *et al.* (1978), MacDonald (1982), Salm and Clark (1984), CONCOM (1985), Kelleher and Kenchington (1991) (for IUCN), and Ballantine (1990).

Each of the biogeographic, biophysical, ecological and threats criteria contained in these published sources are internationally and/or nationally recognised as the preferred basis for developing ecologically-based systems of MPAs. Note that due to limitations in existing marine data and knowledge in S.A., it is not possible to apply all of these criteria systematically across the entire South Australian marine environment. For the representative system, it is efficient to include areas that meet a large number of the specified criteria. Depending on the objectives for the site, one or more criteria may be considered to have greater 'weight' in the subsequent selection, zoning and management process.

The following list of criteria was applied to ensure that the major ecological principles of the SARSMPA can be met.

6.4.1 Primary Biogeographic, Biophysical and Ecological Criteria

- ***Biogeographic 'Significance'*:** Biogeographic features by which an area is characterised over state or national scales. For example, rare or unique habitats at state or national scales. This criterion also includes biogeographically significant populations of rare or threatened taxa, where known.

- ***Major Physical Influences, and Relative Productivity Level*:** These criteria are applied where known, including surrogate indicators. Relative productivity levels are incompletely documented at a state-wide scale in S.A. Major physical influences include estuarine processes, dominant features of the coastal geology and geomorphology, and oceanographic features (e.g. sea surface temperature fronts; upwellings; current strengths; nutrient levels; depth gradients). Some of these oceanographic features are indirect indicators of productivity. Some other surrogate indicators of productivity include areas of high natural productivity of phytoplankton, zooplankton, and/or sediment-producing organisms; comparatively high species biodiversity and/or abundance of marine plants or other benthic biota; high abundance of larvae; high abundance of invertebrate fauna and microbiota involved with nutrient decomposition and recycling; high abundance of significant food web species, such as 'baitfish'.

- ***Habitat Representativeness*:** Classified and/or mapped habitat types that are typical of an area of specified scale (e.g. bioregions and biounits). Some of the major influences and factors considered in the description of known habitat types include tide level and depth, exposure to waves, water movement (including relative current strength where known), freshwater inputs, coastal geomorphology, benthic substrate composition and form, and dominant taxonomic cover on the benthic substrate. This criterion overlaps with **Biogeographic Significance**.

- ***Habitat Rarity*:** Refers to classified and/or mapped habitat types that are unique to an area of specified scale. For example, distinctive habitat features, not found in other parts of a bioregion, or group of bioregions at state and/or national scales. Overlaps with both **Biogeographic Significance** and **Relative Productivity** criteria.

- ***Habitat Diversity*:** Correct application of this criterion is highly dependent upon quality, scale and extent of marine sampling, mapping and classification. A variety of existing data sources have been used to define habitats but a complete and correct habitat classification is not available for all parts of South Australia's jurisdictional marine environment. Habitat diversity is related to, amongst other factors, coastal processes and geomorphology, benthic rock and sediment type, benthic topography, major benthic cover types, structural diversity, and habitat variation according to depth level, where known. Overlaps with **Major Physical Influences** and **Relative Productivity** criteria.

- ***Taxonomic Diversity*:** Refers to relative levels, from phyla to species, where known. Major groups being considered include marine mammals, bony and cartilaginous fish, soft and hard invertebrate phyla, marine plants, and estuarine, coastal and marine birds.

- ***Habitat for Endemic Taxa / Threatened Taxa / Rare or Uncommon Taxa*:** This is a scale-dependent criterion. There is also some overlap between taxa that satisfy the various aspects of this criterion. For example, some species are considered both rare and threatened; others may be endemic to South Australia and rare in distribution, but not threatened; some may be rare but not currently known to be threatened, and others may be recognised as potentially threatened due to various processes and/or activities, but not known to be rare. Note that locations for rare and endemic taxa are poorly known over much of South Australia's marine environment. Major groups being considered under this criterion include marine mammals, bony and cartilaginous fish, invertebrates, marine plants, and estuarine, coastal and marine birds.

- ***Notable Breeding / Spawning, Nursery and Feeding Areas*:** Applied where known, and for taxa that are known.

- ***Other Important Taxa*:** Applied where known, and includes (i) 'relict' species or assemblages e.g. tropical taxa that may exist in limited areas due to unusual oceanographic conditions that are uncommon throughout S.A. (N.B. this overlaps with the **Biogeographic Significance** criterion); (ii) habitat for species with complex habitat requirements, or which are associated with several habitat types through the life phase; (iii) habitat in which aggregations/population members of highly migratory species may occur; (iv) habitat with high abundance of specific site-attached and/or mobile taxa; (v) habitat with concentrations of larger, older individuals of particular species populations, which in some cases contribute in a major way to population reproduction; (vi) habitat for taxa involved with specific, ecologically-important processes (e.g. fish cleaning at "stations", which studies have demonstrated to be important for reef fish health – Shepherd, pers. comm., 2004); (vii) habitat for commercially and/or recreationally significant fish, sharks and invertebrates, which are often locally abundant in particular habitats, and have significant ecological roles; and (viii) habitat for taxa that require two or more spatially-separated habitats through the life phase (the locations of such habitats are considered in the MPA system, to ensure ‘connectivity’ between protected areas).

6.4.2 Social Criteria with Ecological Relevance

A number of criteria that have social value have been included in the identification phase, in cases where the criterion has specific ecological relevance to the development of the representative system. These include:

- ***Shipwrecks and Artificial Reefs***: Included as an ecological criterion because such structures (i) provide additional 3-dimensional structure and habitat with many ‘micro-habitats’, which act as substrate for marine plants and invertebrates, and also attract mobile species, especially fish, and sharks; and (ii) serve as feeding, breeding and/or sheltering areas for some of the many species which aggregate in the habitat provided by the wreck or artificial reef.

- ***Ecological Features of Popular Dive Sites*****:** Such sites usually contain features of biological and/or ecological importance, such as high fish species diversity; high benthic diversity and/or abundance of particular groups, such as marine plants, sponges, ascidians, echinoderms etc; micro-habitat diversity (e.g. platforms, ledges, caves, boulders, overhangs found on reefs); and/or relatively high abundance of socially significant species (e.g. reef fish such as Western Blue Groper, Harlequin Fish and other “popular” reef fish; seadragons; Rock Lobster; abalone; marine mammals, etc).

- ***National and/or International Importance*****:** Includes nationally classified sites of ecological significance (e.g. coastal wetlands); sites listed on the *Register of the National Estate* due to specific marine environmental features; sites listed under international conventions or bilateral agreements (e.g. Ramsar, Bonn, JAMBA, CAMBA) due to outstanding ecological or biological features (e.g. threatened birds, migratory birds and cetaceans).

- ***Overview of Major Commercial and Recreational Bony and Cartilaginous Fish, Molluscs and Crustacean Taxa in each Region*****:** In the absence of detailed biological survey data of the mobile biota across South Australia, this provides an indirect indication of some of the major vertebrate and invertebrate species occurring at bioregional and smaller scales, and in some cases, an indirect indication of their significance to ecosystems at those scales (e.g. where certain taxa are highly abundant in an area, with which they are strongly associated through one or more of the life stages).

6.4.3 Other Information Relevant to the SARSMPA: Risks and Impacts, ‘Naturalness’, and ‘Restorability’

The development of the system of MPAs in South Australia should consider existing impacts and potential threatening processes and activities, as recognised by the Commonwealth as a key requirement for the development of an adequate system of MPAs (e.g. Thackway, 1996; ANZECC, 1999a, 1999b). Such information assists in determining the feasibility of particular choices for the SARSMPA based on ecological grounds, and the adequacy of the MPAs in maintaining biodiversity, habitat quality and ecosystem function. Threats and impacts data are also pertinent to MPA site selection, priorities for establishment, zoning, management and monitoring. Where known, existing and potential human-induced physical, chemical, biotic and combined impacts have been documented at both regional and local scales (**Chapter 9**). Inclusion of data on impacts and risks can assist in determining:

- which habitats and their component biota are most vulnerable to degradation/depletion in both the short and long term;
- suitable sizes and levels of protection/management (e.g. zoning, including number and placement of highly protected 'core' areas and limited use 'buffer zones') for recommended areas that have been identified using combined biogeographic, biophysical and ecological criteria; and
- the performance of MPAs over space and time, in terms of protecting (or, in some cases, restoring) biodiversity and ecological functioning.

To date, descriptive information regarding impacts and potential threatening processes and activities has been compiled at a number of scales, from bioregions to local scales.

Other related criteria that have not been applied at the stage of identifying areas for the SARSMPA, but which may be important in the development of the system, particularly during the selection and management planning phases, include:

- ***'Naturalness'*:** Refers to the often subjective degree to which area has or has not been subject to human-induced change. Valid and systematic application requires a ranking system, and must consider the control and management of impacts and threats in areas identified and selected for a MPA system.

- ***Restorability*:** Related to the preceding criterion, and assessed according to potential management and control of impacts in degraded and partially degraded areas. This criterion can usually only be determined and applied according to the level of protection and management that is proposed during MPA planning, and that ensues following proclamation.

- ***Irreplaceability / Level of Replication*:** Related to **Habitat Rarity** and **Threats**, amongst other criteria, and requires good quality marine habitat information (preferably a statewide classification), and consideration of the design and management of all potential MPAs in the system/network.

6.4.4 Social, Cultural and Economic Values

A list of social and economic criteria has not been formally applied at the initial stage of identifying areas for the bioregional, ecologically representative system of MPAs. However, the social, cultural and economic values of the areas, are of paramount importance in prioritising MPAs for selection, and in developing successful and socially equitable zoning arrangements and management plans for each potential MPA. In view of this, much available information relating to the numerous social, cultural and economic values of potential MPAs, has been collected and summarised during the identification phase.

This preliminary overview of information should be used as background material for further assessment (in conjunction stakeholders), of all major social, cultural and economic values, as well as the implications and impacts of protected area designation. As part of that process, specific, standardised criteria should be used where possible, developed in conjunction with industry, local government and community groups. Flexibility in applying the criteria will be required due to the variety of legislative and management frameworks within South Australia (State and Local government levels), and the individual circumstances relating to specific sites. The information that has currently been compiled should also assist in the stages of MPA zoning and management planning. For each focus area described in **Chapter 8**, examples of available data and information used in the preliminary overview of social and economic values and uses, are provided in **Chapter 9**.

6.5 Data Used to Identify Representative Areas

Approximately 2,000 information sources, most of which are published, have been used to develop a list of potential large, zoned MPAs ("recommended areas") that satisfy the principles of South Australia's proposed bioregional, ecologically representative system, based upon application of the criteria outlined above. The information sources have been used to describe representative areas in terms of their primary biogeographic, biophysical and ecological attributes, and to also produce an overview of the many social and economic values and uses of the recommended areas, as a starting point for community consultation. Threats and impacts information has also been compiled for each area, which is a key requirement for the development of an adequate system.

Available data and resources that have been used to assist this process include:

- databases and maps from the *South Australian Coastal and Marine Atlas* (DTUP, 2000, 2001 and 2003) (e.g. oceanographic data, currents, biotic distributions, shipwrecks, marine activities and zoning, amongst others);
- existing marine benthic survey information for South Australia, collected mainly by government scientists and scientific programs, between 1971 - 2002;
- 1:10,000 scale, coloured aerial photographs, to assist with near-shore habitat delineation;
- published and unpublished material (reports, scientific papers, articles, databases, resource description documents, electronic and printed maps and aerial photographs), collectively relating to the oceanography; coastal geology; geomorphology; biogeography; habitats; ecology; biodiversity; population dynamics of key marine species; location of taxa of special conservation significance (rare/uncommon, threatened, endemic, "special"); fisheries and other resources; social and heritage values; and various activities and uses that occur in coastal marine areas throughout South Australia;
- Commonwealth databases, such as those describing *Wetlands of National Significance*; sites listed on the *Register of the National Estate* (including Natural, Cultural and Indigenous Values); and Native Title application and assessment details from the National Native Title Tribunal database;
- published overviews of areas of conservation significance, such as *Conserving Marine Biodiversity in South Australia - Part 2* (Edyvane, 1999b), and the South Australian chapter of the *Directory of Important Wetlands in Australia* (Morelli and de Jong, 1995);
- available commercial and recreational fisheries information, from various government (e.g. SARDI) and non-government sources, including regional data summaries and stock assessment reports (see **References**); results from the National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003), and PIRSA's *Inventory of Important Coastal Fisheries Habitats in South Australia* (Bryars, 2003);

- relevant government publications, such as PIRSA's Aquaculture Management Plans; SARDI's fishery stock assessment reports; Planning S.A.'s Development Plans for regions of the State, NPWSA's management plans for coastal conservation parks, amongst others;
- relevant non-government publications and other information sources, such as environmental impact assessment reports, regional resource use reports and industrial reports etc; tourism booklets, brochures and web sites etc;
- available unpublished (anecdotal) information, where relevant and verifiable, from marine scientists, industry and marine community groups;
- descriptive (and in some cases quantitative) information for many categories of threat and impact within bioregions, and at finer scales; and
- other published and unpublished data and information sources (see **References** for complete listing).

6.6 Recommended Representative Areas

A list of the areas that have been identified as candidates for large, multiple-use MPAs (which would include some *high protection zones*) is provided in the table below (Table 3). Figure 2 shows the location of recommended areas.

A detailed list of the ecological attributes of these areas is provided in the tables in **Chapter 8.** Each of these recommended areas is recognised as having an outstanding contribution to a bioregional, ecosystems-based system of MPAs for South Australia.

Table 3: Recommended Representative Areas per Bioregion

Bioregion	Locality
Eucla	*To be determined. This bioregion currently contains the Great Australian Bight Marine Park (State and Commonwealth components), and any other area within the bioregion is not currently being considered in the draft list of recommended areas for the SARSMPA. Any additional protected area for the Eucla Bioregion may be considered and publicly discussed at a later date.*
Murat	**1**. Nuyts Archipelago, St Francis Isles and Coastal Embayments
Eyre	**2**. Baird Bay to Cape Bauer (including nearshore islands)
Eyre	**3**. Venus Bay and Anxious Bay coast
Eyre	**4.** Investigator Group Isles
Eyre	**5**. Lincoln National Park Coast, Thorny Passage and Islands
Eyre	**6**. Tumby Bay, Sir Joseph Banks Group and Dangerous Reef
Eyre	**7**. Neptune Islands Group
Eyre	**8**. Gambier Islands Group
Spencer Gulf / Northern Spencer Gulf	**9**. Franklin Harbour and surrounding coastal waters
Northern Spencer Gulf	**10**. Northern Spencer Gulf
Spencer Gulf	**11**. Mid-Eastern and South-Eastern Spencer Gulf
Eyre / Gulf St Vincent	**12**. Western Investigator Strait, including "Toe" of Yorke Peninsula and Northern Kangaroo Island
Eyre / Gulf St Vincent	**13**. South-Western, Western and Far North-Western Kangaroo Island
Eyre	**14**. Southern Eyre coastal waters and islands
Gulf St Vincent	**15**. The "Heel" of Yorke Peninsula

Bioregion	Locality
Gulf St Vincent	**16**. Northern Gulf St Vincent
Gulf St Vincent / Coorong	**17**. Southern Fleurieu / North-east kangaroo Island / Backstairs Passage / Encounter Bay / Upper Coorong
Coorong / Otway	**18**. Upper South-East
Otway	**19**. Lower South-East, to Glenelg River Mouth

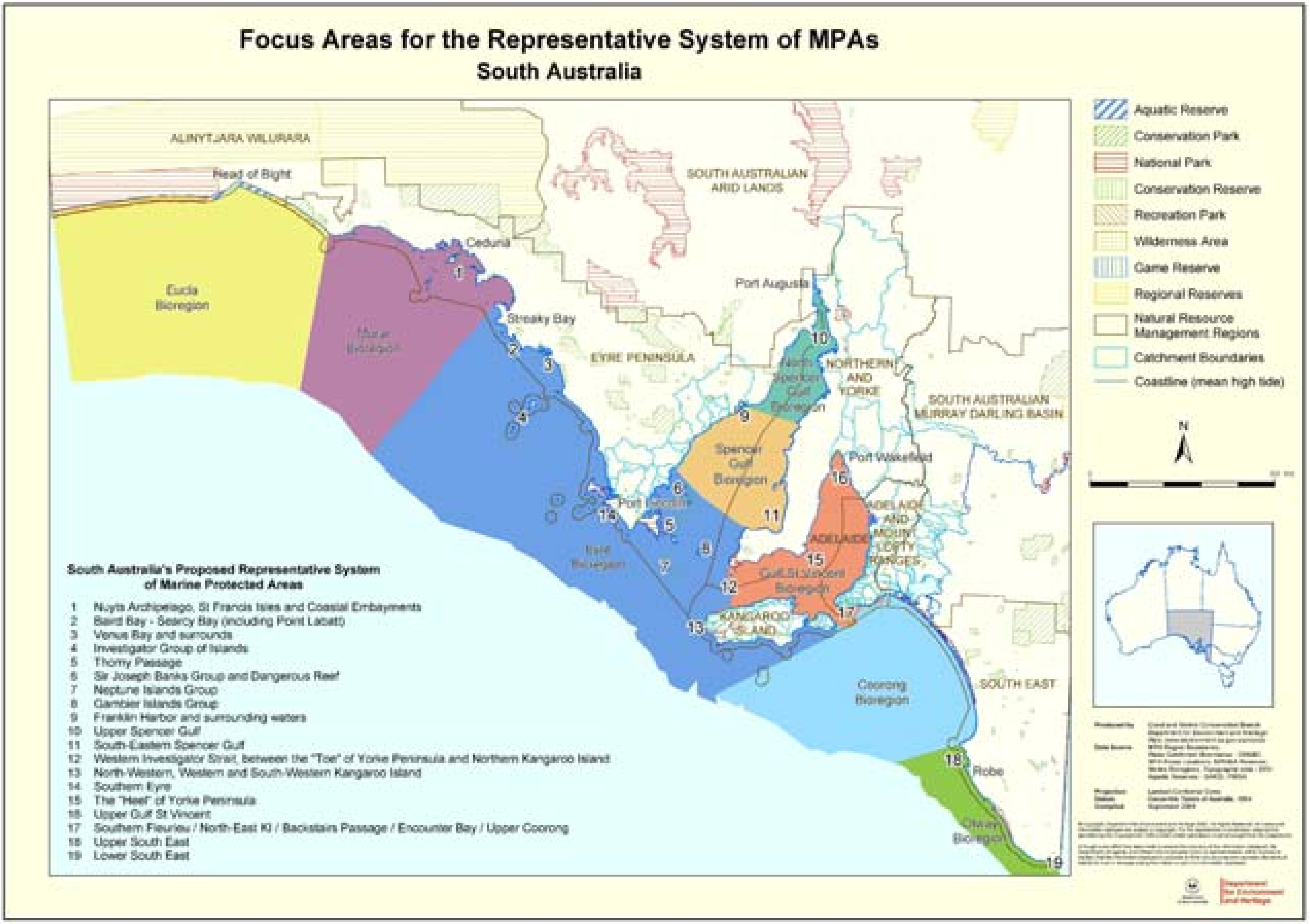

Figure 2: Focus Areas for the SARSMPA

7 A Recommended Design Approach for the SARSMPA

7.1 'Nested' (Zoned) MPAs

The nested approach incorporates several levels of protection, which would be achieved through a system of zoning large, multiple-use marine protected areas. A nested approach would incorporate:

- Smaller high protection ('no-go' and 'no-take') 'core' areas that sustain particular habitats and species, and contribute in a major way to habitat and biodiversity conservation and resource sustainability;
- Limited Special Use ('buffer') zones in some MPAs, in which low impact uses may be compatible with habitat and biodiversity conservation and resource sustainability;
- Larger General Managed Use Areas that balance habitat and biodiversity conservation and resource sustainability with both commercial and recreational activities.

The 'nested' approach to the design and management of new MPAs is recognised internationally (Kelleher and Kenchington, 1991; Brunckhorst, 1994) and nationally (Thackway 1996a, 1996c). The approach is a marine modification of the terrestrial Biosphere Reserve concept, originally developed by UNESCO's Man and the Biosphere Program, in which smaller, high protection ('core') areas are designated inside larger, limited use 'buffer' areas, and surrounded by even larger, General (Managed) Use zones.

A national technical meeting to develop criteria for identifying and selecting a national representative system of MPAs in all states and territories (Thackway, 1996a) concluded that the Biosphere Reserve (nested) approach provides the necessary combination of conservation objectives and sustainable resource use, and has the capacity to achieve multiple-use management.

Multiple zoning approaches to marine conservation and management are inherent in the structure of the Great Barrier Reef Marine Park, as well as the CAR systems of MPAs being developed in Victoria, Queensland and Western Australia. A nested approach has been used in some of the Commonwealth-designated offshore MPAs that have recently been established (e.g. Macquarie Island). Overseas, a nested approach to MPA design has been adopted in some US States, and the Galapagos Islands. In such areas, MPA designs consist of a mix of core protected areas; low-impact (limited use) buffer zones (also called Recreation Zones, in some areas), and larger, multiple-use zones (General Managed Use Areas).

Some of the major supporting reasons for a nested approach include the following:

- Core protected areas of outstanding conservation value are less likely to be degraded and have their ecological and biological functions compromised, if they are 'buffered' by zones in which permitted activities and potential associated impacts are limited. The importance of core protected areas is discussed in more detail in a separate section below.

- The nested approach helps to protect areas through a variety of management arrangements for each kind of zone within the General Managed Use Area, so that the environment can support and sustain multiple socially and economically important activities in the long term, without compromising the ecological values of the MPA system as a whole, or of each protected area in that system.

- The use of large General Managed Use Areas provides a formal framework for regional-scale, integrated conservation and management. Managing large coastal marine regions as a whole, rather than as a fragmentary set of unconnected regulations applying to specific activities and areas, is recognised (e.g. Commonwealth of Australia, 1998; ANZECC TFMPA, 1999) as an effective method for protecting marine ecosystems, and the habitats and biota associated with them, and managing the activities that may impact upon those ecosystems.

- In practical terms, fewer large areas or zones may allow for more effective monitoring of impacts and application of environmental regulations to activities and uses, compared with multiple small areas.

The practical application of the nested approach may not be three-tiered in all cases. For example, in some areas, it may be preferable to set core protected areas inside the larger General Managed Use (GMU) Area, without the need for a designated buffer, if the management (and consequent level of protection) in that GMU Area is considered adequate to protect the core. In other cases, a relatively large, low impact / limited use zone may exist within a larger, regional, GMU Area, but may not contain a core, highly protected area. Some Marine National Parks may fall into this category of low impact zone within a larger managed area.

7.2 Importance of Core (Highly Protected) Areas

A national technical meeting to develop criteria for identifying and selecting a National Representative System of MPAs (Thackway, 1996a) concluded that core protected zones within larger multiple-use areas should primarily be designated for biodiversity conservation, which will encompass a number of specific goals, such as:

- the protection of examples of bioregionally 'representative' habitats and the biota within them;
- conservation of habitat for recognised rare and threatened species;
- provision of 'harvest refugia' (i.e. reserves which function to replenish particular fish stocks with habitat attachment phases; to protect examples of the habitats that are of key significance to the life stages of commercially and recreationally valued fish species; and
- restoration of degraded habitats.

Several other major recognised objectives in declaring 'core areas' are:
- to conserve 'rare' / 'unique' and/or biogeographically significant habitats;
- to protect areas with recognised high diversity of major groups (at species-level or higher level - e.g. phyla)
- to protect areas which have high diversity of habitat types (a surrogate for finer scale biodiversity protection);
- to protect areas of known high biological productivity;
- to protect areas of high significance for breeding/spawning, feeding, aggregation and/or development of major marine groups and/or specific taxa of special conservation significance;
- to provide 'control' sites for monitoring biological, ecological and physical impacts (e.g. highly protected areas also serve as 'ecological benchmarks' against which the effects of natural and human-induced impacts/disturbances in other less protected areas can be assessed); and

- to provide minimally disturbed areas containing ecological features/values that serve the important secondary functions of maintaining and enhancing opportunities for education and passive recreation, whilst ensuring that those functions do not impinge upon the core ecological values of the area.

The ‘forementioned reasons for designating core areas are not mutually exclusive, and a particular core area may serve a number of these functions. Core areas ensure that portions of the protected area network can contribute to the maintenance of ‘ecological integrity’ (i.e. so that evolutionary processes/functions can proceed undisturbed, and that ‘secure’ places are provided for marine biota, in which interactions between species and population members can be maintained, and therefore genetic, community and ecological diversity can be maintained as far as possible).

More recently, the Australian Marine Science Association (2002) supported the concept of totally protected (“no-take”) zones as part of a National Representative System of Marine Protected Areas. AMSA considered that such a system should aim to provide a network of biogeographically based protected areas containing representative examples of all significant marine habitats. According to AMSA (2002), the prime purpose of no-take marine reserves *is to provide maximum protection of their marine ecosystems from human disturbance. As such, they can provide important reference areas by which we can assess the extent to which people have altered similar ecosystems in other places. Reserves should be sufficiently large to meet their conservation objectives* (AMSA, 2002).

A number of international publications (e.g. Roberts and Hawkins, 2000 and Sobel and Dahlgren, 2004) have reviewed the performance of marine reserves around the world, and such publications consider “no-take” reserves to be one of the most powerful management tools to restore and preserve marine biodiversity.

Connectivity of Core Areas – Theoretical Ideals vs Practical Constraints

A ‘network’ of highly protected MPAs, which attempts to maintain ecological processes and habitat linkages, and to protect biodiversity, is theoretically desirable, but in terms of practicality, difficult to implement (see Baker, 2000 for a review). Network designs are easiest to consider for specific species, whose life history patterns are known – the spatial separation of spawning areas and recruitment / nursery area for some marine species, is one common example, and for areas in which good quality, spatially complete and ecologically explicit habitat classifications are available. It is unfortunate for the purposes of designing representative MPA networks, that the relevant biological and ecological information that could assist in optimising a network design, is almost always incomplete, even for marine areas which have been extensively surveyed and researched (e.g. many part of Queensland and New Zealand). Considering these limitations, maximising the variety of ‘connections’ between MPAs is recognised as a defensible precautionary principle (see Ballantine, 1999a), and a consequent requirement is that ‘more rather than less’ is the basic rule for core protected areas.

Single large highly protected areas are unlikely to contain the diversity of habitats that is desirable in MPA systems. Even if one large MPA contains several habitats, it is generally uncommon (depending upon its size and location) for one large area to contain the collective biodiversity of several spatially separated areas that represent an equivalent number of habitat types. Therefore, a network of core protected areas is recognised as important in trying to ensure that the MPA system is ‘ecologically sustainable’, even if adequate indicators for measuring such sustainability are lacking.

Furthermore, minimising the number of highly protected core areas in a MPA system, and relying upon one MPA per large area (e.g. bioregion) to serve as the ‘representative’, is risky in management terms. The reasons for including a variety of core types and locations in the system are discussed further in **Chapter 6**, in terms of ‘irreplaceability’ and ‘replication’.

<u>Recommendations for ‘Core Areas’</u>

For South Australia, it is recommended that core areas be established within each large managed multiple use MPA, within each bioregion. Each new large multiple use MPA (or ‘managed area’) within a bioregion should contain at least one core (high protection) zone, and such areas should satisfy the stated objectives of declaring high protection zones (see above), and be of high conservation significance, according to established biogeographic, biophysical and ecological criteria, as discussed in later sections of this report.

It will be important to designate more than one core protected area in each bioregion, due to the precautionary need to maximise the number and variety of connections between highly protected areas, despite lack of specific information on ideal network design for biodiversity conservation and maintaining ecological processes.

Core areas should collectively (in terms of numbers and locations designated within South Australia) include examples of both ecologically representative reference sites, and sites of special conservation significance, according to the recognised objectives of core areas. When a choice is available between two areas that appear to equally represent habitat types (i.e. ‘representativeness’), and if one of those two sites also includes any of the specified additional conservation values relating to core site designation, then the latter area should take precedence in designation.

Regarding size of core areas, it is recognised that although a network of areas is necessary, the system of MPAs (and each MPA within that system), must be large enough to sustain natural processes in the long term, and that a series of ‘tiny reserves’ is inadequate (Ballantine, 1999). Ecologically, appropriate size of any new MPA depends upon a large number of factors. This includes, foremost, the specific conservation objectives of the MPA. For example, it may be easier to specify an appropriate MPA size if protection of a major spawning stock, or site-attached fish assemblage, or key nursery habitat, is a primary aim. The task is more difficult if a number of MPAs with multiple objectives are being considered (as in a CAR system), and setting a standard size for all high protection MPAs in the system is almost always indefensible in ecological terms. The many important factors determining suitable sizes for core areas include habitat type; size and location; habitat condition/quality; impacts and activities in the surrounding area; number and type of other MPAs in the system; population dynamics/demography and mobility of biota within the MPA; amongst other factors.

Size of core areas should vary, according to the specific set of conservation objectives of each area, and should utilise, where possible, all relevant information on the habitat size; spatial linkages between areas (in terms of ecological and biological functioning within and between areas), human-induced threats to functioning, and (in the case of cores that serve primarily as harvest refuges, or sanctuaries for recognised species of special conservation significance) the population dynamics of the species or groups of species associated with such areas.

There are both advantages and disadvantages to applying standard minimum sizes ('rules of thumb') to all core areas (e.g. 15% or 20% of each major habitat type; 5% of a bioregion etc) Baker (2000) provided a review of proportional representation (also referred to as 'the real estate approach' to MPA design).

Core areas can differ in the types of activities that are permitted and excluded. Some core protected areas exclude all activities other than monitoring (i.e. baseline areas in which all avoidable access is excluded, as with some Strict Nature Reserves that are classifiable under IUCN's 1995 protected area guidelines as Category IA). Examples of core protected areas include the Marine National Parks and Sanctuary Zones declared in Victoria, and the small Sanctuary Zones within Western Australia Marine Parks.

Other core protected areas include reserves in which non-extractive, managed and monitored activities are permitted, but all extractive activities (including fishing) are excluded. New Zealand's marine reserves (Ballantine, 1991, 1999) are an example of core areas that offer a high level of protection to ecosystems/habitats, whilst permitting a variety of recreational, educational and scientific activities to continue and develop.

7.3 'Buffer Zones'

Buffers are associated with core protected areas, and aim to minimise impacts, thus maximising the integrity of the core. "Core" protected areas are less likely to be degraded and have their ecological and biological functions compromised, if they are 'buffered' by zones in which permitted activities and potential associated impacts are limited

Buffers also provide for a variety of uses and activities within relatively large parts of a multiple-use MPA, and are designed to ensure that the mix of activities that is permitted in the "buffer" does not impinge upon the conservation values of the core areas. Buffer zones can contain a different mix of permitted activities, depending upon the specific conservation requirements of each area, particularly the core highly protected areas.

A standard set size is rarely appropriate for buffer zones. Size of buffer zones can vary according to:

- the size and specific objectives of core areas;
- the specific conservation objectives and level of protection/permitted activities within each buffer area;
- size, location, functions and level of management of the larger General Managed Use area.

Size of 'buffer' zones should also utilise, where possible, any relevant information on the habitat size; biological and ecological functioning (including spatial linkages between areas), and human-induced threats associated with all parts of the MPA area.

Buffer zones will function more effectively if management standards and monitoring are negotiated with input from all marine industry and community groups, and accepted by all parties prior to designation.

7.4 General Managed Use Areas

The General Managed Use areas within large multiple-use MPAs have different names and management arrangements in each state and territory. A number of other terms exist for General Managed Use Areas, including Multiple Use Managed Areas, Managed Resource Protected Area, General Managed Area or Zone, General Use Area or General Use Zone, amongst others. It is recognised that some confusion surrounds the term Managed Areas, in the sense that all parts of the marine environment within state water jurisdiction should be managed by that state, and that management should not be limited only to MPAs. The types of activities that are permitted and restricted in General Managed Use areas must be explicitly defined in a Plan of Management for each large, multiple-use MPA.