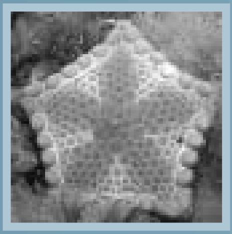
Assessment Report

Ecosystems

nature's diversity

The South-east Regional Marine Plan



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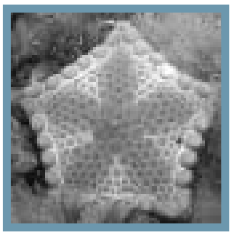


Executive Summary

Although Australia's history of large-scale use of marine resources may be short, it has nevertheless left its mark on the ecosystems of the South-east Marine Region.

Pressures to use the ocean's wealth means that we need to put in place a way of managing all our interests as matter of increasing urgency to ensure the sustainability of marine resources. This requires an understanding of the ocean ecosystems and their responses to human uses and our capacity to predict outcomes.

Despite the recent advances in understanding marine ecosystems our knowledge of the Region is embryonic and this state of knowledge, combined with the complex and dynamic nature of marine ecosystems, have implications for management.

Ecosystem-based management is a significant shift in the management of human use of the environment. In principle, it recognises that ecosystems are complex, interconnected and dynamic and that we rely on these ecosystems for essential resources. It also recognises that our ability to accurately predict the outcomes of our use of marine resources is imperfect, and the need to develop precautionary, adapative structures to minimise the risk of irreversible change to the ecosystems. This shift is a response to the growing realisation that we need to move to a more integrated approach for assessing and managing human use of natural resources if we are to maintain healthy marine ecosystems and the benefits we derive from them.

This assessment will help towards developing an ecosystem-based regional marine plan for the South-east Marine Region by providing an overview of the structure and function of the ecosystems of the Region.

The focus of the assessment is on providing key inputs for developing an ecosystem-based regional marine plan. These inputs include an Interim Bioregionalisation and Conceptual Models of the functional links between ecosystems, along with general background information on the physical and biological characteristics of the Region.

As well, the assessment includes a review of the state of knowledge of the biological and physical characteristics of the Region gathered from relevant scientific literature and meetings with experts as well as a series of commissioned projects.

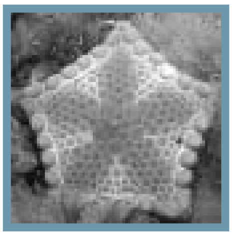
It provides useful tools and information that will assist us in the next phase of the regional marine planning process, as we move from the assessments phase to developing a regional marine plan.

To provide the ecological foundations for the development of ecosystem-based planning and management arrangements for the Region, the biological and physical assessment is organised into three streams of work:

- ecosystem structure – devising planning units based on the characteristics of the ecosystem. The major outcome is an Interim Bioregionalisation for the Region. A Working Group provided expert advice and assistance, and eight research projects were commissioned to develop the bioregions.
- ecosystem function – understanding the dynamics of the ecosystems in the Region and the physical and ecological processes that link them. The major outcome of this work is a set of ecosystem Conceptual Models – illustrative graphics and accompanying text – that provide a basis for developing ecosystem objectives and indicators. A Working Group provided expert advice and assistance.
- synthesising existing knowledge - gathering published scientific information on the structure and function of the Region's ecosystems. We have used this information in developing the ecosystem Conceptual Models and the content for this assessment report.

The Interim Bioregionalisation is the first step in developing planning, management and monitoring arrangements based on our current knowledge of the ecological structure of the Region. The Conceptual Models give an overview of our current understanding of the key processes that drive the dynamics of the different ecosystem types in the Region and what that tells us about their potential vulnerability to different human activities. The synthesis of our current knowledge describes the diversity of plants and animals that comprise the ecosystems of the Region, how they vary in different parts of the Region, and the current status of species of conservation or resource significance. Each of these components develops our understanding of the ecosystems of the Region.

The next steps in developing ecosystem-based regional marine plans for the Region are to define planning and management boundaries, and develop objectives and indicators for ecosystems, to be used in performance assessment and management feedback. While the information obtained from this assessment will inform each of these steps, they need to be developed in conjunction with information from the other assessment streams and with the direct participation of all stakeholders.



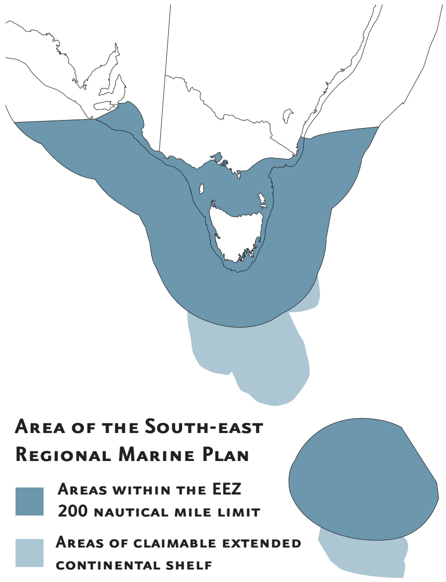
Preface

Australia's Oceans Policy and regional marine planning provides a framework for the people of Australia to explore, use, protect and enjoy our extensive marine resources. As its base, the Policy recognises the need to protect the biological diversity of the marine environment while at the same time promoting and encouraging sustainable, secure marine industries.

Regional marine planning is a way of achieving the Oceans Policy vision. It uses large marine ecosystems as one of the starting points for the planning process by creating planning boundaries that are based on ecosystem characteristics – a major step towards ecosystem-based management.

This assessment report is one of six that are an initial step in better managing Australia's oceans. They provide a knowledge base for developing the South-east Regional Marine Plan – the first regional marine plan being implemented under Australia's Oceans Policy.

The South-east Marine Region brings together three of the large marine ecosystems: the South-eastern, the South Tasman Rise and Macquarie.



The South-east Marine Region covers over 2 million square km of water off Victoria, Tasmania (including Macquarie Island), southern New South Wales and eastern South Australia.

The Region includes both inshore (State) waters (from the shore to three nautical miles) and Commonwealth waters (from three to 200 nautical miles), as well as the claimable continental shelf beyond the Exclusive Economic Zone.

To build a solid understanding of the complexities of the Region, information on ecosystems and human activities were gathered for both State and Commonwealth waters across six areas:

- biological and physical characteristics – identifying the key ecological characteristics in the Region, their linkages and interactions

• uses within the South-east Marine Region – describing our knowledge of the nature and dimension of human uses and their relationship with each other

• impacts on the ecosystem – providing an objective analysis of how activities can affect the Region's natural system

• community and cultural values – ensuring community wishes and aspirations are reflected in the planning process

• Indigenous uses and values – gaining an understanding of and support for Indigenous interests in the Region

• management and institutional arrangements – analysing current legislative and institutional frameworks to determine the best mechanism for implementing regional marine plans.

Specific scientific projects have filled gaps in our knowledge wherever possible and have clarified some areas in our understanding of the deep ocean's ecosystems. Specialist working groups of stakeholders and experts in their fields have provided invaluable direction and input to the planning process. As well, stakeholder workshops, community surveys and consultations have all helped build our knowledge base and have provided a voice for the people of the South-east Marine Region. Without this consultation, the picture would not be complete.

Moving forward

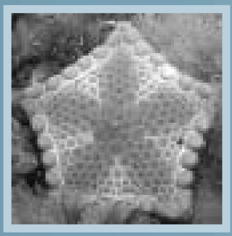
The six assessment reports are about increasing our understanding and appreciation of the Region's wealth and ecosystem diversity, and starting to define what we want for the Region. From this shared understanding, we will move forward to define a plan that maintains ocean health and supports competitive yet sustainable industries, as well as enhancing the enjoyment and sense of stewardship the people of Australia feel for the oceans.

While the Region includes State coastal waters, the South-east Regional Marine Plan will focus on the Commonwealth ocean waters.

The shared values and understanding of the Region gathered during the assessment stage give us a foundation for building a plan for the Region. The National Oceans Office has produced an Assessment Summary which brings together the key findings of the six assessment reports.

Supporting this Summary is a Discussion Paper which provides topic areas to help communities, industry and government begin discussion on the planning objectives, issues and concerns for the South-east Regional Marine Plan. The Discussion Paper also details the next stage of the planning process for the South-east Regional Marine Plan.

Your input into the regional marine planning process is important. To register your interest or for more information about the South-east Regional Marine Plan, Australia's Oceans Policy and the National Oceans Office, visit www.oceans.gov.au, or telephone (03) 6221 5000.



Introduction

Australia has a shorter history of large-scale industrial utilisation of marine resources than many other countries. Our marine industries have developed relatively recently in comparison to countries in the northern hemisphere and, so far, have not given rise to the large-scale resource and environmental problems that have occurred elsewhere. This gives us an advantage in managing our use of the marine environment. We have an opportunity to develop ways of managing our use of marine ecosystems to detect signals of undesirable change and modify our practices in time to avoid long-term or irreversible damage to them. This is a fundamental concept underlying precautionary, adaptive management.

Although Australia's history of large-scale utilisation of marine resources may be short, it has nevertheless left its mark on the ecosystems of the South-east Marine Region. For example, historical harvesting of marine mammals and seabirds in the Region has reduced populations of some species to very low levels (see the Uses assessment report for further information). Only now are some of the populations of seals, penguins, whales and other higher predators recovering from historically low levels (Appendix D).

Pressures to use the ocean's wealth mean that we need to put in place a way of managing all our interests as matter of increasing urgency to ensure the sustainability of marine resources. This requires an understanding of the ocean ecosystems and their responses to human uses and our capacity to predict outcomes.

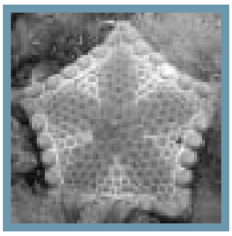
But how much do we know about these ecosystems, the organisms that inhabit them and how they interact and function?

Over the past few decades, our knowledge of the physical and biological components of marine ecosystems has improved rapidly thanks to new technologies and capabilities. Yet, our knowledge of the fauna and flora of the continental shelf and slope around Australia is still so limited that every new expedition brings to light many undescribed species.

We do know that the Region is distinguished by very high species diversity and many endemic species (species which occur only in the Region). We also know that the marine environment of the Region includes unique geological features, such as Macquarie Island and numerous seamounts (underwater volcanoes) and canyons, and is subject to complicated mixing and movement of large-scale ocean currents. These physical and biological components form oceanic ecosystems that are complex, dynamic and variable at a range of scales in both space (millimetres to thousands of km) and time (seconds to millions of years).

Despite the recent advances in understanding marine ecosystems our knowledge of the Region is embryonic and this state of knowledge, combined with the complex and dynamic nature of marine ecosystems, have implications for management.

The cost of acquiring such knowledge is high and will take many decades. While additional information will help us to better understand the ecosystems of the Region, we will never have perfect knowledge or perfect powers of prediction.



Ecosystem-based management

Ecosystem-based management is a significant shift in managing of human use of the environment. In principle, it recognises that ecosystems are complex, interconnected and dynamic and that we rely on these ecosystems for essential resources. The effects of human actions on one part of an ecosystem cannot be considered in isolation from the rest, nor from the combined and cumulative effects of all human activities that affect the whole ecosystem. This shift is a response to the growing realisation that we need to move to a more integrated approach for assessing and managing human use of natural resources if we are to maintain healthy marine ecosystems and the benefits we derive from them.

Management needs to address the complexity and uncertainty in the marine ecosystem. To do this it must be pro-active, managing the ocean so that we avoid further damage to the diversity and long-term productivity of ocean ecosystems. Management also needs to be precautionary, this means we must not postpone management because of scientific uncertainty and it must be adaptive so that new information and understanding can be incorporated. Adaptive management requires 'feedback' mechanisms, such as monitoring the effects of use on the ecosystem through 'indicators'; setting 'targets' for desirable states of the ecosystem and 'limits' for undesirable conditions; and developing agreed 'rules' for changing use in response to signals from the monitoring.

Adaptive management relies on ecosystem objectives and indicators of ecosystem health and integrity. These objectives and indicators need to be based on the best possible understanding of the structure and function of the Region's ecosystems and should be developed in the context of the natural variability and inherent uncertainties in our understanding of marine ecosystems. They should also reflect the relative vulnerability of different ecosystems to individual, combined, and cumulative impacts of human uses. Once we have developed objectives and indicators we can use them to develop adaptive strategies, monitor the status of the ecosystem, the impacts of human activities and the effectiveness of management.

Ecological boundaries and the scope of this assessment

Ecosystem-based management requires a move away from boundaries based on jurisdictions and sectoral patterns of use towards planning based on the characteristics of the ecosystem. There are few 'hard', well-defined boundaries in ecosystems. Gradients of change in characteristics between different areas are common, and a variety of ecosystem processes link the different areas. This assessment covers all marine environments of the Region – both State- and Commonwealth-managed.

Ecosystem-based boundaries are a way to identify areas that have recognisable differences from adjacent areas. They are flexible, to accommodate new knowledge and to allow for differences in the characteristics of a particular area and predictions of how these areas will respond to human uses and management.

This assessment will help towards developing an ecosystem-based regional marine plan for the South-east Marine Region by providing an overview of the structure and function of the ecosystems of the Region. The focus of the assessment has been on providing key inputs for developing an ecosystem-based regional marine plan.

These inputs include an Interim Bioregionalisation and Conceptual Models of the functional links between ecosystems, along with general background information on the physical and biological characteristics of the Region.

- Interim Bioregionalisation – identifies spatial structures (bioregions) based on ecological attributes (ie geology, ocean currents, biota) between the continental shelf-break and the limits of Australia's Exclusive Economic Zone. This project has significantly improved our knowledge of the deep-water ecosystems of the Region and the resulting bioregions provide an ecosystem-basis for developing planning units for the Region.
- Ecosystem Conceptual Models – illustrate how the ecosystems of the Region function. These Conceptual Models provide a basis for developing more formal models for specific management issues that will be addressed by regional marine planning. They also provide a basis for developing ecosystem objectives and indicators – key elements in performance assessment and adaptive management systems.

As well as developing the Interim Bioregionalisation and the Conceptual Models, the assessment includes a review of the state of knowledge of the biological and physical characteristics of the Region gathered from relevant scientific literature and meetings with experts as well as a series of commissioned projects.

These tools and information will assist us in the next phase of the regional marine planning process, as we move from the assessments phase to developing a regional marine plan.

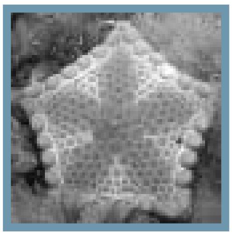
We will use the Interim Bioregionalisation to define ecosystem-based planning units for the Region in the next phase of the planning process. Information on patterns of use across the Region and practical management considerations will also affect our delineation of planning units, which may involve different levels and configurations depending on the planning purpose.

The next phase of the planning process will use the Conceptual Models together with the Interim Bioregionalisation and the outcomes of the other assessments to analyse the range of potential impacts and evaluate the risks posed to the ecosystems of the Region. Where appropriate (ie for priority planning issues) and possible (sufficient information and understanding), the Conceptual Models may be developed into computer models to assist in the assessment and evaluation of the potential impacts of actual and planned activities in the Region.

Structure and contents of this report

The biological and physical assessment is organised into three streams of work:

- ecosystem structure – developing the Interim Bioregionalisation for the Region. A Working Group provided expert advice and assistance, and eight research projects were commissioned to develop the bioregions.
- ecosystem function – understanding the dynamics of the ecosystems in the Region and the physical and ecological processes that link them. The major outcome of this work is a set of ecosystem Conceptual Models – illustrative graphics and accompanying text – that provide a basis for developing ecosystem objectives and indicators. A Working Group provided expert advice and assistance.
- synthesising existing knowledge – gathering published scientific information on the structure and function of the Region's ecosystems. We have used this information in developing the ecosystem Conceptual Models and the content for this assessment report.



Chapter 1 provides a brief summary of the current understanding of ecosystems of the South-east Marine Region. We identify areas of knowledge that are particularly relevant to developing ecosystem-based regional marine plans.

Chapter 2 outlines the approach taken to developing the Interim Bioregionalisation. It also provides an overview of the current knowledge of the physical environment, including the geology of the sea floor, and the characteristics and movements of the water masses in the Region. It includes brief introduction to the plants and animals that live in the Region, including those listed as threatened and introduced species.

Chapter 3 introduces a general conceptual model of marine ecosystems and describes the large-scale physical and ecological processes that drive the dynamics in the Region. It also presents the Conceptual Models of specific ecosystem types that occur in the Region.

Chapter 4 outlines how information from the assessment can be used in an ecosystem-based regional marine plan, including how we can move towards planning units and operational objectives. This will take us from assessments to integrated monitoring and adaptive management.

The report also includes four technical appendices with information on:

- the Interim Marine and Coastal Regionalisation of Australia meso-scale bioregions
- the Interim Bioregionalisation developed as part of this assessment
- knowledge of species harvested by commercial fisheries
- the status and ecology of species of conservation significance.

This report is not a comprehensive description of all known biological and physical aspects of the Region, but rather highlights information relevant to the regional marine planning process and provides an entry point into additional sources of information.

There is a wealth of published literature on the biological and physical characteristics of the Region and we have not attempted to include it all in this report. We have provided the details of recent review publications that can provide further references. Key sources and suggested further reading are provided at the end of each section.

The history of human use of the marine environment is covered in detail in the report *Resources – using the ocean*. A classification of potential impacts and the natural system associated with human use are covered by the report *Impacts – identifying disturbances*.

Chapter 1
The state of knowledge

Hidden and unsuspected wealth in the deep sea

The Challenger expedition, in the second half of the 19th century, demonstrated that the deep reaches of the ocean were not a lifeless desert as people had long believed. They collected over 1500 species from more than a kilometre below the surface. Since then, deep sea exploration has revealed that the deep ocean, far from being sparsely inhabited by a limited number of organisms, hosts a rich array of life forms including entire ecosystems that are independent of solar energy. Some of the key discoveries of life in the deep ocean are shown in Figure 1.

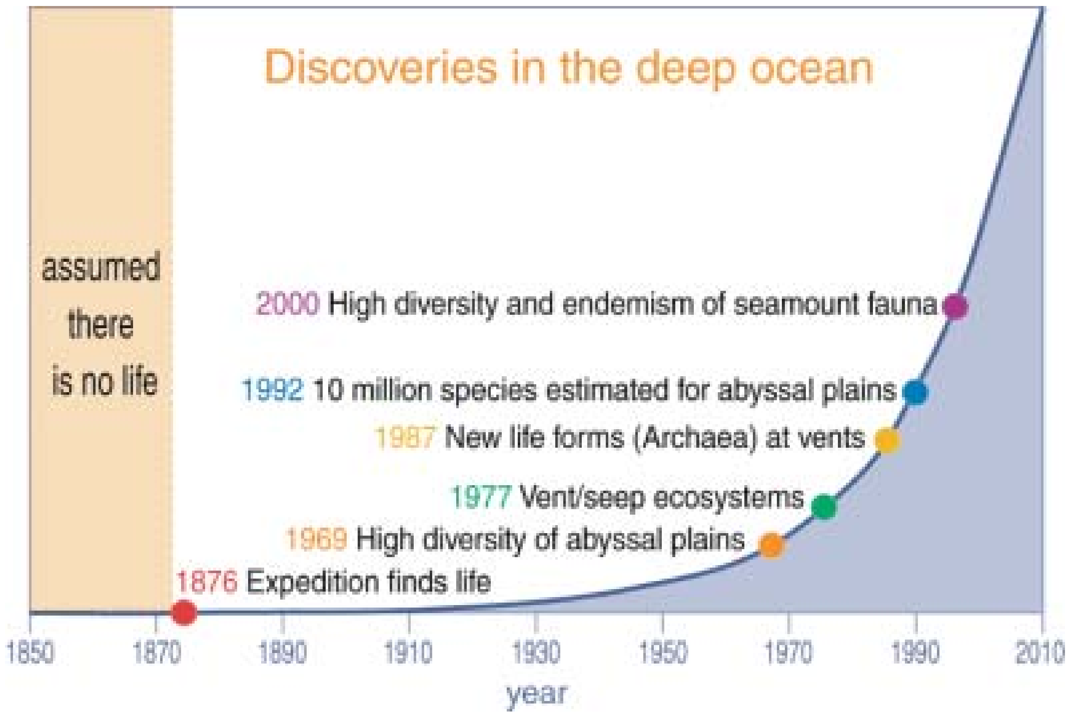
Complex seafloor topography

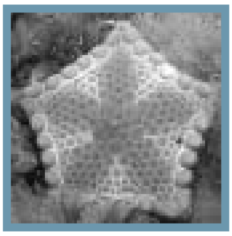
Remote-sensing technology (multibeam swath sonar) enables us to investigate larger areas of the ocean at greater depths than was possible with previous technology. We are starting to build a broad-scale picture of the structural and geological characteristics of deep-sea environments around Australia. This picture is revealing a far more complex topography of the seafloor than has been previously known.

Recent surveys sponsored by the National Oceans Office have extended the coverage of seafloor maps of the Region and our understanding of the structural features of the deep-sea habitats. These expeditions, named Austrea-1 and Austrea-2, have surveyed and mapped 260 000 km^2 of seafloor, unveiling previously unsuspected and spectacular features, such as canyons, seamounts and fractures (see page 18 for a detailed description of seafloor features).

Despite recent progress our picture is incomplete, because it is built upon very few observations – the area for which we have information is only a small proportion of the whole. Only about a tenth of the seafloor habitats in the Region have been surveyed to date, and mostly in water shallower than 30 metres. Even in such an economically important area as the grounds of the South East Fishery, only 11% of the continental shelf (itself a small portion of the total fishing grounds) has been surveyed. Consequently, our knowledge of the marine habitats in the Region is sparse and largely limited to the more accessible inshore environments.

Figure 1: *A timeline of some key discoveries in the deep ocean. Reprinted with permission from CSIRO Marine Research.*





Unique and unfamiliar organisms

Samples of marine organisms have been collected for centuries by explorers, but mostly from inter-tidal and shallow waters. Biological information requires direct sampling, which, relative to the area sampled, is far more time and cost consuming than the remote sensing techniques that provide us with physical information.

As a result many species that live on or above the continental shelf and slope of the Region are unknown – one estimate is that only about a tenth of the fauna that live on the Australian continental slope have been described. For example, of the fish that live on or near seamounts in the Region 15–25% may be either new to science or new records for Australian waters. In another example, only 9.7% of the isopod (sea lice) species sampled by a recent survey of the continental slope had previously been described.

A consequence of our limited knowledge of these environments is that newly-described species are thought to be endemic – that is, found only in that locality. For better-known shallow environments there is little doubt that temperate Australia is indeed rich in endemic species. However, for deeper under-explored habitats, records of new species may simply reflect the fact that we have not looked elsewhere. An example is the prawn *Paracrangon australis*, which was first collected from a seamount off southeastern Tasmania and thought to be endemic to that habitat, but was later found on the Macquarie Ridge and the deep (1500 m) slope off Flinders Island. Similarly, the seastar *Smilasterias clarkailsa*, initially recorded from around Macquarie Island, was recently found on the southeastern Tasmanian seamounts.

The most well-studied of the flora and fauna of the Region are those that have a commercial or cultural value to us. However, basic biological parameters for many target species in the South East Fishery, and the Region generally, are poorly documented and results from earlier studies (particularly work on ageing of fish) are sometimes misleading. For example, most outer-shelf and slope species appear to be much older and grow more slowly than initially thought, which has significant ramifications for stock assessments in that earlier assessments may have been overly optimistic about sustainable long-term yields.

Because of the focus on particular high-value species, data on either bycatch or several low-valued fisheries in the Region and their target species is inadequate (see Appendix C) despite high catches (tonnage) of some of these species. This means that our ability to predict the potential long-term effects on the fishery and broader ecosystem is limited at best.

Understanding species interactions

Understanding feeding relationships – 'trophic' interactions – is an important part of understanding how ecosystems work. Scientists attempt to understand trophic interactions by collecting data on natural systems and modelling the interactions of species on computers. Investigators piece together studies of stomach contents, species distributions, reproductive strategies and environmental conditions to understand the relative importance of different links and how they may change under different conditions.

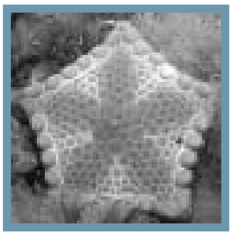
It is difficult and time-consuming to gather detailed data on trophic interactions. As a result, most data from the Region describes the number, abundance and distribution of species rather than their direct trophic interactions. Trophic interactions can sometimes be determined from habitat information, but habitat and diet may not be directly correlated. For example, some species use particular habitats as much for protection as for feeding.

Other species are opportunistic feeders, so a one-off stomach contents study may not identify all the foods the animal eats, or how this may change. Computer models allow us to explore the relative importance of different types of information, which in turn helps prioritise research.

From the few studies that have been conducted we have learned about energy flows between a limited set of species and between ecosystems. For example, pelagic off shelf production is now regarded as playing a significant role in the productivity of some fishing grounds in the South East Fishery and possibly more broadly across the Region. Researchers have also found that many species previously thought to be primarily demersal (ie. living near the seafloor) may feed in, or occupy, various levels of the water column at different times and be more reliant on pelagic prey than bottom-dwelling prey species.

Although understanding the links and functions in the complex and under-explored deep sea ecosystems may take decades, we have sufficient knowledge to tentatively describe links and functions within and among ecosystems and design our management and research programs to increase our understanding and improve management outcomes over time.

Some key references and further reading:
(Bax & Williams. 2001), (Bax, et al. 2001), (Bax & Williams. 2000), (Bernardel, et al. 2000), (Bernardel & Symonds. 2000), (Bruce, et al. 2002), (Butler, et al. 2000), (Hill, et al. 2000), (Kloser, et al. 2001), (Koslow & Gowlett-Holmes. 1998), (Koslow, et al. 2001), (O'hara. 1999) (Phillips. 2001), (Poore. 1995), (Williams & Koslow. 1997), (Williams & Bax. 2001), (He & Furlani. 2001).



Chapter 2 The Region's ecosystems: key components & structure

Classifying ecosystems

Marine ecosystems can be viewed as hierarchically structured systems – each ecosystem contains finer levels of organisation, each contained within a large context. Which level we examine will depend on the planning and management purpose. Although hard boundaries in ecosystems are the exception rather than the rule, there are real discontinuities that can be recognised. It is these that allow the development of classification schemes that have specific management applications.

The definition of particular marine ecosystems relies upon our ability to detect and interpret associations between organisms and the biophysical characteristics that structure the environment they inhabit. An audit of ecosystems within such a large area as the South-east Marine Region requires a classification scheme that can accommodate the diversity of structures that occur in the marine ecosystem. To do this, the scheme needs to consider the broad-scale influences on the ecosystem – geology, climate, oceanography and the species' evolutionary history – in order to understand the finer-scale structures or habitats. These can be characterised from information on which species live where, seafloor topography and local oceanographic patterns.

A matter of scale

Broadly defined, a 'habitat' is the place, or type of site, where an organism or a population occurs naturally. On land we can observe organisms directly, so we have been able to classify most of our terrestrial environments into detailed habitat types. For example, we can map the distribution of many land-based animals or can estimate their distribution from maps of vegetation communities in which they normally live. In a similar way, the shallow waters along much of the coastline have been directly surveyed, and different types of coastal habitats have been identified through mapping and sampling (eg inter-tidal wetlands and rocky foreshores). Even with the recent advances in technology, this detailed habitat mapping is very difficult in the deep oceans. But our understanding of marine ecosystems cannot rely only on detailed habitat mapping – it needs to be placed in a broader context. In this assessment we have focussed on developing a hierachical classification of the Region. It will inform priorities for areas of detailed habitat mapping.

Nested structures

The structure of marine ecosystems can be considered at a range of spatial and temporal scales. At the broadest scale we can identify large regions that reflect differences in geological structure (bathymetry, tectonic elements and fault lines, continental-plate age) and biological patterns (distributions of fauna and flora). Such information can be used to infer long-term ecosystem processes such as evolutionary history. An example of this evolutionary history is that species living in the north-west of Australia are different from those in the south-east. Nested within these broad-scale regions, we can identify differences between plant and animal assemblages in different areas at increasingly finer levels of spatial and process scales. In this way, within the South-east Marine Region we can determine that areas on the continental slope (at depths greater than 200 m) support different marine ecosystems than inshore areas. Within the inshore, kelp forests are different from mudflats; within mudflats, areas of coarse sediment are different from those with fine silts; and so on.

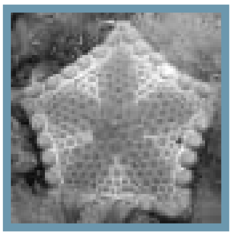
Of course, we cannot map the deep waters directly and we haven't sampled every species of animal or plant. The challenge is to find other, innovative ways of estimating these finer scale levels and how they differ from place to place and year to year. To do this we use surrogates as a substitute for different elements of the marine ecosystem (see box – Suitable substitutes).

Suitable substitutes

Surrogates for process: the current distribution of a fish species that lives at or near the seafloor and does not tend to move very far, can tell us a lot about its historical distribution. Combined with information about geological history in an area, the current distribution of a fish species (or even a group of fishes) can be a useful surrogate for evolutionary history (a long-term ecosystem process) of the area and the animals and plants associated with it.

Surrogates for habitats: we can apply a similar logic to identifying benthic assemblages. For example, the water depth, roughness of the seafloor and mobility of the sediments all influence the types of animals and plants that might live there. Consequently, we can use water depth, seafloor roughness and sediment mobility as surrogates for the habitat type.

Once we recognise this hierarchy of scales we are better able to describe the characteristics of a habitat or biological community and may be able to predict the type of communities that are likely to occur in a particular area. For example, we could travel the entire length of the Australian coastline marking where the sandy beaches are, but what would this tell us? To call these beaches 'habitats' we must classify them further by answering questions such as whether the beaches are in a tropical or temperate area, exposed to strong waves, subject to frequent storms or backed by coastal vegetation or dune systems. When we can classify a sandy beach as, for example, a temperate beach with low-energy waves and coastal scrub on the dunes behind the beach, we have a habitat that might be supporting a penguin rookery. By using surrogates we can extend this kind of mapping over larger areas and in environments that are difficult to observe directly, like the deep sea.



other. Recognising these gradients and representing them appropriately is another way of illustrating the overall complexity of the system.

Broad environment types

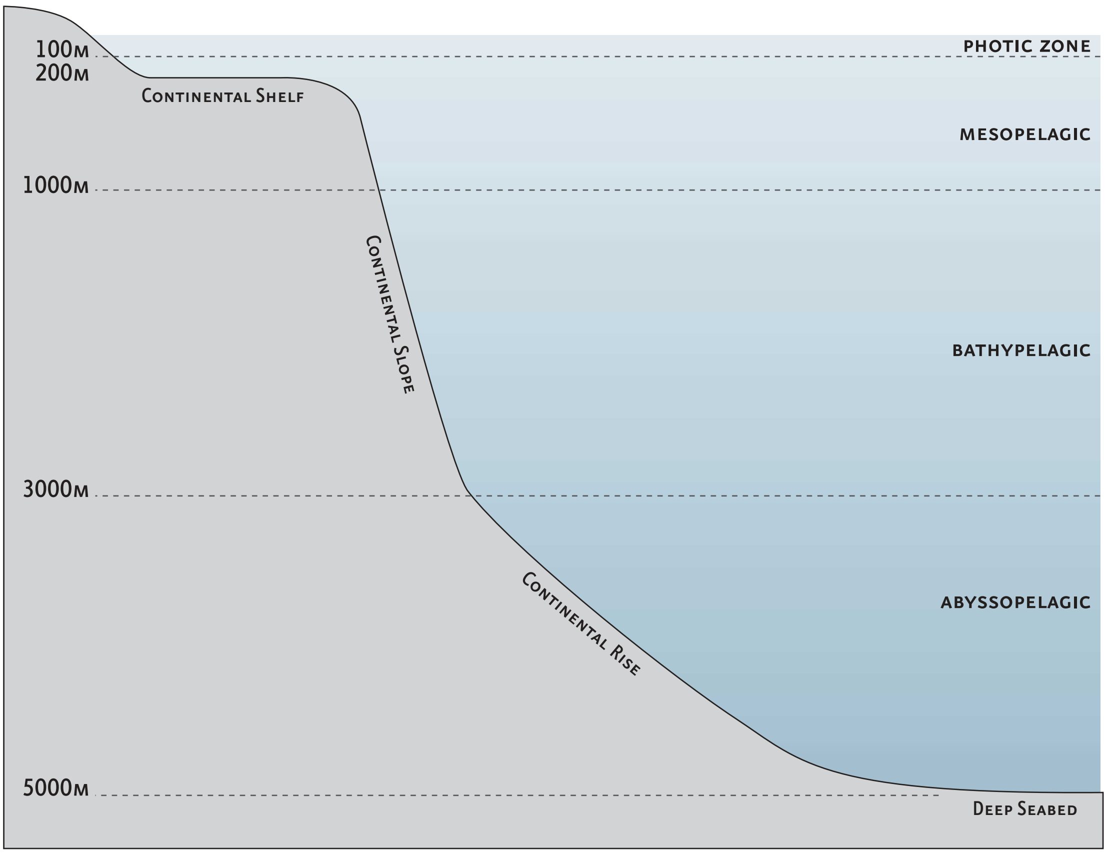
Marine ecosystems can be divided into broad environment types according to their depth, distance from the coast and the processes that create them. Thus, the continental plate is made up of the continental shelf, the continental slope and the continental rise. Similarly, the water above the seafloor can be divided into the photic zone (between 0 and 100 m where the sunlight penetrates and enables photosynthesis) and the upper pelagic, mesopelagic, bathypelagic and abyssopelagic zones. These broad environment types are shown in Figure 2.

Within these broad environment types, a variety of topographic and oceanographic features provide habitats for different assemblages of species. Understanding such habitats and communities provides us with a way to 'map out' the ecosystem that accounts for some of its complexity and provides a base for developing ecosystem-based plans. But it is important to remember that marine ecosystems grade into each other. Recognising these gradients and representing them appropriately is another way of illustrating the overall complexity of the system.

Broad environment types can be generally identified in any area of the marine environment. For planning and management purposes we need a more specific understanding of a particular region, what species assemblages we can expect to find, what geological and oceanographic features shape the ecosystem, what habitats may be there, and the nature of the ecological processes that link them. For this reason we need to improve our understanding from the generic classification of broad environment types, like that in Figure 2 to a classification specific to the region.

Some key references and further reading:
(Butler & Harris. 2001), (Day, et al. 2000), (Greene, et al. 1999), (Holling. 1992)

Figure 2: *Generic, broad marine environment types. Depths and horizontal distances are not to scale.*



Creating manageable units

Recent attempts to describe the hierarchical structure of the marine ecosystem in Australia have provided a basis for additional studies to refine our understanding of the Region, including two major classification systems:

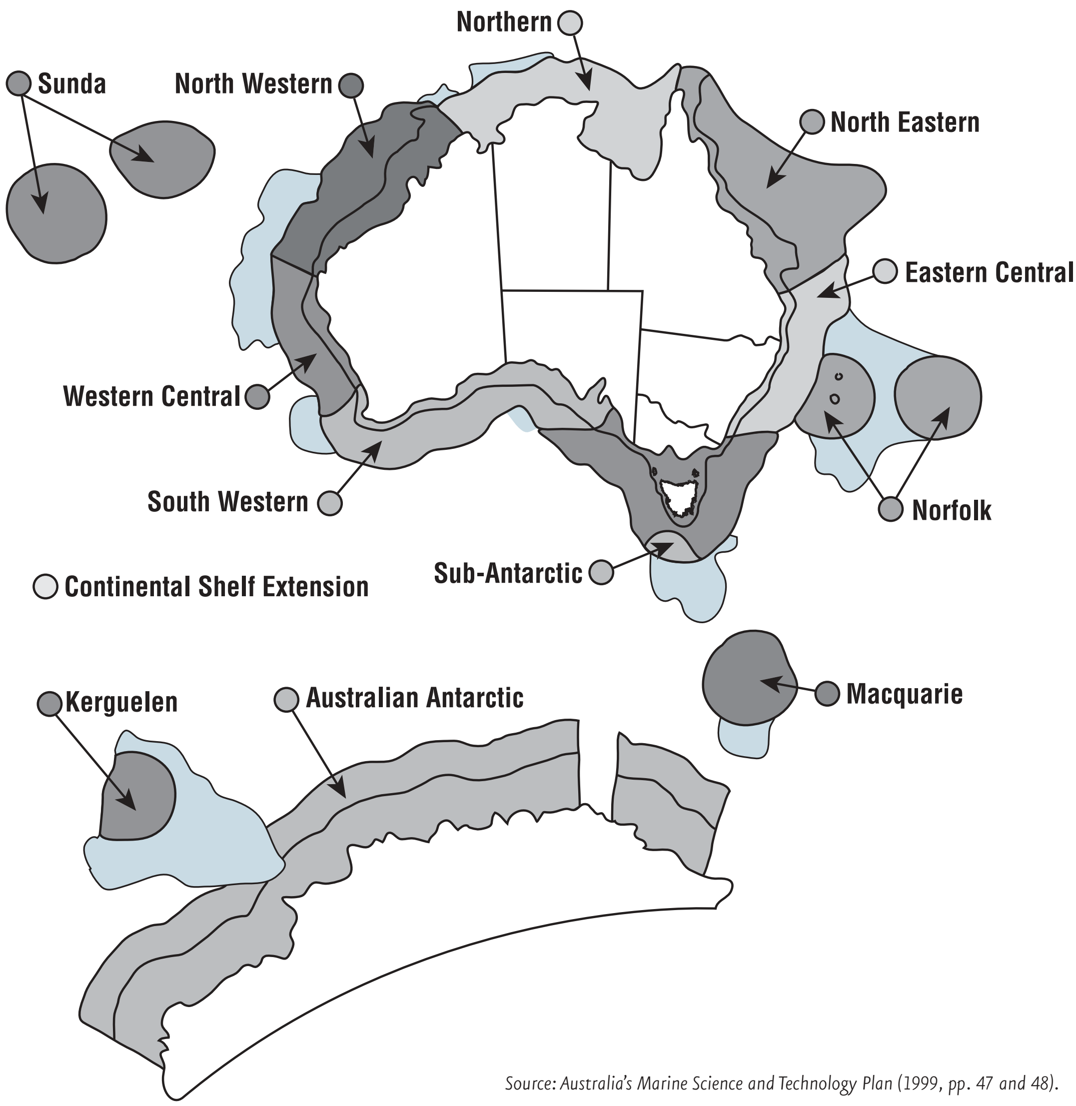
- Large Marine Domains (LMD)

- The Interim Marine and Coastal Regionalisation of Australia (IMCRA).

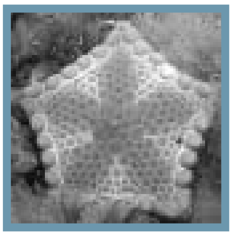
Large Marine Domains

The IMCRA project included developing demersal and pelagic provinces for the offshore areas in Australia's EEZ. These provinces and associated biotones have since been merged into major ecological domains (Large Marine Domains) – seven around mainland Australia, five domains in the external territories and one subantarctic domain in the waters directly to the south of Tasmania. These Large Marine Domains were identified by characteristics including bathymetry and ocean properties such as temperature, salinity and the age of the seafloor plate.

Figure 3: *Large Marine Domains modified from CSIRO 1998 and Marine Planning Regions.*



Source: Australia's Marine Science and Technology Plan (1999, pp. 47 and 48).



The Interim Marine and Coastal Regionalisation of Australia (IMCRA)

IMCRA (Version 3.3, 1998) focuses on the continental shelf (waters less than 200 m deep). At the largest scale, these provinces and associated biotones (areas that contain a mix of elements from core provinces) are the 'top layers' or broad context for the inshore areas of the Region. There are two types of provincial boundaries (see figure 4):

- one based the demersal environment (demersal organisms live close to the seafloor and benthic organisms live on, or burrow into, the seafloor)
- a second based on the pelagic environment (pelagic organisms live in the water, sometimes far above the seafloor).

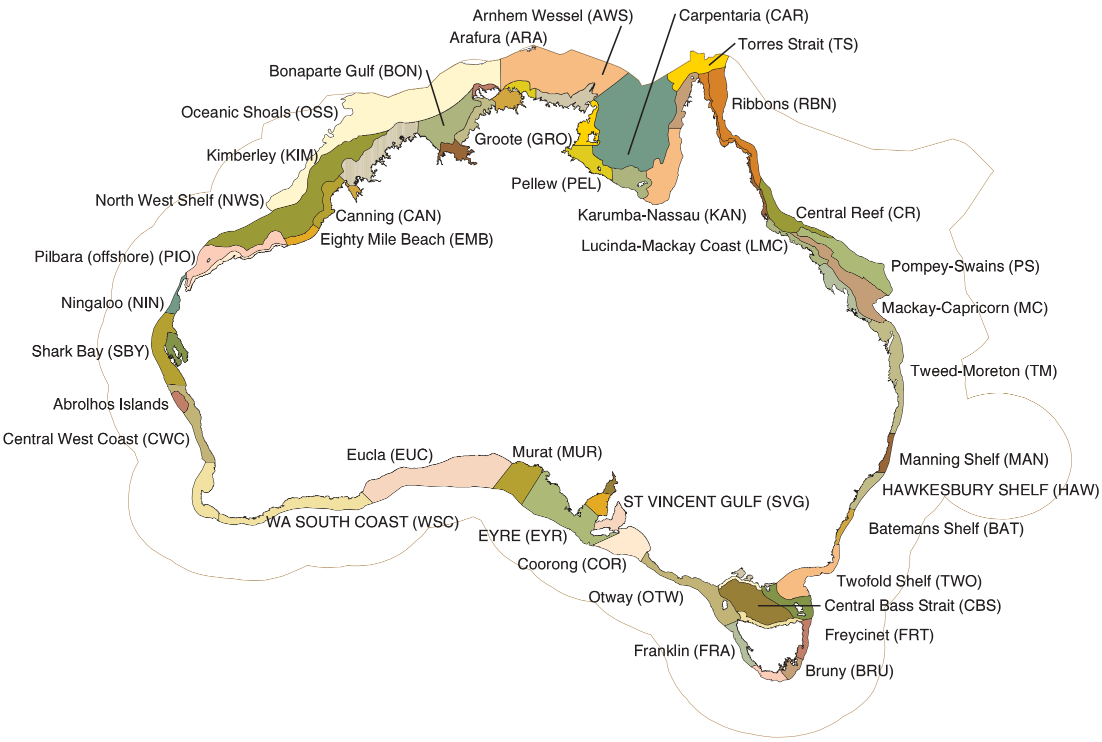
IMCRA relies primarily on information about fish species' distribution and physical characteristics (eg seafloor topography and oceanographic data) to identify provincial boundaries. Within the provinces and biotones, IMCRA included bioregions, typically hundreds to thousands of kilometres in size.

LMD and IMCRA in the South-east Marine Region

The South-east Marine Region consists of three Large Marine Domains (based on CoA 1999; p47–48):

- South-eastern – extending from Gabo Island, through Tasmania and Bass Strait, to east Kangaroo Island, in South Australia. Seasonal surges of warm subtropical water are found along both flanks of this Domain. In the east, it is the southern extension of the East Australian Current. In the west, the warm Zeehan Current combines with the seasonal west-east flow of waters of the Subtropical Convergence Zone in the southern half of the Domain, creating a diversity of environmental conditions that support a range of endemic cool temperate species. This domain contains the southern Tasmanian seamounts, the endemic relic species of Port Davey in the southwest corner of Tasmania, and some endemic species found in Bass Strait. The south and southeastern parts of this Domain are favoured feeding grounds for a variety of pelagic fish, including southern bluefin tuna, as well as being on the recruitment path of the southern rock lobster.

Figure 4: *IMCRA version 3.3, 1998.*



- Sub-Antarctic (or South Tasman Rise) – consists of the northwestern portion of the South Tasman Rise – a subantarctic, deep-water continental rise forming the southern ridge of a deep-water channel between the rise and the southern tip of Tasmainia. Water currents in this channel mix the warmer waters from the Zeehan and extended East Australian Current with those in the cooler Subtropical Convergence Zone. The area is still being explored; remarkable submarine cliffs and seamounts have recently been discovered there.
- Macquarie – defined by Macquarie Island, ridge and associated seamounts, it is a subantarctic region with the dominant fauna sharing affinities with New Zealand and other fauna being more closely aligned with Antarctica. Macquarie Island which is narrow east-west, but long north-south, is on the Macquarie Ridge which is connected to the south of New Zealand. It is an area of high earthquake activity. The commercially valuable mid-water Patagonian Toothfish has recently been found there.

Under the IMCRA bioregionalisation, there are eleven of bioregions within the South-east Marine Region, capturing some significant ecological patterns (refer to Appendix A for more information):

- The northeast of the Region is characterised by a warm temperate influence, high numbers of plant and fish species and distinctive assemblages of reef fish, echinoderms, gastropods and bivalves. The Bass Strait has diverse infauna (ie animals living buried in the sediments) and seasonally variable water temperatures.
- The waters to the south east and south-south east of Tasmania are typically moderate to high in fish and plant species richness and the south-southwest inshore areas have a high number of endemic species.
- Along the western coast of Tasmania is an area with no uniquely characteristic plants and animals and a low species richness (possibly because it is a very exposed coastline). The western portion of the Region is influenced by the extension of the Leeuwin Current carrying species typically found in South Australia and areas further west. As a result, this area has high species richness.

Some key references and further reading:
(Anzecc & Group. 1998), (Lyne, et al. 1998), (Commonwealth of Australia. 1999).

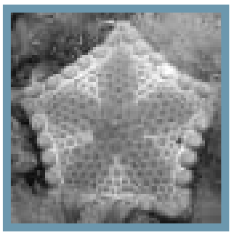
Interim Bioregionalisation

While there are similar patterns in the LMD and IMCRA classifications, the developers of both regionalisations noted that additional information would be required to advance our knowledge to a finer scale and further refine the broad-scale provincial and domain boundaries.

This was particularly the case for the deeper outer continental shelf and slope waters of the Region, so the National Oceans Office commissioned the Interim Bioregionalisation of the South-east Marine Region. One of the aims of the project was to complement the existing regionalisations, particularly IMCRA. This new project has significantly improved our knowledge of the deep-water marine ecosystems of the Region.

The Interim Bioregionalisation is a significant collective achievement of the project teams, the National Oceans Office and the Bioregionalisation Working Group. Eight projects were commissioned for the Interim Bioregionalisation (refer Table 1).

A summary of the eight projects is included in Appendix B.



The bioregionalisation analysis project undertaken by CSIRO Marine Research and Geoscience Australia (Project 8) integrated the data from each of the other projects as the basis for the Interim Bioregionalisation. They worked closely with the other project teams and the Bioregionalisation Working Group to refine the methods and theory behind the bioregionalisation and to define the details of the Interim Bioregionalisation.

More information about the analytical approach and the data sets used in the project is in Appendix B and the project report (Butler et al. 2001).

The Interim Bioregionalisation of the Region identifies bioregions based on ecological attributes. It encompasses benthic and demersal (near-bottom) areas deeper than 200 m within the South-east Marine Region, including around Macquarie Island. In this way, the Interim Bioregionalisation complements earlier work defining bioregions on the shelf (IMCRA).

Because of the hierarchical nature of marine ecosystems, the Interim Bioregionalisation has nested levels. The hierarchical structure of the Interim Bioregionalisat-ion is fully explained in Figure 5 and the project team have identified provincial (Level 1), biomic (Level 2a and 2b) and geomorphological units (Level 3) across the entire Region:

- the highest level corresponds to the large-scale, long-term geological and evolutionary history of the Region; it includes four large provinces which were determined using biological (fish ranges) and geological data.
- the next level separates the continental shelf, slope and abyssal plain. It also identifies patterns of depth layering in groups of fish species over the continental slope and shelf-break. These groupings are thought to be associated with depth layering in the major oceanic water masses. One surprising and important result of this pattern are long and thin bioregions that trace depth layers along the continental slope.
- the third level includes 60 units based on discrete geological features (eg a field of small seamounts or one large seamount) and tells us about the types of biological assemblages that might occur in a given area.

Table 1: *Oceans Office/CSIRO Intermim Bioregionalisation projects and teams.*

	Project	Project Team
1	Production of a consistent, high-quality bathymetric data grid for the South-east Marine Region.	Geoscience Australia (formerly the Australian Geological Survey Organisation).
2	Seabed characterisation of the South-east Marine Region (including seabed sample data).	
3	Upgrade of computer sediment model (GEOMAT).	
4	Refine broad scale bioregionalisation (Provinces and Biomes). CSIRO Marine Research	CSIRO Marine Research
5	Upgrade deepwater nutrient, water properties and ocean-current models.	
6	Rapid assembly of ecological fish data (community composition and distribution) for the South-east Marine Region.	CSIRO Marine Research (in collaboration with the Australian Museum, Museum Victoria and NSW Fisheries)
7	Rapid assembly of ecological invertebrate data (community composition and distribution) for the South-east Marine Region.	Museum Victoria (in partnership with the Australian Museum and CSIRO Marine Research)
8	Bioregionalisation analysis: integration of biological, geological and oceanographic data.	CSIRO Marine Research in collaboration with Geoscience Australia

The data used and numbers of units at each level are included in Figure 5. Additional work on mapping habitats (Levels 4 to 7) will be done as planning and management priorities are identified and/or when the results of further survey work becomes available (see Table 2).

Consistent with the IMCRA demersal provinces and biotones, the new provincial boundaries identified during this project reflect the significant influences of the East Australian Current and Leeuwin Current on assemblages of fish species. While similar patterns have emerged from all regionalisations, the provincial boundaries have been refined by each of the subsequent projects (LMD and IMCRA in the south east Marine Region).

While these regionalisations provide us with a way to describe patterns in the biophysical characteristics of the Region, they are not necessarily the best way of organising and presenting information about the Region. Instead of using the provinces or biomes, the following sections of this report use the broad environment types (ie inshore and inner shelf, mid- and outer continental shelf, continental slope and pelagic). This has been done because we can describe the key attributes of each environment type, but do not yet have sufficient information to describe the individual provinces or biomes in detail.

Some key references and further reading:
(Butler, et al. 2001)

Table 2: *Primary data inputs and numbers of units in the Interim Bioregionalisation for the Region.*

Level	Names	Examples
1	Province	Large-scale biogeographic units. The Interim Bioregionalisation includes three provinces over the continental slope and deep seafloor in the Region and one for Macquarie Island. Provinces are typically of the order of ~1000 km² in extent.
2	2a Biome	Continental shelf, slope, abyssal plain and offshore continental blocks (eg South Tasman Rise) are dictated by gross geomorphology. These are nested within provinces and are typically several hundreds of km² or more in extent.
	2b Sub-biomes	Upper, mid and lower slope, as well as shelf-break. These subdivisions are dictated by the distributions of animal communities, some of which have quite narrow depth ranges.
	2c Mesoscale Units	Along-slope subdivisions within, eg mid-slope unit, again typically dictated by fauna distributions. IMCRA identified 12 mesoscale units on the continental shelf in the Region, from 50 to 350 km² in size.
3	Geomorphological Units	Areas with similar geomorphology. These may include (on the continental shelf) fields of sand-waves, rocky outcrops, incised valleys and flat muddy seabeds and (on the slope and at abyssal depths) submarine canyons, seamounts, oceanic ridges and troughs. Such units are typically about 100 km² in extent.
4	Primary Biotopes	Low-profile reefs; soft-sediment areas between reefs. Such units may be tens of km²s in extent.
5	Secondary Biotopes	Rock types (eg fossiliferous limestone, granite); sediment types (eg shelly sands) or biota (eg seagrasses).
6	Biological Facies	Biological indicator (eg a seagrass species).
7	Microcommunities	Species that depend on facies (eg isopods on seagrass).

(Modified after Butler, et al., 2001:8)

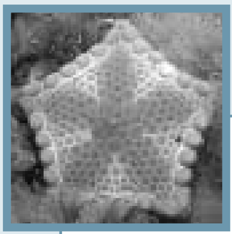
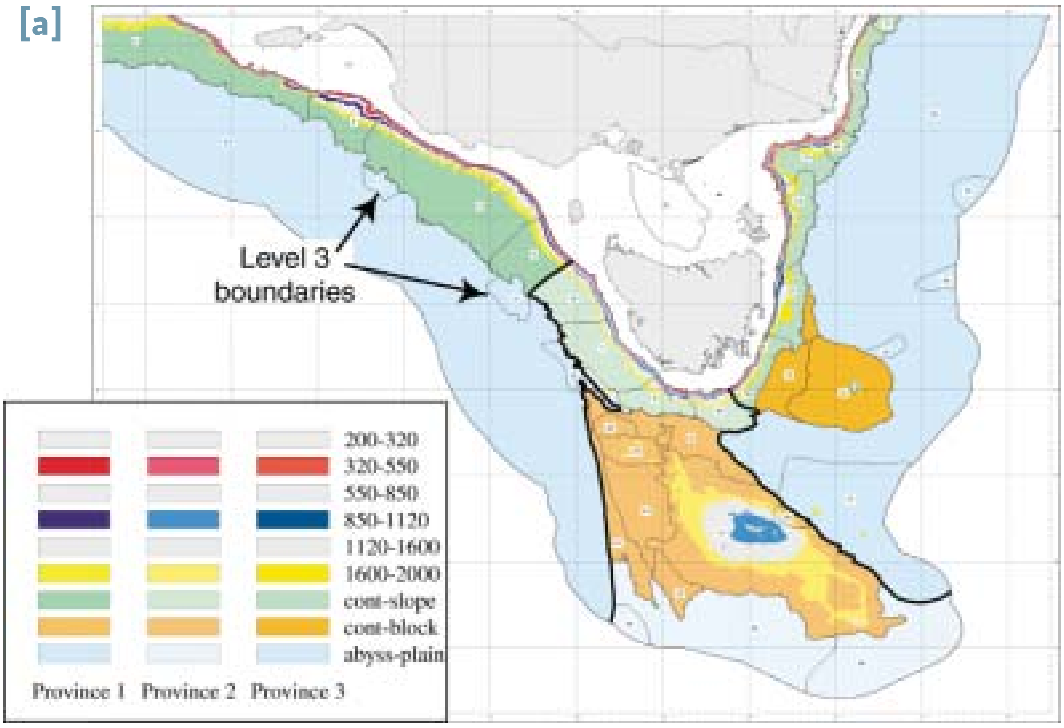
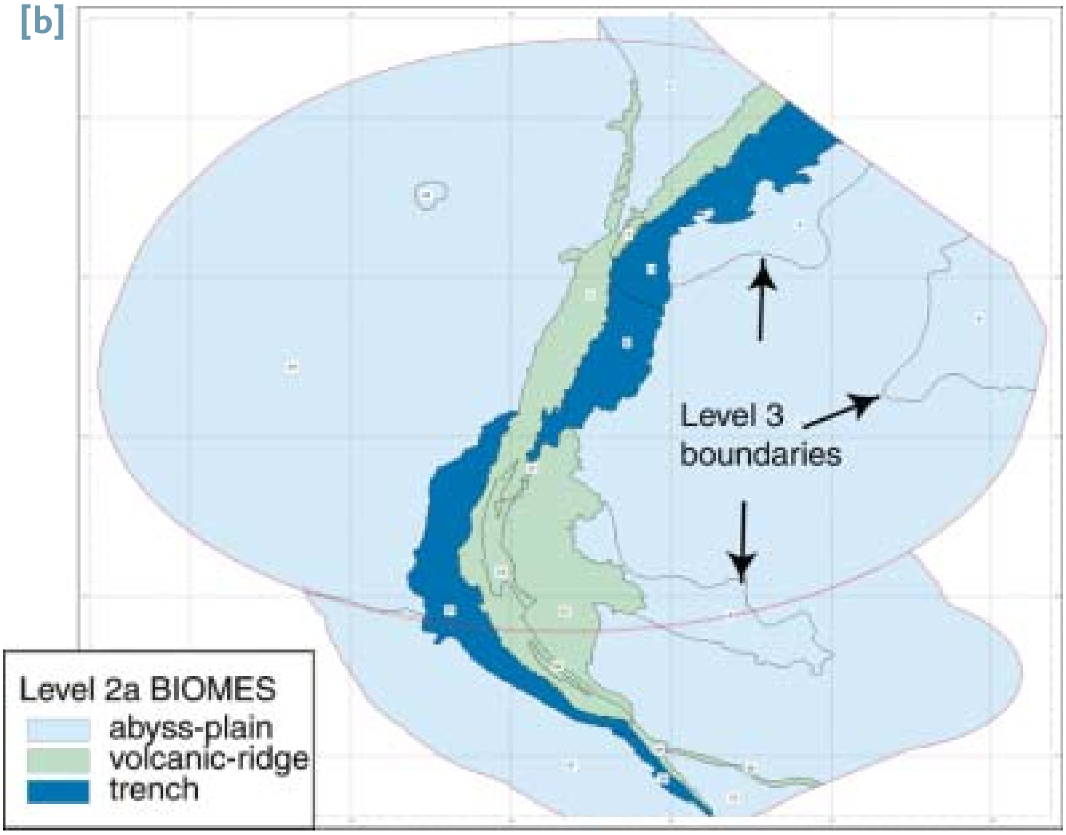


Figure 5: *Interim Bioregionalisation of (a) waters around the Australian continent including Tasmania and (b) waters around Macquarie Island area.*

[a]



[b]



Identifying the largest-scale province boundaries (Level 1, bold lines) relied on the distribution data of selected fish assemblages, as well as large-scale geological patterns. This information was used as a surrogate for diversity. Within the Level 1 provinces, the geology, (eg continental blocks and abyssal plain) played an important role in determining the Level 2a (biome) boundaries. The assumption made in defining the biome boundaries is that gross geology will influence the assemblages of fauna and flora that are found in an area. In particular, the demersal fish assemblages found on the continental slope may vary significantly from those found on the shelf or in the deeper waters of the abyssal plain.

Within the broad biomes, the most significant pattern in fish distributions was depth layering – many species live within a very narrow depth range. Sub-biomes (Level 2b) were defined around fish assemblages that demonstrated distinct depth distributions. The definition of the sub-biome boundaries also incorporated the changes in ocean temperature at different depths and, to some extent, the distribution of key invertebrate species. These sub-biomes are particularly noticeable on the continental slope, where there are boundaries at every few hundred metres of depth.

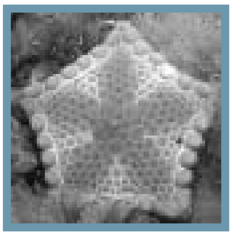
The geomorphological unit boundaries (Level 3) correlate with areas of similar seafloor geomorphology such as the large single and steeply-sided seamount (~ 23 km in diameter) northwest of Macquarie Island, and to the east of Tasmania and the numerous, deeply-incised canyons on the slope to the east of the Furneaux Group of islands in eastern Bass Strait. Other major features in the Region include extensively incised continental-slope areas, abyssal plains with rotated continental blocks, saddles between major continental blocks, the Bass Canyon, and the approximately 6000 m deep Hjort Trench near Macquarie Island.

A summary is provided in the table below.

For a more detailed description of the Bioregions, see Appendix B.

Hierarchical structure of the Interim Bioregionalisation for the Region.

Level	Primary data-sets for each level and number in Region
Level 1 (Province)	Distribution data of selected fish species, as well as large-scale geological patterns (eg continental blocks and abyssal plain). South-east continental margin: 3 Macquarie: 1
Level 2a (Biome)	Large-scale geomorphology (continental shelf, slope, abyssal plain and offshore continental blocks). Level 2a biomes are nested within Level 1 provinces. South-east continental margin: 4 biome types Macquarie: 3 biome types
Level 2b (Sub-biomes)	Depth ranges of groups of fish species, corroborated with water mass information. Level 2b sub-biomes are nested within the Level 1 provinces and Level 2a biomes. South-east continental margin: 3 sub-biome types with zootones in between Macquarie: (insufficient data for determination)
Level 3 (Geomorphological Units)	Areas of similar seafloor geomorphology (eg a single, large seamount, an area of continental slope that is extensively incised by canyons, saddles between major continental blocks). Identified primarily from bathymetry. Corroborrated with crust age, acoustic facies, seabed sediment type, sedimentary basins, ocean currents. South-east continental margin: 39 Macquarie: 21



The seascape of the South-east Marine Region

The complex structure of the seafloor provides the physical background for all of the life and biological activity in the South-east Marine Region.

Geological history

Some 160 million years ago, Australia was a part of a super-continent – Gondwana land – one of two giant landmasses at the time. Gondwana also included all of Antarctica, South America, Africa and India. Laurasia, the second landmass, contained the northern continents. Over time, the heat of the Earth's core drives the movement of large sections of the Earth's crust, known as oceanic and continental tectonic plates. This process resulted in fracturing of the super-continents into smaller components that slowly moved around the surface of the globe (see Figure 7).

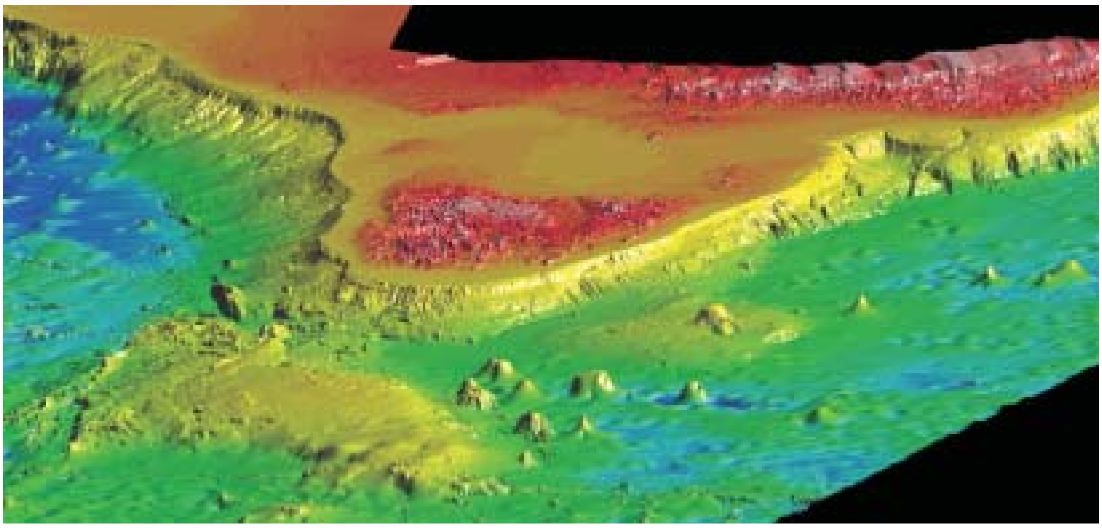
The geological evolution of the Australian continent has defined the South-east Marine Region as it is today. The continental shelves along the coastline have deeply canyoned slopes and the shallow Bass Strait is a wide bridge of continental shelf linking Tasmania to the mainland. Beyond Australia's continental shelf, abyssal plains are interrupted by undersea mountains and ocean ridges.

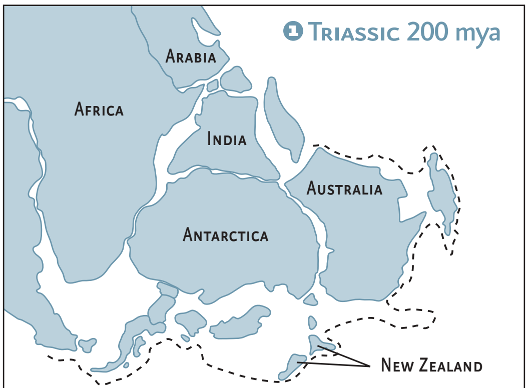
The shape of the sea floor in the South-east Marine Region is currently far better known than for most other areas of Australia, because of the multibeam sonar surveys carried out by Geoscience Australia since 1994 (see Figure 6). These surveys are documented by Exon et al. (1995), Hill et al., (1997, 1998) and Hill et al. (2000).

The chemical make up, movement and origin of seafloor sediments can also tell us about the history of the Region, and its resources. The presence of calcium carbonate, for example, tells us that the sediment was formed in an era rich in marine life. The remains of marine life on the seafloor form organic sediments, which after burial sometimes form a hydrocarbon resource, such as oil or gas.

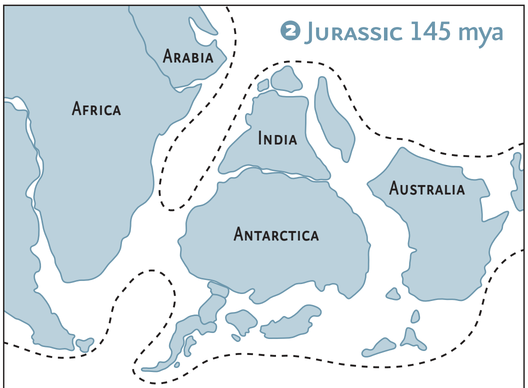
The presence of terrestrial sediments in the marine environment can provide information on the history of sea level change and the rivers that flowed into the sea, and the influence of the land on the ocean. The presence of riverine sediment fans on the continental shelf may indicate old river mouths that have since moved up or down the coast, or perhaps delineate the coastline during a glacial period when sea levels were lower.

Figure 6: *Bathymetry of the South-east Marine Region, prepared for the National Oceans Office by Geoscience Australia. Dry land is indicated by red, with Tasmania in the middle of the image. Bass Strait and continental shelf around the region stretches from the land to the shelf break, where the seafloor slopes away toward the abyssal depths. Large seamounts dot the deep seafloor in the southeast of the Region and the continental block of the South Tasman Rise appears in the lower left of the image (south of Tasmania).*

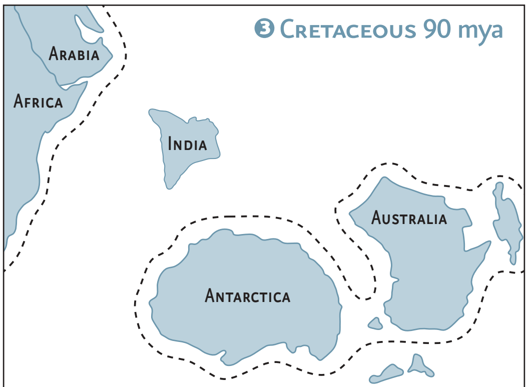




Ⓐ One supercontinent exists called Pangaea, containing all landmass of the globe. Dashed line indicates Triassic coastline.



Ⓑ Pangea has separated into two landmasses: Laurasia to the north and Gondwana to the south. The Tethys Sea lies between these. Gondwana rifts separating Africa from Antarctica. Dashed line indicates Jurassic coastline.

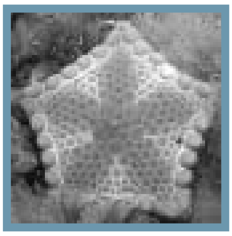


Ⓒ New Zealand and India separate from the Australian-Antarctic landmass. Australia begins to rift from Antarctica along the Great Australian Bight. Dashed line indicates Cretaceous coastline.

Ⓓ Australia and Antarctica are still conected by the submerged South Tasman Rise. Bass Strait is periodically exposed by changing sea levels. Shaded area indicates submerged continental shelf.

Ⓔ Modern day Australia. New Zealand is separate from Australia. Bass Strait is submerged.

Figure 7: *Geology and topography of the South-east Marine Region sea floor. Depth soundings of coastal shipping lanes were the earliest forms of bathymetry (the study of water depth). The purpose of these soundings was to develop a picture of the sea floor that would ensure safe passage for vessels.*



The nutrient content of the fine silts and oozes of the continental slopes and abyssal plains is an important component of marine ecosystems. In areas of upwelling, deep ocean water is carried to the surface, bringing with it the nutrients that have been locked away in the sediments, sustaining the ecosystems of the ocean.

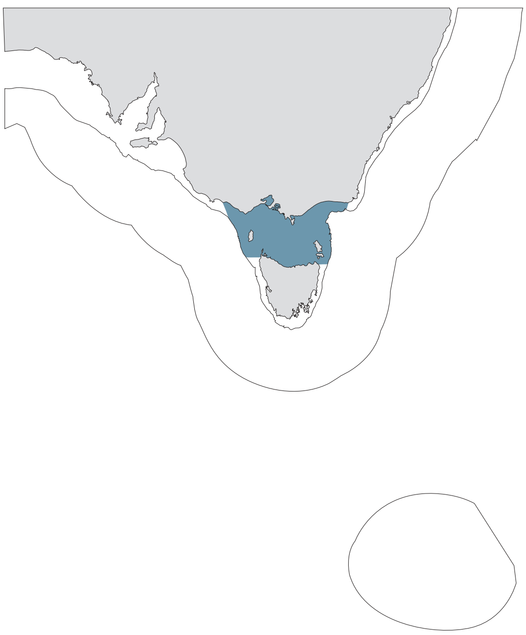
Considerable research has been done on the sediment types of the continental shelf of the South-east Marine Region. The Tasmanian shelf is rich in carbonate sediments and poor in sediments of terrestrial origin because there are not many large river systems depositing material off the coast. The shelf area has been studied in detail, including a map of the grain size and calcium-carbonate content of the sediment by Jones and Davies (1983). In contrast, very little is known of areas beyond the shelf.

Bass Strait (Locality map 1)

The average depth of Bass Strait is 60 m. During ice ages the formation of ice at the poles removes water from the oceans and sea level drops. In the past this has resulted in shallow features such as Bass Strait being exposed to the air. The last time this occurred was around 10 000 years ago.

The topography of Bass Strait could be described as a perched valley, with the eastern and western margins of the Strait being slightly raised granite ridges. King Island in the west and Flinders Island in the east are visible parts of these ridges. Both margins have submarine dune systems associated with them, probably because of the strong tidal currents on the rim of the Strait. Within Bass Strait, several sedimentary basins (Sorell, Otway, Bass and Gippsland basins) have large or potential hydrocarbon reserves of significant economic value. The centre of the 250 km-wide Strait forms the shallow Bass Basin depression, which was a large lake or wetland when the Strait was a land bridge.

Locality map 1: *Bass Strait location*



The sediments of Bass Strait are distributed in a concentric pattern of grain-sizes, with the finest materials in the centre of the Strait. The coarsest material, on the high-energy margins, is as much as 44% carbonate gravel. The high-energy tide and wave patterns around the rim of the Bass Strait transport the lighter and finer material into the centre of the Strait, where the waters are deeper and calmer. The sediments here are mainly muddy, with less than 6% coarse gravel and have been broken down by the biological activity of organisms. This process, known as bioerosion, changes sediments from the coarser structure they had when they were transported into an area into a fine, homogenous material that cannot be linked with its original form.

Outside of the Bass Basin, the Otway and Gippsland coastlines are typical sand-dominated environments. On the inner continental shelf, although calcium carbonate has probably been deposited at much the same rate as in the rest of the Strait, tides and waves have removed the fine materials, leaving only sand behind. On the eastern margin of the Strait, the massive Bass Canyon (Figure 8) cuts 60 km into the edge of the continental shelf. The mouth of the Canyon is 15 km across, with sheer walls a thousand metres high. The main floor of the Canyon is 4000 m deep, and is connected to the top of the continental shelf by tributary canyons and valleys.

West of Tasmania (Locality map 2)

To the west of Tasmania there are numerous canyons cut from the continental shelf (at about 300 m depth) to the continental rise (at about 3500 m depth). The Tasman Fracture Zone, a series of steep escarpments and troughs, rises two to three km above the seafloor. South of Cape Sorrell as much as 40% of the seafloor is exposed limestone bedrock. Elsewhere, the west Tasman margin is generally characterised by gentle to moderate sloping ground.

The movement of sediments from the continental shelf to the abyssal plain has been modelled for the west Tasman margin. The shelly sands of the outer continental shelf (70% calcium carbonate) grade into ooze on the slope (60–65% calcium carbonate – derived from the remains of small calcareous organisms called foraminifera). Further down on the abyssal plain, the sediments are pelagic ooze (less than 50% carbonate). Similarly, sand concentrations also grade from the outer shelf (60% sand by weight) down to the slope (10–15% sand by weight) through to the abyssal plain (less than 10% sand by weight).

Locality map 2: *west Tasmania location.*

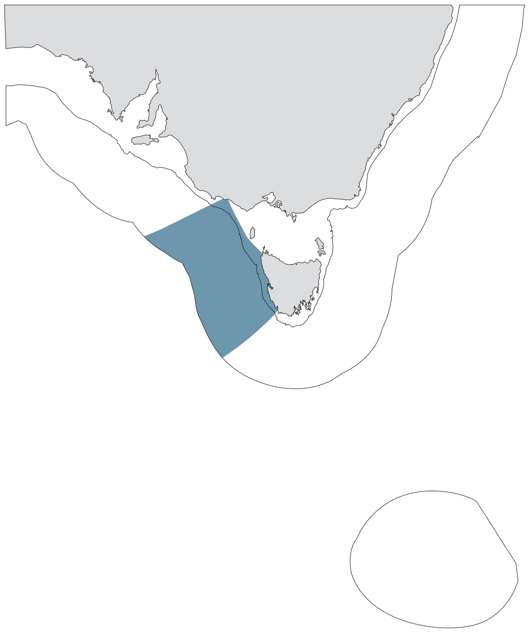
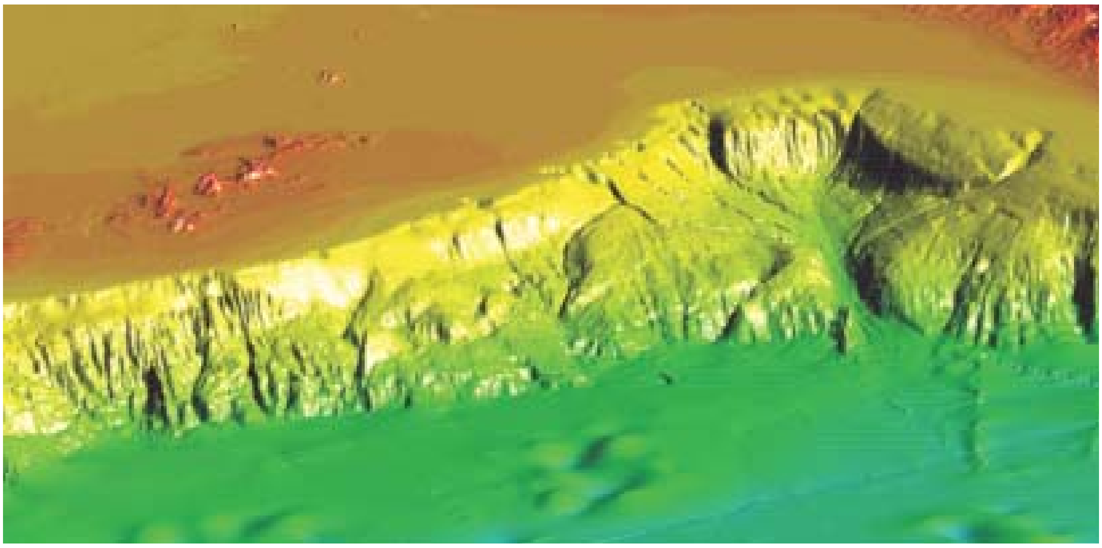
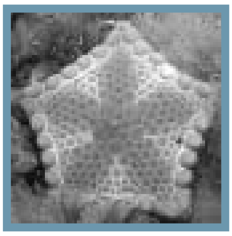
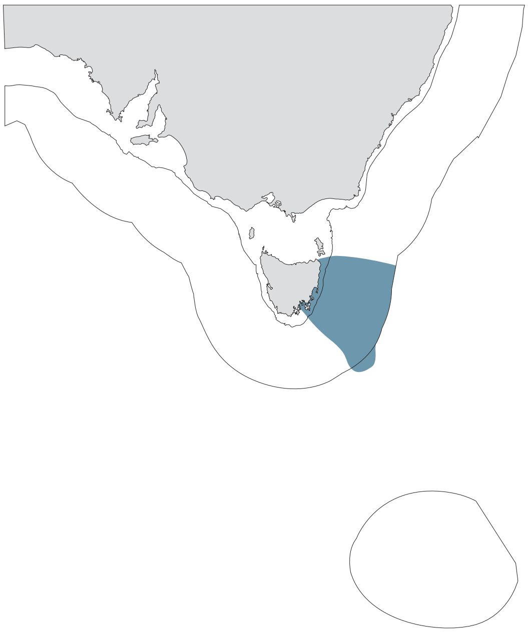


Figure 8: *Bass Canyon, viewed from the east. Flinders Island appears in red to the left of the Canyon, while eastern Victoria is visible in the upper right of the image. Blue-green colours represent the deep seafloor below the continental slope.*





Locality map 3: *east Tasmania location.*



East of Tasmania (Locality map 3)

The east Tasman margin has a narrow continental shelf with a shallow gradient rise. The slope is steep and cut with numerous canyons, some as long as 30 km, which connect the shelf with the abyssal plain. The plain itself has several extinct volcanic seamounts rising up to 1300 m from the sea floor.

About 100 km southeast of Tasmania is the East Tasman Plateau. It is a relic of the rifting of Lord Howe Rise from Tasmania 75 million years ago during the formation of the Tasman Sea. It is thought that the Plateau was once adjacent to the South Tasman Rise. It is roughly circular, with a surface area of about 50 000 square km. Its surface is about 3000 m below the sea surface, surrounded by waters of 3500 to 4000 m deep. The flat surface of the high Cascade Seamount that rests on the Plateau is about 700 m below the surface. The basement of the Plateau is of continental origin, and it is surrounded on all sides by oceanic crust except to the northwest in the east Tasman Saddle. Ocean currents have eroded a 200 m deep moat around the Plateau.

South Tasman Rise (Locality map 4)

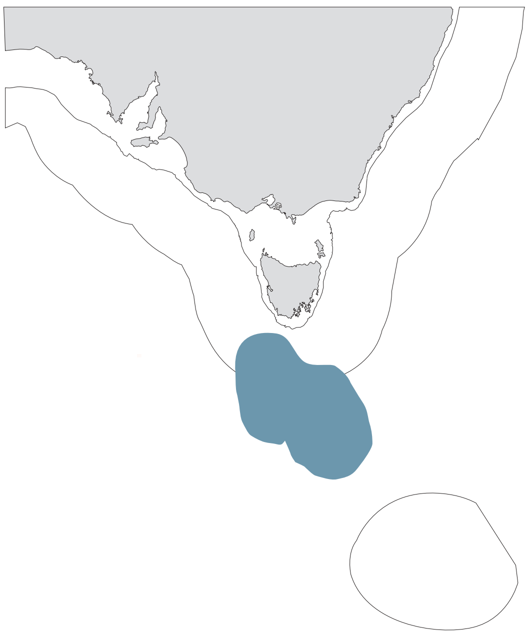
To the southwest of Tasmania, a submerged ridge of continental rock stands as the last remnant of the link between Australia and Antarctica. Deformed by the massive rifting process, the South Tasman Rise has created unique environments for marine life and is an area of great scientific interest.

At 1400 m depth, the rise is about 150 km across with a total area of about 200 000 square km. The bathymetry of the Rise reveals a spectacularly complex topography. The Rise is a large, dome-shaped plateau that peaks at a depth of about 800 m and is surrounded on three sides by oceanic crust 4000 m deep. On the north side is a thin layer of continental material about 3000 m below the surface, known as the south Tasman Saddle, linking the ridge to Tasmania. The north and north-east flanks are cut by several canyons up to 50 m deep and punctuated by rocky, conical, and probably volcanic, hills about 200 to 300 m high.

Approximately 80% of the surface area of the South Tasman Rise is covered with a layer of unconsolidated sediment while the remaining 20% is characterised by outcropping basement rocks. The surface layer of sediments is composed mainly of relatively recent Quaternary sands of shells of foraminifera (calcareous plankton). There is evidence of manganese nodules and crusts on older outcrops are largely marine.

There are several volcanic seamounts of considerable size on the rise that are much larger than, but may be of similar age to, those in the nearby Tasman

Locality map 4: *South Tasman Rise location.*

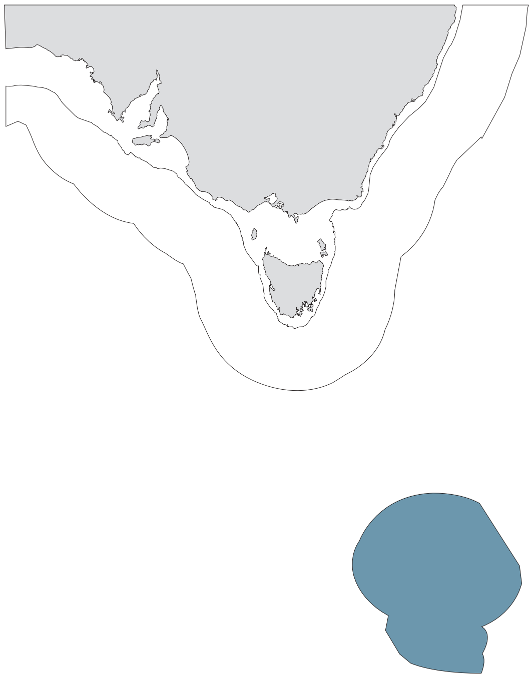


Seamounts Reserve. Some of these mountains have flat summits, which may indicate a period of exposure above the water at some point.

Volcanic seamounts have been found in several places in the Region. Recent voyages and satellite gravity recordings have discovered dozens of seamounts, including a group of more than 70 extinct volcanoes about 170 km south of Hobart, some of which are now in the Tasman Seamounts Marine Reserve. The Reserve is on the southern flank of the Tasmanian block. Isolated seamounts have been found on the South Tasman Rise, the East Tasman Plateau and off St Helens on the east coast of Tasmania.

Forming the western flank of the South Tasman Rise is the Tasman Escarpment, and extending north-northwest to the west Tasmanian margin, the Tasman Fracture Zone is the largest single geomorphic structure on this side of the island. The Fracture is a series of high ridges and deep troughs, with some escarpments rising to two or three km. The Fracture separates the higher continental rocks on the top of the scarp from abyssal ocean crust at depths of greater than 4000 m, and the escarpment is 400 km long.

Locality map 5: ***Macquarie Island.***

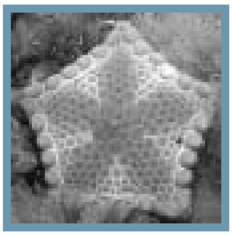


Macquarie Island (Locality map 5)

Macquarie Island lies in the middle of the Southern Ocean about 1500 km southeast of Tasmania, in one of the world's most inhospitable and unpredictable ocean environments. The Island is about 34 km long and 5.5 km wide. Macquarie Island was discovered purely by chance in 1810 by a sealing vessel that was blown off course. The only sign of civilisation that the Captain found was the wreck of a sailing vessel.

Macquarie Island turned out to be a find of scientific importance. It is one of the world's largest subantarctic seal and bird breeding grounds, and has a large number of endemic species although the diversity of seal and bird species is low.

Macquarie Island is the only above-water part of the Macquarie Ridge Complex, which extends 1600 km north from a latitude of about 60°S towards New Zealand. This ridge system is one of the few features that stand in the way of the Antarctic Circumpolar Current as it moves around the Antarctic continent.



One unique feature of Macquarie Island is that it is composed entirely of upthrusted oceanic crust. The Macquarie Ridge Complex began as a mid-ocean ridge between the Pacific and Australian tectonic plates, as illustrated in Figure 9. As the two plates moved apart, heat from the Earth's interior caused the volcanic eruption of new oceanic crust from the rift, building a basaltic seafloor spreading ridge. At some point, the ocean floor stopped spreading and the ridge was compressed by the surrounding tectonic plates. The ridge buckled upwards, thrusting Macquarie Island above the surface.

Today the Macquarie Ridge Complex extends from the junction of the Australian, Pacific and Antarctic plates, to the Alpine Fault of New Zealand's south island. The complex has four component ridges: the Puysegar, McDougall, Macquarie and Hjort provinces. Each ridge is parallelled by a deep ocean trench, the deepest of which reaches more than 6 000 m, a product of the same compressive forces that caused Macquarie Island to reach the ocean surface.

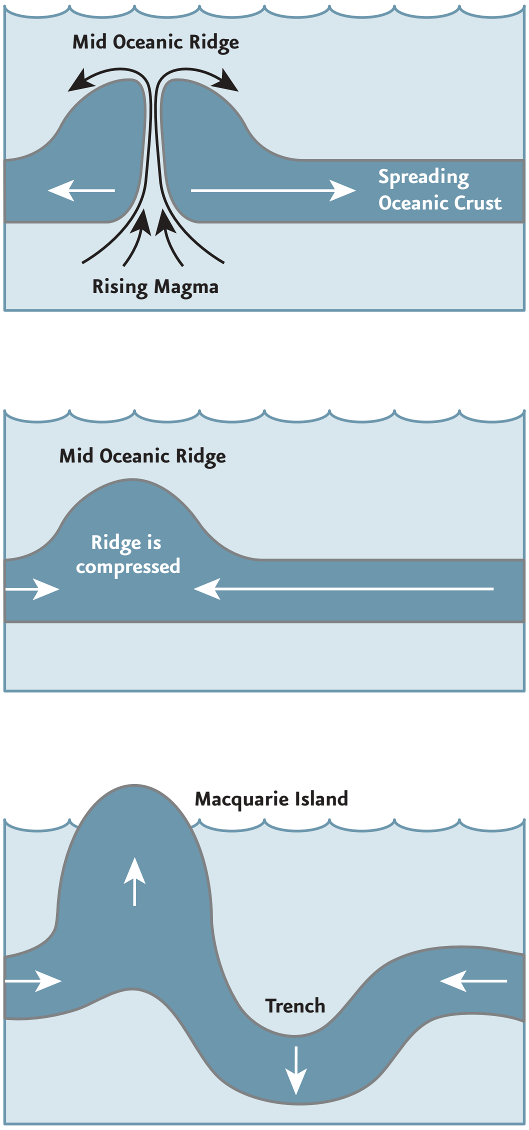
Although Macquarie Island continues to be thrust upwards, there is evidence on the Island that the basalt rocks are being actively eroded. The sediments deposited around the Island are marine in origin. Preliminary surveys of the offshore geology of Macquarie Island have indicated that there are few, if any, geological resources of economic value.

In 1994, the research vessel *Rig Seismic* mapped about 170 000 square km of the central Macquarie Ridge Complex. It was the first major effort to map the sea floor of the complex.

In January 2000 *L'Atalante* mapped about 80 000 s quare km of the southern part of the Macquarie Ridge Complex as part of the Geoscience Australia Austrea 2 cruise commissioned by the National Oceans Office. This cruise provided detail of the seafloor and some insight to the nature of the waters within the Macquarie Island Marine Park. The final leg of the cruise tracked along the axis of the Complex toward New Zealand, filling in data gaps left from previous cruises.

Until recently, relatively little was known about the waters around the Island. The bathymetric data gained in the last decade will provide a baseline understanding of the environment for the South-east Regional Marine Plan.

Figure 9: *Evolution of Macquarie Island.*



Some key references and further reading:
(Poore. 1995), (Bernardel & Symonds. 2001), (Hill, et al. 2001), (Exon, et al. 1995), (Hill, et al. 1998), (Butler, et al. 2002), (Bernardel, et al. 2000), (Connell & Sikes. 1997), (Exon, et al. 1997), (Exon, et al. 1997), (Exon & Crawford. 1997), (Feary, et al. 1993), (Harris, et al. 2000), (Harris, et al. 2000), (Hill, et al. 1997), (Hill, et al. 1997), (Hill, et al. 2000), (Ipcc. 1996), (Jones, et al. 1994), (Kloser, et al. 2001) (Royer & Rollet. 1997), (Scott. 1994), (Whitmore & Belton. 1997).

Oceanographic characteristics

Currents and water properties such as temperature and nutrient content, play vital roles in the ecosystems of the South-east Marine Region. Ocean currents link marine ecosystems, while fronts and upwellings structure the open-ocean pelagic environments and tides and local currents determine the life conditions for near-shore species.

One example of this influence is the Antarctic Circumpolar Wave, a pattern of anomalies in temperature, wind and sea ice that influences ocean conditions (temperature and nutrient levels) around both Macquarie Island and southern Tasmania. It is understood to influence the composition and biomass of the phytoplankton communities and in turn, linked to variations in seal and krill numbers and distributions around Macquarie Island.

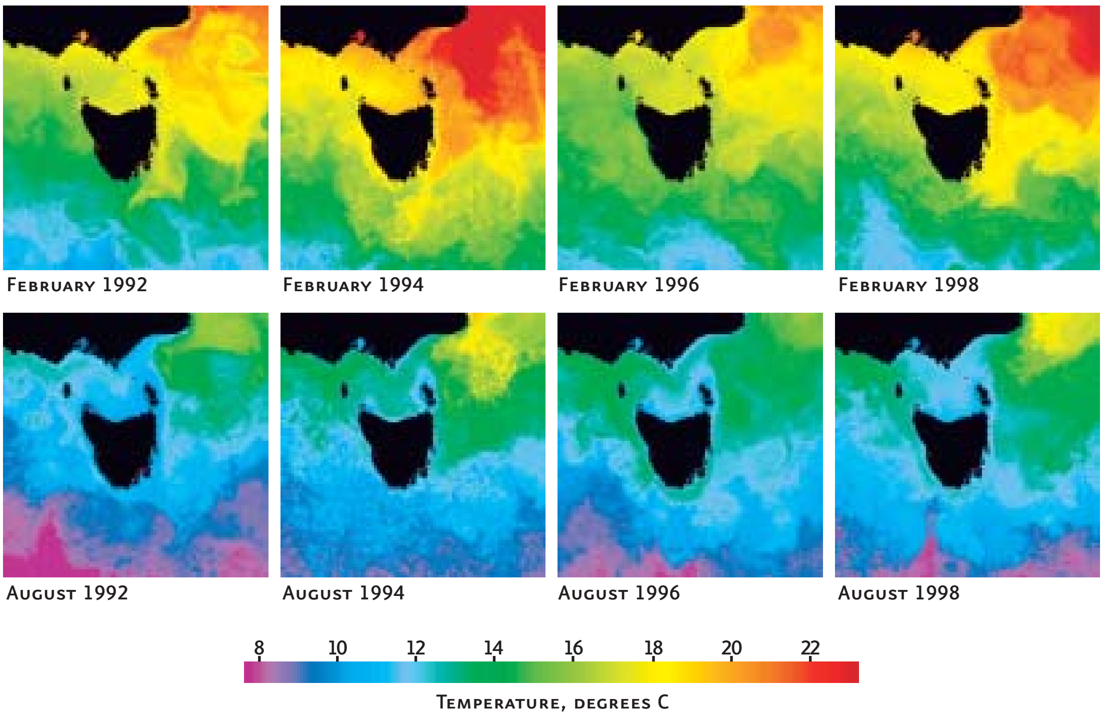
Waters throughout the Region are constantly moving and changing with daily, seasonal and yearly patterns. Tides alternately cover and expose shoreline, and they also force local currents along the coasts. These tidal currents dominate the flow of water through Bass Strait and many of the larger bays in the Region.

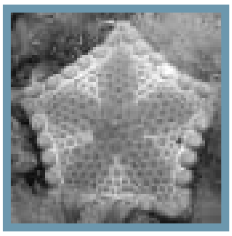
Short-term changes in the ocean are embedded in longer-term cycles and patterns. Seasonal temperatures and prevailing winds modify coastal currents and provide nutrient-rich upwellings, while longer-term phenomena, such as the El Niño Southern Oscilation, (usually referred to as simply El Niño, an episodic climatic change that causes warming of the equatorial Pacific) may amplify or moderate these seasonal patterns. Figure 10 illustrates this variability.

The water of the South-east Marine Region has four layers (see Figure 12):

- the surface layer: which consists of many different subtropical and subantarctic water masses
- the second Antarctic Intermediate Water: which slips north towards the equator about a kilometre below the surface
- the thick third layer (Deep Water): made up of waters from the Pacific, Indian and Atlantic oceans – some oceanographers differentiate another deep water-mass termed Circumpolar Deep Water
- the fourth and deepest layer: northward-flowing Antarctic Bottom water. Most of the global oceans have a layered structure similar to that in the Region.

Figure 10: *Sea surface temperatures of the Region in summer (February) and winter (August) over selected years in the 1990s. Cool water enters the Region from the south throughout the year, while the warm swath of East Australian Current water flows into the Region from the northeast during summer. The East Australian Current in 1994 and 1998 – La Niña (non El Niño) years – was stronger than in 1992/3 and 1996/7 – El Niño years. The position of the subtropical front (between warm northern waters and cold southern waters) also shifts between seasons and years (see Figure 11).*





GEOMAT and Physical Oceanography Models

GEOMAT (Geological and Oceanographic Models for Australia's Ocean Territory) is a computer modelling tool designed to be used for environmental management. GEOMAT uses geological and oceanographic data to estimate the location and frequency of sediment movement on Australia's continental shelves. The model has been used in the design of the Interim Bioregionalisation.

Work on the GEOMAT model began in 1997 in Hobart's Antarctic Cooperative Research Centre. Initially research focussed on the effect of wave processes, but was later expanded to also include the effect of tidal processes on shelf sediments. The GEOMAT model demonstrates the relative importance of wave and tidal currents in moving sediment in different locations. It is a predictive tool that can be used for any application where the movement of sediment material is important, such as habitat mapping, coastal engineering and regional marine planning.

In August 2001, the National Oceans Office commissioned Geoscience Australia (formerly AGSO) to upgrade the GEOMAT computer model to improve our understanding of seabed processes and provide sediment information that could be integrated with other physical and biological data. The upgrade primarily involved incorporating new data and parameters into the existing model.

As well as upgrading the GEOMAT project, the National Oceans Office also commissioned CSIRO to upgrade deepwater nutrient, water properties and ocean current models. This project has produced datasets and maps on the seasonal distribution of nutrients (nitrogen, phosphate and silicate), temperature, salinity and dissolved oxygen in the South-east Marine Region. Maps and animations of ocean currents have also been produced.

The first layer: surface waters & currents

The open ocean's 'upper layer' is 1000 m deep – a fifth of the water column over the abyssal plains. Most of the life in the oceans lives in the top few hundred metres in the surface waters where sunlight supports the plankton at the base of the ocean food web. Near the coast – over the continental shelf – the layer is less than 200 m deep and mixed with fresh water from estuaries and deeper waters rising from below. The dominant influences are:

- the Antarctic Circumpolar Current
- the East Australia Current
- the Leeuwin Current
- the Zeehan Current.

These are influenced by several fronts, or boundary zones where water masses meet and strong currents form:

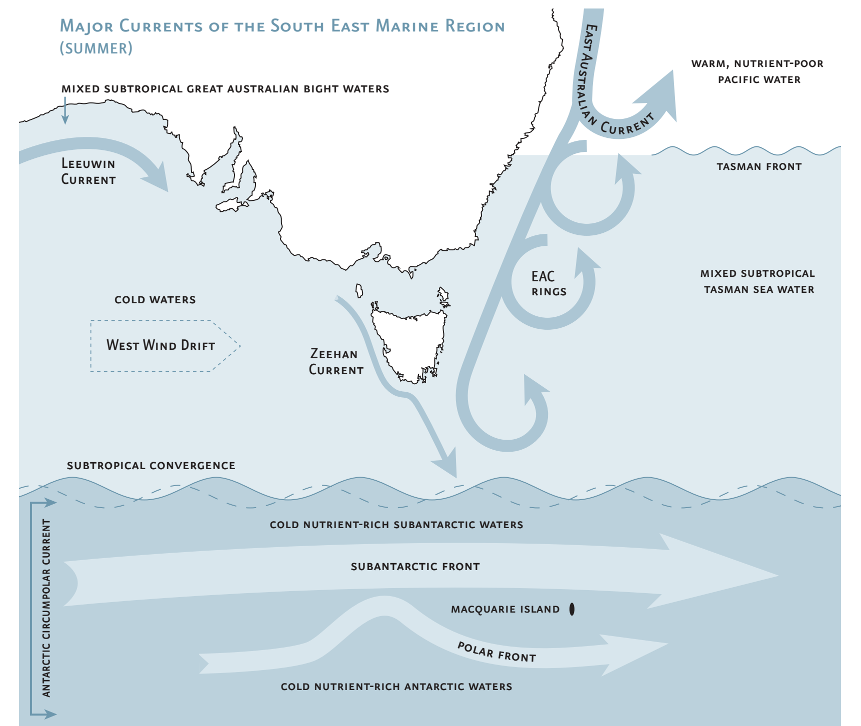
- Subtropical Convergence
- Subantarctic Front
- Antarctic Polar Frontal Zone
- West Wind Drift.

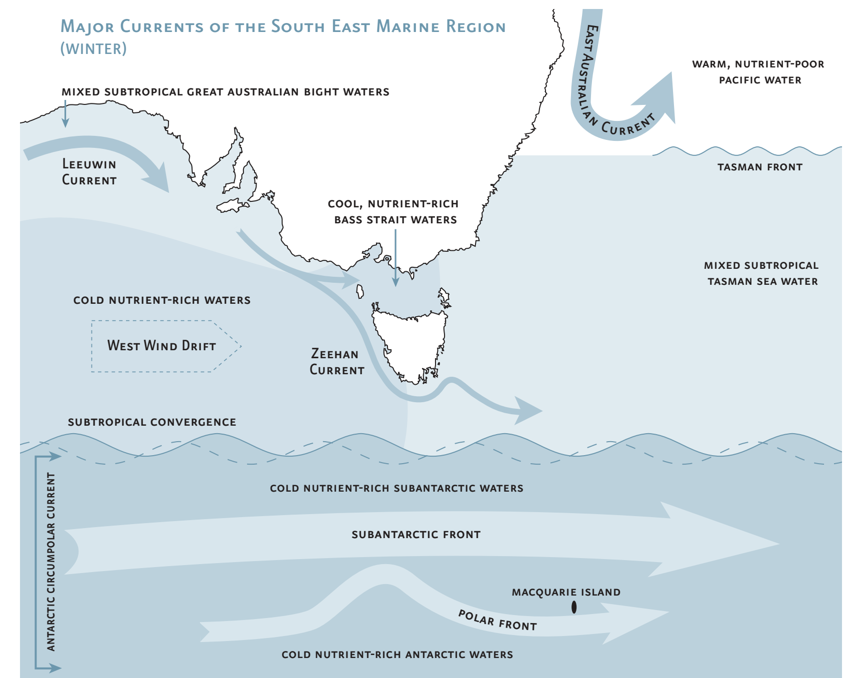
Antarctic Circumpolar Current

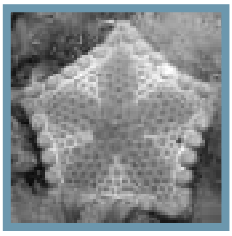
The Antarctic Circumpolar Current is the largest single current in the world; it is a surface, middle and deep current all in one, flowing throughout the entire water column. It circles the Antarctic continent in an eastward direction, connecting the waters of the Pacific, Indian, Atlantic and Southern oceans. This huge current is actually a combination of strong jets flowing along fronts. Each of these major fronts wraps all the way around the globe, their paths constantly changing as they move north or south and meanders move along them. These large meanders play a crucial role in the dynamics of the Southern Ocean, transporting heat southward to replace that lost to the atmosphere off the coast of Antarctica.

Within in the Southern Ocean, the northernmost front is the Subtropical Front (also called the Subtropical Convergence, 46°S) which generally runs just south of Tasmania and New Zealand, separating salty, warm subtropical waters from the colder, fresher waters of the Southern Ocean (Figure 11).

Figure 11: *The main surface currents and water masses of the South-east Marine Region in (a) summer and (b) winter. The darker-shaded areas are typically high in the nutrients needed for primary productivity (nitrates and phosphates). Cold Southern Ocean waters are much higher in nutrients than the warmer waters of the tropics and subtropics. The size of the arrows represents the strength of the currents, which are measured in Sverdrups (1 Sv = 1 million cubic metres of water per second (ACC = 135 Sv, EAC = 30 Sv, EAC extension or rings = 5-10 Sv, Leeuwin = 5-10 Sv, Zeehan = 1 Sv). Sources include: Church & Craig 1998, Crawford et al. 2000, Cresswell 2000, Rintoul 1997, Rintoul 2000.*







South of this front is a swath of cool Subantarctic Mode Water, beyond which is the Subantarctic Front (51°S). The current along this front transports most (around 75%) of the total flow of the Antarctic Circumpolar Current.

South of the Subantarctic Front is the Antarctic Polar Frontal Zone, a series of similar fronts surrounding the Antarctic continent. These southern fronts are much smaller and steadier than those in the north of the Region.

The Macquarie Island Ridge Complex is one of the few obstructions in the path of the powerful Antarctic Circumpolar Current as it flows through the Southern Ocean. Branches of the current are deflected to the south and north of the ridge, while some of the flow is channelled through two of the deep passes that divide the Ridge at about 53.5° and 56° latitude. The water temperatures around Macquarie Island are influenced by cool Subantarctic Front waters and very cold Antarctic Polar Front waters as well as seasonal warming of surface waters.

Cold and fresher, water masses from the Southern Ocean mix with more saline subtropical waters throughout the Region. Southern Ocean waters provide seasonal feeding grounds for many species that migrate through the Region, while the Antarctic Circumpolar Current plays a vital role in the earth's climate (see Box – Oceans and Global Climate Change on page 31).

The West Wind Drift is a slower flow that moves around the globe, and is a general eastward movement of mixed subantarctic and subtropical waters. The West Wind Drift introduces a cold water mass into the Great Australian Bight, which may sometimes become part of the mix of water in Bass Strait.

The East Australian Current (EAC)

The East Australian Current is a strong, consistent flow and the largest coastal current in Australia. It is fed by the waters of the South Equatorial Current, which flows west across the Pacific, and it carries these waters south along the Australian coastline. The flow is strongest in summer and its speed increases offshore, so that the bulk of the flow is offshore of the continental shelf. At 33° latitude, the current veers east, separating from the continental slope and diverting most of the flow east towards New Zealand. This eastward arm of the East Australian Current, known as the Tasman Front, separates the waters of the Coral and Tasman seas.

Despite this diversion, the East Australian Current injects large amounts of warm, salty water into the Region. Most of this water arrives during summer, when the current extends further south in pulses, pinching off anti-cyclonic eddies as it loops back north. The EAC eddies, generally a few hundred kilometres across, become microcosms of heightened productivity as they slide up onto the continental shelf (These eddies are shown in Figure 11). The tropical water in their cores is generally low in nutrients and productivity, but the surface water isolated in the eddies tends to cool and sink, leading to mixing that brings nutrients up to the photic zone. This process accelerates as the eddies encounter the edge of the continental shelf; the eddies simmer with life, as the plentiful phytoplankton and zooplankton attract fishes of all sizes to feed.

The strength and southward reach of the East Australian Current varies from year to year. Measurements from Maria Island along the east coast of Tasmania, over the past fifty years, show an increase in salinity and temperature, and a decrease in nitrates. These changes are thought to result from the East Australian Current increasing in strength and extending further south. This southward extension of the East Australian Current may have enabled southward extensions in the ranges of some subtropical species while other species that prefer the colder subantarctic water masses, such as southern bluefin tuna, move further south or into deeper water away from the influence of the warmer East Australian Current.

Between the warm tropical waters of the Coral Sea and the cold water of the subantarctic lie the mixed subtropical waters of the Tasman Sea. The water masses in the Tasman vacillate throughout the year: warm East Australian Current water predominates in summer, while the waters of the Zeehan Current (see below) and subantarctic waters bounded by the Subtropical Front cool the area in winter. As with most subtropical waters, the Tasman supports rich communities sustained by the nutrient-rich EAC eddies, upwellings along the shelf-break and the subtropical front.

The Leeuwin Current

The Leeuwin Current flows south along the western edge of Australia, turning east at Cape Leeuwin and bringing its warm tropical waters into the Great Australian Bight. While only a quarter as strong as the EAC, the Leeuwin is an unusual current as it flows against prevailing southerly winds. During La Niña (non El Niño) years the strength of the Leeuwin Current increases and it exerts a stronger influence on the Region.

The Zeehan Current

The largest of the local currents along the coasts of the South-east Marine Region is the Zeehan Current. It flows from the eastern end of the Great Australian Bight, skirts the western end of Bass Strait and then along the west coast of Tasmania, tracing the edge of the continental shelf. The Zeehan, unlike the East Australian Current, is a shelf-break current, narrower, closer to shore, and moving much less water. The waters in the Zeehan are freshened by the major rivers flowing into the sea along the west coast of Tasmania. In summer, the Zeehan leaves the coast at the southern end of Tasmania, heading south and east where its waters are mixed with the remnants of EAC eddies. During winter, the Zeehan moves faster and extends further around Tasmania, bringing waters up to four degrees colder than the East Australian Current water onto the shelf and slope off eastern Tasmania. The difference in the Zeehan in winter and summer is shown in Figure 11.

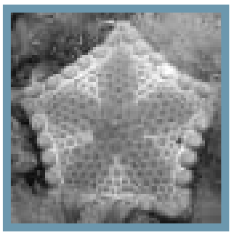
Coastal upwellings in the Region's northwest

Between the eastern end of the Bight and the western edge of Bass Strait is one of the few areas in Australia with consistent coastal upwellings that occur when seasonal winds push surface waters offshore. These colder nutrient-rich waters support pelagic habitats. A well-studied upwelling occurs in summer and autumn when winds from the southeast blow parallel to the Bonney Coast (south-eastern South Australia western Victoria between Cape Dombay and Cape Nelson), known as the 'Bonney upwelling'.

Shifting seas in the shallows of Bass Strait

Tidal currents dominate the flow within the shallow Bass Strait. These local currents influence the size of sediments on the seafloor: areas with strong currents have larger sediments, the smaller sediments having been carried away and deposited in quieter areas (see page 20 on sediments in Bass Strait). A slow net eastward flow moves water through the Strait, becoming stronger in winter with the strengthening Zeehan Current. Wind blowing over the surface of the Strait tends to cool the water, which becomes heavier and sinks in a process termed 'convective overturning'. The waters of Bass Strait can therefore become colder, saltier and more deeply mixed than the surface waters of the Tasman Sea to the east. It cascades off the continental shelf and part way down the slope, sinking under the Tasman water mass. Similar cascades might also occur occasionally at the western end of the strait.

Some key references and further reading:
(Butler, et al. 2002), (Hallegraeff. 1995), (Baines, et al. 1983), (Church & Craig. 1998), (Crawford, et al. 2000), (Cresswell. 1983), (Cresswell & Peterson. 1993), (Cresswell. 2000), (Godfrey, et al. 1980), (Jeffrey, et al. 1990), (Nilsson & Cresswell. 1981), (Rintoul. 2000), (Rochford. 1986).



The second layer: Antarctic Intermediate Water

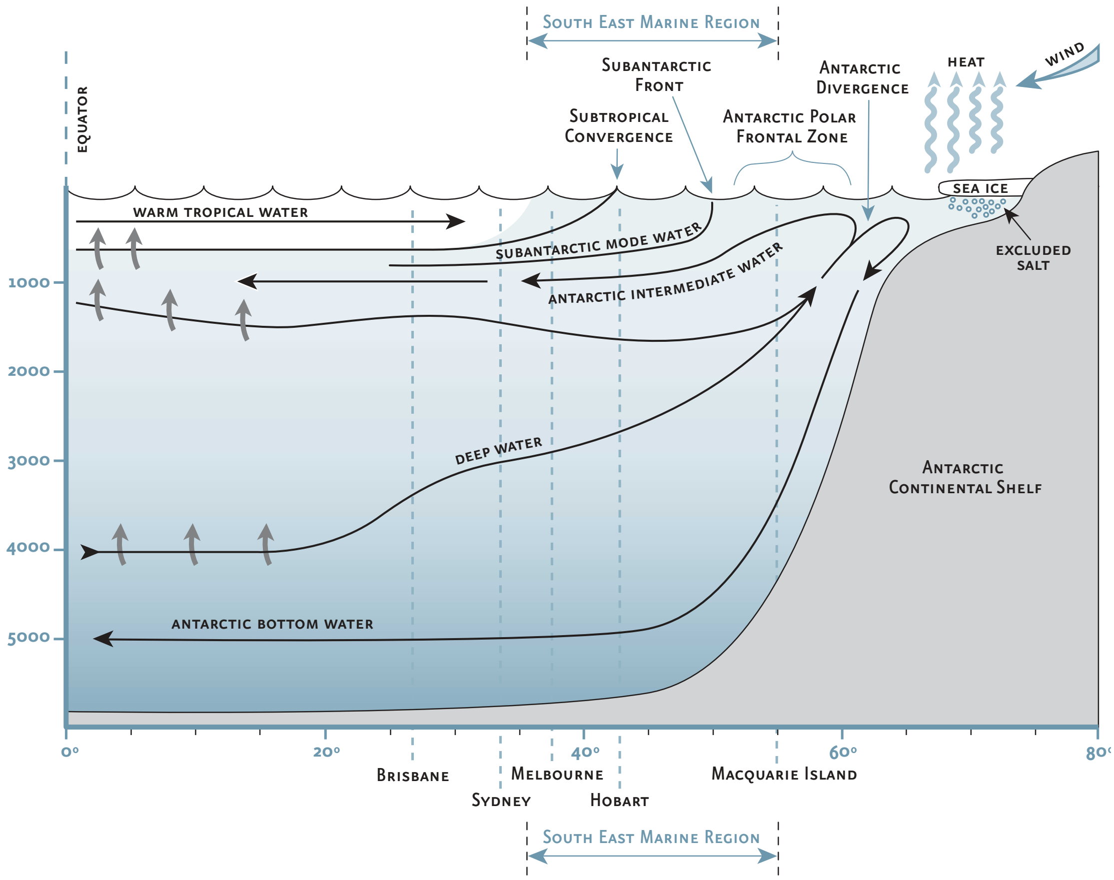
Below the tropical and subantarctic surface waters, the Antarctic Intermediate Water flows towards the equator in a relatively thin layer about 400 m thick. This mass is colder and fresher than the subantarctic surface waters and has less dissolved oxygen, as it has been away from the surface longer. This water mass encounters the mid-continental slope (between 800–1200 m depth) all around the South-east Marine Region.

Antarctic Intermediate Water is formed in the Southern Ocean, where surface waters cool and sink to form a heavier layer. Scientists suspect that it sinks near the Subantarctic Front, which runs round the globe through the middle of the Southern Ocean, between 50–60°S degrees latitude. Waters sinking near Macquarie Island may contribute to this intermediate water.

The third and fourth layers: deep waters and currents

Below the Antarctic Intermediate Water a wide swath of deep water fills thousands of metres between the Antarctic Intermediate Water and the deepest of all layers, the Antarctic Bottom Water. This deep water is broadly called Pacific Deep Water, Indian Ocean Deep Water, or Antarctic Circumpolar Deep Water in the respective ocean basins. It generally has less oxygen than either the Antarctic Intermediate Water above or the Bottom Water below, both of which were in contact with the atmosphere more recently before they sank in the Southern Ocean. Much of the deep water has been away from the surface for a long time – in some cases for thousands of years. It is relatively salty and very cold. Below this, the newly formed Antarctic Bottom Water is higher in oxygen, saltier and even colder. The process of Antarctic Bottom Water cooling and sinking near the Antarctic continent is shown in Figure 12.

Figure 12: *A vertical slice of this overturning (the horizontal axis is the degree of latitude from the equator to Antarctica, the vertical axis is the depth from the surface to the abyssal plain at 5000 m). The surface waters (0–1000 m depth) in this figure include warm tropical waters, colder subantarctic water, and extremely cold Antarctic waters. Below these waters the Antarctic Intermediate Water flows toward the equator. Further down, deep waters from the Pacific, Indian and Atlantic oceans flow towards the pole, and deeper still, Antarctic Bottom Water flows north.*



Currents

Compared to the strong flows in the surface layers, the currents of the deep are sluggish. They are strongly influenced by the seafloor topography and flow more quickly through narrow passages and around obstructions such as canyons and seamounts.

Within the South-east Marine Region scientists have measured relatively fast deep flows near Macquarie Island, where the Antarctic Circumpolar Current squeezes through the Ridge. They have also measured fast flows near seamounts, as these obstacles intensify local currents. These flows concentrate food and inhibit sedimentation, creating ideal and unique environments for corals and other filter-feeding bottom dwellers, as well as such fishes as orange roughy and oreo dories. Scientists also suspect the flows are faster near the South Tasman Rise and the East Tasman Rise, where the scoured seafloor indicates water movement.

Deep currents also occur as a sort of physical 'mirror' of strong surface currents, but usually in the opposite direction. Oceanographers have found indications of a deep reverse flow below the East Australian Current while the deep currents below the Antarctic Circumpolar Current tend to be in the same direction as the surface current.

Oceans and Global Climate Change

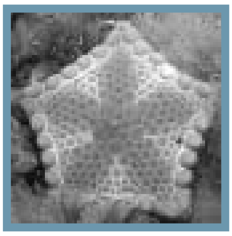
The ocean plays a complex role in the global climate by storing and moving huge amounts of heat, salt, oxygen, carbon dioxide and other elements. Most of the waters in the deep ocean are extremely cold and have a high salt content, reflecting their origin in the polar Regions, where they cooled in contact with the atmosphere, became heavy with salt excluded when sea-ice formed, and sank. As 'new' deep water sinks, warmer water flows from the equator towards the poles to replace the sinking water. The exact nature and magnitude of the impacts of global climate change on the oceans of the South-east Marine Region cannot be predicted.

The physical processes that occur in the oceans are extremely complex, and changes to one aspect of the system could have huge consequences for the system as a whole or may have no effect at all.

Global climate change may produce changes in sea temperature, ocean circulation, sea level and the extent of polar ice coverage.

Changes in atmospheric conditions, such as wind patterns, could also affect ocean processes including ocean currents and wave patterns. One possible result of global climate change is changing sea levels. Rising sea levels are a concern given that the majority of the world's population and over 85% of Australians live within 50 km of the coast.

Some key references and further reading:
(Antarctic CRC. 1997), (Antarctic CRC. 1998), (Butler, et al. 2002), (Reid 1965), (Ipcc. 1996), (Rintoul & Bullister. 1999), (Rintoul, et al. 1997), (Rintoul. 2000), (United Nations Division for Sustainable Development. 2001), (Allan, et al. 1996).



Life in the South-east Marine Region

The variety of life forms that inhabit the South-east Marine Region is remarkable by global standards. This section of the report can provide only a glimpse of the Region's richness of species, a large part of which is still unknown to science. Below, we briefly consider some of the aspects of, and reasons for, such high diversity and introduce the main groupings of flora and fauna in the Region. The information presented here reflects the bias in our knowledge which comes primarily from inshore ecosystems and more recently from seamounts.

The component of the Region's biodiversity that is known to be threatened, and the animals and plants that only recently have been introduced by human activities, are discussed separately.

Southern Australia: a global 'hot-spot' of marine biodiversity

The southern coast of Australia, including the coastal waters of Victoria and Tasmania, is recognised as a major marine biogeographic region. The marine environments of temperate Australia, when compared not only to this continent's subtropical and tropical coasts but also to most of the world's marine environments, display an enormous diversity of marine plant and animal species.

Although we do not know how many species there are in the Region's marine environments, we can get an idea of their diversity from studies of species richness in limited areas or in specific groups of organisms. For example, a recent review of literature and museum collections identified a total of 2350 species of decapods, molluscs and echinoderms in Victorian waters, but these are thought to represent only 20–25% of the marine macrofauna (ie macroscopic animals, that can be seen by the naked eye). Along the east Gippsland coast and adjacent Bass Strait, recent examination of 104 grab samples of benthic infauna (ie animals living buried in the sediments) yielded a total of 803 species, over half of which were undescribed.

Some 1180 species of marine algae (see Table 3) have been identified in temperate Australia, comprising what is believed to be the most diverse marine floral assemblage in the world. By comparison, the other three marine areas considered to have a highly diverse marine flora – the Mediterranean Sea, Japan and the Philippines – are estimated to have about a thousand each.

High diversity, in terms of number of species, is a feature common to most plant and animal communities (ie assemblages of different species living together) in the Region. For example, all seven fish communities that live on soft sediment environments of the continental shelf off northeastern Bass Strait are species-rich, including up to 80 different species of fish.

High levels of endemic species

Alongside high diversity, southern Australia is notable for the large numbers of endemic organisms – species that are found nowhere else in the world. An example is the fish fauna of southern temperate Australia, which consists of about 600 species, of which 85% are believed to be endemic and 11% are shared only with neighbouring New Zealand. Among other groups of animals, up to 95% of molluscs and 90% of echinoderms are also considered endemic to southern temperate Australian waters. The marine flora of southern Australia has the highest level of endemism in the world, with an estimated 60% of the species found only in these waters.

The South-east Marine Region shares the generally high endemism characteristic of temperate Australia. Such high diversity and endemism in the South-east Marine Region is a result of the complex interaction of evolutionary, geological and biological processes, as well as the interactions among organisms.

The southeastern Tasmanian coast for example, despite a lower species richness compared to the rest of the Region, has a high number of endemic species, including four species of handfish (*Brachionichtys* spp.); three species of seastars (*Patiriella vivipara*, *Marginaster littoralis*, *Smilasterias tasmaniae*); a sea urchin (*Pachycentrotus bajulus*) and several algae.

The geographical and hydrographical isolation of seamounts, as of islands, encourages the evolution of unique species. A survey of the seamounts off southern Tasmania yielded 262 species of invertebrates of which between 16 and 33% differ from species known from seamounts in New Zealand and are thought to live only on these seamounts (although some of these species have since been found in samples from upper- and mid-slope environments).

The geological and climatic history of the South-east Marine Region is marked by events that promoted the development of new marine environments in which a variety of flora and fauna species could evolve, adapt and spread. Animals and plants from the ancient Tethys Sea (which was located between the super-continents of Gondwana and Laurasia) mixed with organisms of Austral origin when Australia separated from eastern Antarctica (see page 18 on the seascape of the South-east Marine Region). The relative stability of the climate in the region, due to a steady northward movement of the Australian tectonic plate compensating for global cooling, sustained favourable conditions for marine life over long geological time scales.

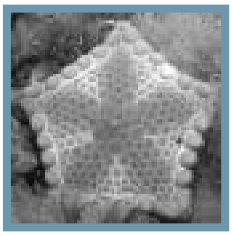
The tectonic history of Australia has also meant that the southern coasts of Australia have been isolated geographically from other Gondwana continents for 80 million years – far longer than any other land-mass except Antarctica. This isolation limited the exchange and flow of genetic materials from other regions. Another key tectonic episode, although modern in the geological time-scale, was the recent and repeated submergence and emergence of the Bass Strait area. The phases of discontinuity in these marine environments have strongly moulded the present-day composition and distribution of species.

Broad-scale circulation patterns of warm and cold water masses physically delimit population dispersal and species ranges, promoting, over geological time, the development of new species. As a result some fish groups that do not produce pelagic larvae, and therefore cannot disperse widely, have diversified into several species. For example the syngnathids of the Region include a unique range of seahorses, pipefish and seadragons.

Broad-scale patterns of species distribution and richness

The same geological and evolutionary processes that resulted in high species richness and endemism are also largely responsible for the present-day distribution of species across the Region, although local factors also play a considerable part in determining what species live where.

Most of the factors that act at local scales are discussed in detail under each major ecosystem considered in Chapter 3. Chapter 2 also discusses biogeographical patterns in the context of their usefulness for subdividing the Region into smaller and ecologically meaningful areas. Below, we briefly consider how large-scale differences in latitude, longitude and depth across the Region affect the distribution and diversity of marine flora and fauna.



A number of species and groups of species (assemblages) show strongly-marked latitudinal patterns across the Region. Richness of species also varies latitudinally, decreasing from northern to southern latitudes and showing in the Region a low-point of diversity in southern Tasmania. These patterns are linked mainly to sea temperatures and the broad-scale influences of large water masses and currents. There is some evidence that the progressive shift to lower latitudes of the East Australian Current observed over the last few decades has resulted in a southward expansion in the distribution of many species previously not found, and now common, in south-eastern Tasmanian waters.

Longitudinal patterns of distribution are also evident in the Region. Along the South Australian coasts, for example, the occurrence of species of tropical or warm-temperate origin decreases from west to east, while the opposite is true for temperate and cold-water species. An example of the gradient is the species composition of the foraminifera in the plankton in southern Australia. These differences are attributable to the Leeuwin Current that extends the distribution of some warm-water species from Western Australia south and east. As the Leeuwin Current meets the colder subantarctic waters, cooler-water species become dominant, hence the longitudinal pattern.

Marine species composition in the Region also changes dramatically with increasing depth on both the continental shelf and down the slope. Changes in species composition with depth in shallow waters are driven primarily by decreasing light availability, resulting in disappearing vegetated habitats below about 40 m depth. However, depth also plays a role below the 'photic zone' (where light penetrates the water). For example, deep-sea corals that cover many seamounts off southern Tasmania, seem to be restricted to habitats less than 1300 m deep.

The marine biota of southeast Australia differs considerably from that of Macquarie Island, where the distribution of its flora and fauna species is strongly influenced by the major water circulation features adjacent to the Island. Macquarie Island sits approximately 20 n miles north of the Antarctic Polar Front, the southernmost limit of the Antarctic Convergence, and is at the crossroads of major surface water currents and subsurface water masses. The north-south Ridge also deflects currents in a complex way. As a consequence, elements from different biogeographic regions are found here, including species from southern New Zealand and south-eastern Australia, for which this may be the southernmost limit, and species from the Antarctic, for which it may be the northernmost limit.

Some key references and further reading:
(Bax & Williams. 2000), (Coleman, et al. 1997), (Gray, et al. 1997), (O'hara. 2001), (O'Hara & Poore. 2000), (O'Hara & Barmby. 2000), (Phillips. 2001), (Poore. 1995), (Poore, et al. 1994), (Richer De Forges, et al. 2000), (Wilson & Allen. 1987), (Butler, et al. 2000).

Marine Flora

Southern Australia, including the South-east Marine Region, has the most diverse marine benthic flora in the world. Moreover, it has the highest level of species endemism; up to 62% of macroalgae in southern Australia are thought to be endemic. A rich genetic pool derived from the ancient, tropical, Tethys Sea provided the original stock from which today's species of macroalgae evolved.

Below, we describe some of the main characteristics and key representatives of marine flora in the Region, including microalgae, macroalgae and marine flowering plants, or seagrasses.

Microalgae

Microscopic algae, or microalgae, are one-celled organisms that contain photosynthetic pigments and therefore photosynthesise sunlight as land plants do. They live in the ocean either as free-floating species near the surface (phytoplankton) or attached to hard surfaces. Two main groups – the diatoms and dinoflagellates – form the bulk of the phytoplankton biomass (in terms of mass rather than numbers) in the Region.

The species composition of phytoplankton assemblages differs across the Region. The main assemblage is made up of temperate neritic species (those living in shallow waters near land). The assemblage is common in continental shelf waters of southern Australia, where it has a different species composition from the tropical oceanic and tropical neritic phytoplankton assemblages. A subantarctic phytoplankton community is also found off Tasmanian waters, although only from time to time.

Microalgal communities have seasonal patterns in species composition and occurrence, associated with local nutrient changes (including upwellings) and changes in light availability and temperature. For example, diatom species (notably *Thalassiosira partheneia*) dominate the early spring algal blooms that, in suitable climatic and oceanographic conditions, form on the continental shelf east of Bass Strait. Later blooms in the same area, however, tend to be dominated by dinoflagellate species. Other diatoms characteristic of the Region include species of *Pseudonitzschia* and *Rhizosolenia*, commonly found in the nutrient-rich waters of the warm-core eddies that generate off the southern tail of the East Australian Current.

The blue-green algae, or cyanobacteria, also photosynthesise to produce carbohydrates, and contribute considerably to the Region's ocean productivity. Most cyanobacteria live attached to the seafloor or other surfaces, where they form mats or gelatine-like masses, as in the common southern Australian species belonging to the genus *Rivularia*.

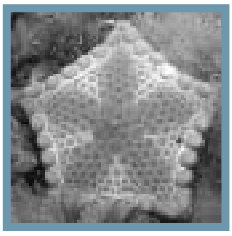
Macroalgae

Some 1150 species of macroalgae (or seaweeds) have been recorded from southern Australia. Mirroring their global patterns of diversity, red algae (or Rhodophyta) have the highest number of species in temperate Australia (around 800), followed by brown (Phaeophyta – about 240 species) and green algae (Chlorophyta – about 140 species).

Brown algae (Phaeophyta) species range in size from very small through to 35 m in length (Macrocystis pyrifera or giant kelp). Kelp forests consist of stands of large brown algae anchored to hard surfaces on the seafloor by their large holdfasts. Kelp forests are usually found close to shore, although where local conditions, particularly water clarity and light availability, are favourable, they may grow in waters up to 50 m deep.

Table 3: *Approximate numbers of species of macroalgae occurring worldwide and in southern Australia, and percent of species endemic to southern Australia. (Data from Phillips 2001 and Edgar 2000).*

Number of Species	Phaeophyta (brown algae)	Rhodophyta (red algae)	Chlorophyta (green algae)
Worldwide	900–1500	4000–6000	1040
Southern Australia	240	800	140
Proportion of endemic species to southern Australia	60%	77%	40%



Different kelp species prefer either shallower or slightly deeper environments, as well as more or less exposed sites. These habitat preferences determine their relative distribution along the Region's coasts, with important implications for the distribution of many other plants and animals that tend to associate with different kelp species. High-energy environments along Tasmanian coasts, for example, are usually dominated by macroalgae up to a depth of 10 m, but their depth range and abundance decline considerably in sheltered environments. Below 10 m, in more exposed habitats, the beds of the bull kelp *Durvillaea potatorum* are replaced by the laminarian kelp *Lessonia corrugata* and the fucoid *Phyllospora comosa*. These two species form almost monospecific habitats by preventing other species from settling or surviving with their long sweeping fronds. *Lessonia corrugata* holdfasts host a number of macroinvertebrate species.

Another important species is *Macrocystis pyrifera*, which occurs in moderately exposed environments and at depths of 5–25 m, alongside *Lessonia* and *Phyllospora*. *Macrocystis* fronds form extensive canopies on the surface that intercept wave energy and light, thus influencing the type and numbers of animals and other plants that live at the site. *Macrocystis* habitat has shrunk over the last 40 years, with entire forests disappearing, particularly from the northern Tasman Peninsula. This decline may be due to the changes in water temperature, salinity and nutrient conditions observed off the east of Tasmania (see below Pelagic Shelf Habitats). In deeper waters, up to 35–40 m, the habitat becomes dominated by the kelp *Ecklonia radiata*.

Macroscopic green algae, or *Chlorophyta*, stand out on rocky substrates because of their usually bright green colour. They display a range of shapes, from long thin filaments such as in common *Cladophora* species, to globular masses like in *Codium pomoides*, the sea apple frequently encountered on exposed reefs, especially in Tasmania. Another group of green algae that is widespread in the Region is the genus *Caulerpa*. They often dominate both rocky and sandy bottoms with erect and branching fronds.

A little-known but noteworthy feature of the Region is the occurrence, at depths up to 70 m, of large stands of *Palmaclathrus*, a green alga that sheds its thallus every year, leaving a perennial stem on the seafloor that can live up to 10 years. Southeastern Australia is the only area of the South-east Marine Region where extensive beds have been recorded, while more restricted stands have been found in the Great Australian Bight.

Coralline algae belong to the red algae group (Rhodophyta) and, by tolerating lower light levels, tend to dominate deeper and/or darker waters, where green and brown algae become relatively less competitive. Southern Australia has the largest number of red algae than any other area surveyed, with 800 species being recorded so far. Like their green and brown relatives, red algae display a variety of shapes. Characteristic and widespread are the species belonging to the family *Corallinaceae*, commonly called coralline algae because of their rigid calcium carbonate structure, which can have encrusting as well as erect forms. Coralline algae tend to occur on exposed rocky substrates and they dominate the so-called 'barren' habitats, common particularly along the coast of New South Wales, where the growth other algae is prevented by sea urchin grazing.

Seagrasses

Seagrasses differ from macroalgae (seaweeds) because they have roots and produce simple flowers whose pollen is transported by the water. Seagrasses of the South-east Marine Region belong to one of five genera: *Amphibolis*, *Halophila*, *Heterozostera*, *Posidonia* or *Zostera*. Some species are found throughout southeastern Australia while the distribution of others is more restricted. For example, species of the genus *Posidonia* do not extend further south than the northern coast of Tasmania while a number of species occur throughout the Region. None of the seagrass species are endemic to the South-east Marine Region and none are found on Macquarie Island.

Seagrass beds are most common in estuaries, lagoons and embayments, as they tend not to withstand the strong waves along most of the coast. The most common species are *Zostera muelleri*, *Z. capricorni*, *Heterozostera tasmanica*, *Amphibolis antarctica* and *Posidonia australis*.

Seagrass beds occur around Tasmania, where the distribution of the different seagrass species creates several distinct zones. In the northern parts of the State, *Posidonia australis* and *Amphibolis antarctica* are dominant; in the southern part, dominant species are *Heterozostera tasmanica* and *Halophila australis*. In South Australia, the large Coorong lagoon system supports extensive beds of *Zostera muelleri*, and there are even larger beds of other species just west of the South-east Marine Region. There are also extensive seagrass beds in coastal embayments of the Victorian coast.

Some key references and further reading: (Phillips. 2001); (Edgar. 2000) (Edgar. 2001), (Womersley. 1991), (Butler & Jernakoff. 1999); (Poiner & Peterken. 1995), (Edyvane & Baker. 1998), (Barrett et al., 2001) see also references at the end of page 58 inshore and inner shelf ecosystems.

Marine Invertebrates

Marine invertebrates (primitive animals without backbones) include a great variety of group such as sponges, crabs, seastars, anemones, octopus, squid and molluscs. Collectively, their species considerably outnumber the vertebrates (fish, birds and mammals). Many invertebrates are poorly known, in particular those from the deep sea that may eventually form a large component of the Region's known fauna.

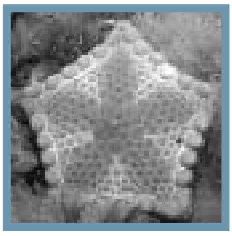
Below we provide a broad description of the main invertebrate groups found in the Region and briefly consider some of their better-known representatives. Further information sources are listed at the end of this Section.

Sponges

Sponges are a very rich and widespread group, but very difficult to classify and identify. In the South-east Marine Region, sponges have been recovered from samples taken from shallow waters to deep slope environments. Possibly 1000 species have been collected and recorded, but most of these are yet to be described. Only very common species, usually from shallow water – such as those belonging to the genus *Tethya* – are usually recognised.

Sponges are filter-feeders, so are found in environments with high concentrations of particulate matter and where currents bring them a steady food supply. They are found at virtually all depths, although they do not dominate very shallow sites; there the faster-growing macroalgae thrive and outgrow other organisms. However, sponges are perhaps the most common group in low-light environments, including caves and deeper waters, and shallow reefs of southern Tasmania where high levels of tannins from river runoff restrict light penetration.

Sponges have a variety of growth forms – encrusting, branching, massive, leaf-like – that can change in different environments. Sponge beds are common below 25 m on the floor of the continental shelf. They are attractive to divers, with their bright colours and varied shapes, and their rich associated fauna.



Cnidarians

About 410 species of cnidarians – a group of marine animals that includes jellyfish, corals, anemones and seapens – have been collected from the seafloor and open ocean of temperate Australia.

Pelagic cnidarians, together with the similar but unrelated comb jellies (Phylum Ctenophora) and salps (Class Thaliacea), contribute considerably to the zooplanktonic fauna of the Region. These gelatinous animals can range in size from microscopic dimensions to more than a metre in diameter, as in the Lion's mane jellyfish.

Benthic cnidarians, live attached to the seabed and are found at all depths, from below 20–30 m. In these areas they contribute significantly to the rich faunal communities that, with decreasing light level, gradually replace the algae dominated communities. Sea pens have been collected on soft sediments from depths up to 2000 m during recent surveys of the Region's continental slope, where they often represented a dominant component in the samples. *Solenosmilia variabilis* is the dominant hard coral on many seamounts off southern Tasmania where it forms a lattice-like matrix, thus creating a multitude of microhabitats for other species. In general, deep-sea corals from the Region are not well known. Work elsewhere has shown that they are slow growing and long lived organisms, and as such they are not resilient to disturbance. Unpublished data using C14 aimed at ageing bamboo corals from the south Tasmanian seamounts indicates that some colonies may be approximately 100 years old.

Marine worms

The term 'marine worms' groups at least six different phyla that have little in common except for a worm-like appearance. Most marine worms are small, inhabit cryptic environments, such as crevices in hard substrates and the spaces between sediment grains on soft substrates, and many excavate their own shelters. Sedentary marine worms are often filter-feeders, capturing microscopic organisms and organic matter floating and carried by the currents. Deposit-feeders are also common among worm species and eat the organic matter that falls onto the seafloor and that results from the waste and decomposition of a variety of organisms, from small planktonic algae, to detached, adrift seagrass and kelp, and large marine mammal carcasses. They are a key component of the marine infauna (ie animals living buried in the sediments) that contribute to the recycling of organic matter in the ocean's ecosystems. Some marine worms, however, are benthic and pelagic predatory species, and many worms (notably those belonging to the Phylum Plathyhelminthes, or flat-worms) are parasites of fish and other organisms. Polychaetes, a class of Annelids, are perhaps the best known and most diverse group of marine worms.

Pycnogonids

Pycnogonids ('sea spiders') are distant relatives of land spiders and usually have four pairs of long walking limbs. They are found in many environments, with some species occurring at depths of a few metres and others below 1000 m. Shallow-water species are often very small (<1 cm) and not very visible. Large specimens are commonly found on soft sediments on deep seabeds, for example the base of the Big Horseshoe Canyon, off north-eastern Bass Strait at 2000 m depth, where they are thought to feed on sea pens and anemones.

Crustaceans

This is a very large group worldwide with an estimated 100 000 species. They live in most marine environments, and have a variety of life histories and strategies. Crustaceans include many species that are specialised to living in the intertidal zone (eg barnacles), as well as microscopic zooplankton and several species of high commercial value, including rock lobsters (*Jasus edwardsii* and *Jasus verreauxi*), crabs and shrimps. Crustaceans are one of the best known invertebrate groups in the ocean, as specimens are relatively easily identified and classified. Of particular importance in the Region is the krill *Nyctiphanes australis*, which swarms at the surface of inner continental shelf waters, primarily in summer and autumn, feeding on microalgae and being eaten by a variety of marine animals. It is, for example, the main food for blue whales – the largest animal inhabiting the oceans – that visit the Region regularly, and is a vital link in many different food chains.

Molluscs

The Phylum Mollusca includes a variety of animals, in terms of size, shapes and habits. Gastropods, bivalves and cephalopods represent the most common and widespread of the marine molluscs. They inhabit a broad range of habitats and depths and, within the Region's ecosystems, they include species of high commercial value, such as the blacklip and greenlip abalone (*Haliotis rubra* and *Haliotis laevigata*), scallops and squids. Most gastropods are grazers, that is, they feed on marine plants by scraping them from the surface, while bivalves, which lack scraping 'teeth', are mostly filter-feeders. They have a gill system that, besides being used for respiration, is also designed to assist in feeding on particles caught in their inhalant siphon.

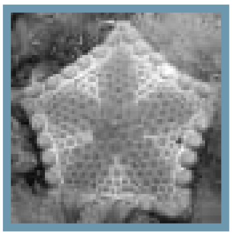
Cephalopods, including octopuses, cuttlefish and squids, are typically predators and have evolved complex nervous systems that make them highly competitive against their vertebrate counterparts.

At least eleven species of octopuses are found in the Region at a range of depths, living primarily in close association with the seafloor. Recently, a likely new species belonging to the deep sea genus *Benthoctopus* has been collected from the deep seamounts off southern Tasmania. The biggest molluscs are the giant squids that can reach up to 18 m in length including the pair of long feeding tentacles. Very little known about the giant squids and they are only occasionally caught, with two specimens recently being fished from the Region's waters, off King Island and Tasmania.

Echinoderms

Echinoderms comprise seastars, sea feathers, brittle stars, sea urchins and sea cucumbers, together providing a diverse array of shapes, feeding and moving modes. Many echinoderms have cryptic habits, that is, they spend most of their time and particularly during the day, hidden in crevices and under rocks. Sea feathers, or crinoids, are usually associated with algae or other structural components of the habitat, such as black corals. Beds of stalked crinoids have been recently described from deep sites (~180 m) on the Region's continental shelf, seemingly supported by a stream of food derived from upwelling and associated algal bloom events at the shelf break and transported from offshore by seasonal currents.

Sea urchins in shallow habitats help to structure macroalgal communities by regulating the settlement and growth rates of most algae but not the coralline algae (see 'barren habitats' on page 58 on inshore and inner shelf ecosystems). Sea urchins have been found in deep environments on seamounts, where they represent widespread scavengers and detritivores and characterise communities that differ in species composition and general levels of biomass from the usually shallower, coral-dominated communities on the Region's seamounts. Among seastars, the largest species are predators that feed on a variety of smaller animals, while most species are scavengers or graze on algae-covered surfaces. In the Region, *Coscinasterias muricata* is the largest species, reaching up to 25 cm in diameter. It is considered an important determinant of the structure and composition of surrounding habitats and communities, by predating on molluscs such as scallops thus preventing in places these species from forming extensive beds.



Salps

Salps are pelagic animals with a barrel-shaped body that is semi-transparent and can luminesce brightly. They feed by drawing water through the front of their bodies, filtering it for food, and then ejecting it from in a powerful jet. Large swarms are formed in favourable conditions. At certain stages of their life cycles, salps form large colonies. The colonies of *Pyrosoma atlanticum*, a prominent species in the Region, form colonies up to 500 mm long. This species is regularly seen off the coast, but is most abundant offshore in deep water.

Some key references and further reading: (Edgar. 2000; Edgar. 2001); (Kloser, et al. 2001), (Norman & Reid. 2000), (Koslow & Gowlett-Holmes. 1998), (Andrew. 1999), (Bax & Williams. 2001).

Vertebrates

Vertebrates (fishes, birds and mammals) include some of the best-known marine animals of the Region. Appendices C (South-east Marine Region commercial fish species) and D (Species of conservation significance) consider in detail 45 species of relevance for the Region's commercial and recreational fisheries and 120 species (including invertebrates, fishes, turtles, seabirds, seals, whales and dolphins) that are of significance for the conservation of Australia's biodiversity.

Fish

The known fish fauna of temperate Australia consists of around 550 to 600 species, most of which live inshore and on the shelf. About 85% of them are endemic to southeastern Australia. Fish include both bony fish and sharks and rays, or cartilaginous fish. The composition and distribution of fish communities are strongly influenced by depth and structure of the environment (bottom type and water characteristics), both on the Region's continental shelf and slope.

Of the species that inhabit the deeper shelf and slope, many are long lived (> 20 years), have relatively low rates of production, and form large aggregations to spawn. Most of the information available is on commercial fishes. Research has focussed on their stock sizes and population dynamics (see Appendix C: South-east Marine Region commercial fish species) and shallower water coastal species that are easily studied. We have relatively little knowledge of the biology, distribution and population dynamics of all but a few species of fishes from slope environments.

A diverse range of sharks and rays occur in the Region. Our knowledge of this group of fishes is more limited than the bony fishes as they are more difficult to identify and occur in lower numbers. What is known about sharks and rays is that there is a high level of endemism in the Region and that the general biology of these fishes, such as the deep water dogfishes, (long-lived, slow growing, low reproduction rate) makes them particularly vulnerable to over-harvest. Several species of mainly nocturnal sharks are found in continental shelf environments of the Region. Pelagic shark species, both schooling and solitary predators, are common inshore and offshore and some species are targeted by fisheries (see Appendix C: South-east Marine Region commercial fish species). One of the largest fish found in the Region's waters is the great white shark (*Charcharodon charcharias*), which can reach up to 7 m in length. White sharks are found commonly in inshore waters and particularly in proximity of rocky reefs and seal colonies where they feed. They can travel considerable distances (up to 1400 km according to one tagging study) but the extent and reasons for moving are not clear, with some individuals remaining at the same locality for years.

Turtles

Four species of turtles (the loggerhead, green, hawksbill and leatherback) occur regularly or occasionally within the Region. The most common species is *Dermochelys coriacea*, the leatherback or leathery turtle. Among sea turtles, the leathery turtle has the southernmost distribution and it has been reported frequently from northern Tasmania between the months of November and May. Very little information is available about the behaviour of the leathery turtle at sea and its migration patterns. A recent study of previous records and anecdotal evidence derived from interviewing fisherman, indicates that sightings of leathery turtles around Tasmania appear to be more likely in two areas: east-northeast of St Helens and west of King Island. It seems that a main determinant of the seasonal occurrence of leathery turtles in Tasmanian waters is water temperature, with the period of highest temperatures coinciding with the period of highest frequency of sighting.

Birds

The biology of some seabirds in the Region, such as the short-tailed shearwater (*Puffinus tenuirostris*) or muttonbird, is well understood.

However, in general terms the knowledge of the distribution and status of seabirds of the Region is poor. For many of the Region's seabirds general aspects of their ecology are also not well understood including their activities at sea and feeding.

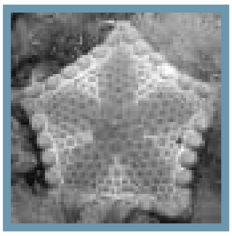
Plankton-eating seabird species are predominant in the Region, particularly in Bass Strait, South Australia and around Macquarie Island. Consequently the ocean production of the Region, in particular, Bass Strait, South Australia and south Tasmania is crucial for maintaining plankton-eating seabird populations. Breeding short-tailed shearwaters feed on krill *Nyctiphanes australis* at least until their nestlings require food. Although there is little information, it is thought that they feed mainly in the productive waters of southern Tasmania.

There are few non-plankton-eating seabird species in the Region. The little penguin (*Eudyptula minor*) which feeds on small fish represents 98% of the total in biomass of this group. It is widespread across southern Australia, with breeding colonies in Victoria, on Bass Strait islands and mainland Tasmania. The colony on Phillip Island constitutes about a third of the Victorian breeding population. Little penguins spend most of their time at sea when not breeding. The male penguins return to colonies between June and August to ready their nests for the egg laying season, which usually peaks in September and October. Little penguins appear to rely heavily on pilchards and southern anchovies for food; mass deaths at Phillip Island and Port Phillip Bay have been linked to die-offs of pilchards, such as the event off the coast of Victoriain 1995.

Most of the seabird species that breed and/or occur in the Region, around mainland Australia, Tasmania and Macquarie Island, are listed and described in Appendix D (Species of Conservation Significance).

Seals

Pinnipeds, (seals and sea lions) tend to display different feeding habits and social behaviour during and outside of their breeding seasons or stages of maturity. The South-east Marine Region includes some of the largest colonies of pinnipeds in Australia. Nine species of fur seals, seals and sea lions, out of the ten living in Australia, are found in the Region. These are listed and described in Appendix D (Species of Conservation Significance).



Whales and dolphins

Although some 34 species of cetaceans – baleen whales, toothed whales and dolphins – have been recorded in the Region, only a few live permanently in the Region, with the rest visiting on their migrations. All cetaceans are protected in Australia and further information on individual species is provided in Appendix D (Species of Conservation Significance).

Some key references and further reading: (Bone. 1998; Ross, et al. 1995), (Skira. 1991), (Garnett & Crowley. 2000), (Dann. 1992; Dann, et al. 2000), (Reid & Hindell. 2000), (Shaughnessy. 1999), (Gales. 1990; Gales, et al. 1992; Gales & Pemberton. 1994), (Graham, et al. 2001), (Walker. 1999), (Last & Stevens. 1994), (Smith, et al. 2001.), (Bruce et al. 2002)

Threatened species

Apart from marine mammals and reptiles (turtles), relatively little attention has been given to the conservation of marine species. This is partly because they are 'out-of-sight' and partly because they are largely unknown. Marine ecosystems are closely connected because of the fluidity of the environment and the patterns of water circulation. Larvae are mostly dispersed by currents, which can carry them across considerable distances. As a result, marine organisms tend to be widespread. If local populations decline they may have a greater ability to recolonise environments than their terrestrial counterparts. The complex linkages that exist in the ocean may, to some extent, buffer marine species from extinction.

Because we cannot 'see' what goes on in the ocean, we know very little about the conservation status of many species. We believe though that both fishery and ecological extinctions do occur in the marine environment. The term 'fishery extinction' refers to the sudden and unexpected collapses in commercially exploited fish populations. A species that is fishery-extinct may not be ecologically extinct, as it may survive in small numbers or in other locations. While the species may survive, its role within the broader marine ecosystem may be dramatically changed due to decreased numbers. Animals caught as bycatch in a fishery or killed directly by fishing gear but not physically caught, can also be under threat, and declines in their numbers is more likely to go unnoticed. Because bycatch is usually discarded, we have less information about these species than those that are marketed. The bycatch of albatross species in long-line fisheries is one example. Based on our current understanding of the ecological and biological dynamics operating in the ocean, we can draw an 'identikit' of a marine species that are vulnerable to extinction. Organisms that have one or more of the following traits are likely to become threatened in the ocean:

- reliant on geographically or physically restricted habitats, such as coastal embayments, estuaries or seamounts
- no larval stage (which would spread the species over long distances), or a short larval stage
- long life-span until reproductive maturity
- infrequent reproduction or bearing only a few young at a time
- threatened habitat or food supply
- susceptible to large interannual variability in recruitment.

In the South-east Marine Region, about 90 species are currently listed under State and/or Commonwealth legislation as being in danger of extinction. Appendix D lists these species and briefly describes their ecology. The currently listed organisms range broadly across the spectrum of biological diversity, from marine plants (the brown alga *Cystoseira trinodis* and the seagrass *Zostera mucronata* are listed as Rare under Tasmania's and South Australia's legislation respectively) to invertebrates and vertebrates, including fish, turtles, birds and mammals.

Invertebrates and fishes, which vastly outnumber marine mammals, birds and turtles, are under-represented in conservation (see Appendix D: Species of Conservation Significance). This is probably a reflection of public interest and being less visible and charismatic than the mammals and birds. However, as our knowledge and understanding of the marine ecosystem develops and we better appreciate the ecological roles and requirements of individual species, our conservation efforts are broadening to include species that do not have the high-profile of whales, turtles and penguins. For example, twelve species of marine invertebrates have recently been nominated for legislative protection in Victoria. In Tasmania, a number of seastars are considered to be highly vulnerable to population declines, as they live in intertidal habitats and do not produce larvae. Similarly, some South Australian cowry shells that also lack a larval stage are possibly threatened, in this case by shell collectors.

Some key references and further reading:
(Edgar, et al. 1991), (Jones & Kaly. 1995), (O'Hara & Barmby. 2000).

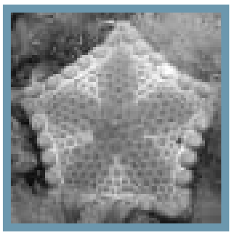
Introduced marine species

Introduced marine species are those species that occur outside their natural or historical ranges. Extensions in the ranges of marine life forms are sometimes due to natural processes, such as the breakdown of geographic or climatic barriers or gradual range expansion due to shifts in oceanic current patterns over time.

Marine species are also introduced to new areas by humans. In contrast to the natural processes, which tend to be gradual and occur over ecologically long time periods, movements caused by humans can be frequent and rapid. In some cases, introduced species can have a competitive advantage over native species because they are outside their natural environments without their natural predators and parasites. This can threaten the resident species and can become a conservation issue if the resident species are endemic.

It is often difficult to know whether a species has been introduced or is native, but previously unrecorded. This is particularly the case for uncommon species and species whose distribution patterns are not well known. Species for which there is not enough evidence to define them unequivocally as introduced are called cryptogenic, (literally 'of hidden origin').

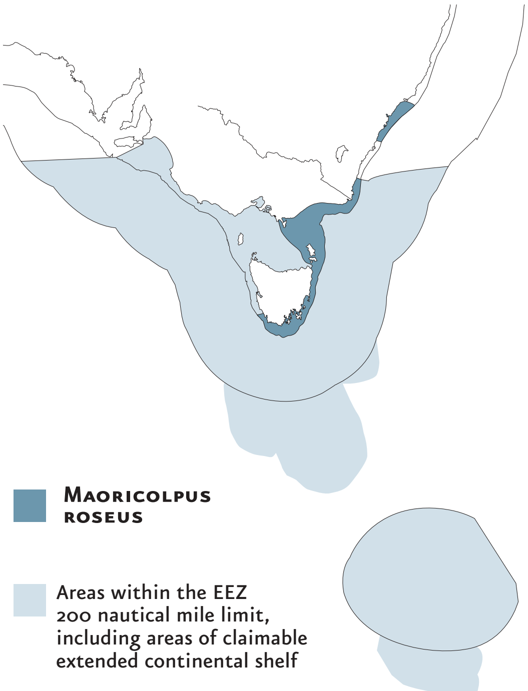
More than 250 introduced marine species have been detected in Australian waters. In the South-east Marine Region, 115 species have been introduced and an additional 84 have been identified as cryptogenic. The high number identified in the Region as compared to the total in Australia may be partly because researchers have recently surveyed a number of sites within the Region, including Port Phillip Bay, where all the phyla studied were found to contain introduced and cryptogenic species. There is also a long history of museum collecting in southeastern Australia, so the flora and fauna are relatively well documented and invasive species may be more readily recognised.



Introduced terrestrial species can also effect marine species. On Macquarie Island, for example, at least four species of birds and several species of mammals (ie. cats, rats and rabbits) have affected populations of seals, penguins and other seabirds. The extent and severity of such affects are detailed in Appendix D (Species of Conservation Significance) and discussed in the broader context of ecosystem function.

Some key references and further reading:
(Carlton. 1996), (Cohen, et al. 2001), (Currie & Crookes. 1997), (Currie, et al. 1998), (Hewitt, et al. 1999).

Map 1: *Distribution of* Maoricolpus roseus *in the South-east Marine Region.*



The New Zealand screw shell

The New Zealand screw shell (*Maoricolpus roseus*) is fawn to purplish-brown. The strong shell can grow up to 87 mm in length and 25 mm in width, bigger than any living relative native to southern Australian waters. The screw shell can aggregate in beds of up to several hundred per square metre. Historical evidence from mollusc dredgers in the Region suggests that this species was probably introduced after 1920, either with live oysters imported from New Zealand to the Hobart Fish Market, or within semi-dry ballast in timber vessels. Since it was first identified in the D'Entrecasteaux Channel in south east Tasmania, its distribution has greatly expanded. It is now found in waters up to 80 m from Southport in southern Tasmania across the eastern part of Bass Strait, around Flinders Island and further up the east coast of mainland Australia. The most northerly sightings are currently from Botany Bay and Sydney Harbour (see Map 1).

Although several fish species feed on the screw shell (particularly fish with strong mouthparts), predation on screw shells in Australian waters is likely to be light, given its recent introduction. This may be one reason it has spread so rapidly. Screw shells considerably modify the habitat they live in. They are so abundant in some areas that the substrate has changed from fine sand or mud to a dense covering of live and dead shells. There is evidence that the Australian native screw shell (*Gazameda gunnii*) and commercial scallop species have declined since the introduction of *M. roseus*, possibly as a result of direct competition for food and space. An indirect impact of the screw shell results from their robust shells providing excellent homes for hermit crabs. This might lead to hermit crabs becoming more abundant and increasing predation on native species. Based on the habitat modification it causes, its high densities and widespread distribution, the screw shell may well be the most damaging introduced marine species in southern Australia today.

Some key references and further reading:
(Allmon, Jones et al. 1994), (Bax, McEnnulty et al. 2001), (Greenhill, 1965).

Chapter 3
Ecosystem links & functions

A marine ecosystem consists of the physical environment and the plants and animals that live in the physical environment. The physical environment provides the necessary ingredients for biological production: energy, nutrients and oxygen, which biological processes use to build biomass and cycle nutrients back to the physical environment.

We define an ecosystem as a part of the marine environment in which the processes that drive and distribute biological production are more consistent and internally connected than they are with the processes of neighbouring systems. Throughout these sections we focus on the functions of marine ecosystems that are relevant to management goals of maintaining ecosystems in a healthy state. The range of ecosystem processes can be broadly classified under the following themes:

- energy sources, nutrient flows and biological production
- energy flows and food webs
- population dynamics and life-history strategies
- dispersal and migration
- structural complexity.

These themes are used to describe the processes that drive the Region's dynamics and diversity of ecosystems under three main topics:

- life in the ocean: briefly introduces the themes: their roles in ecosystem dynamics; key links with other natural processes; and relevance to management considerations
- large-scale processes in the South-east Marine Region: presents Conceptual Models for the large-scale processes that drive the dynamics at a range of time and space scales in the Region
- Examples from the South-east Marine Region: describes Conceptual Models of the different ecosystem types and discusses the links between them.

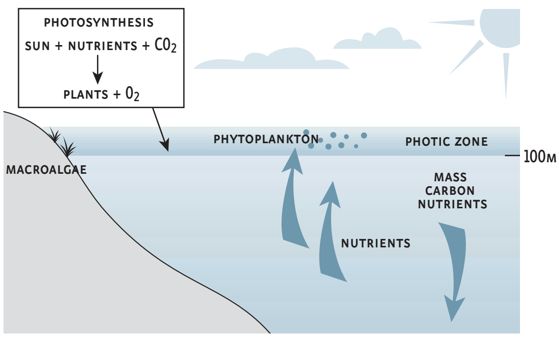
Life in the ocean

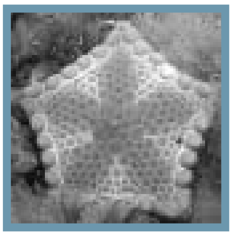
Energy sources, nutrient flows and biological production

Biological production in the oceans starts with marine plants and some bacteria that combine energy from the sun with carbon dioxide and nutrients to grow and produce oxygen via photosynthesis. Photosynthesis can only occur where there are sufficient quantities of all three ingredients. Carbon dioxide is rarely in short supply in the ocean. However, sunlight penetrates only the surface layer (top 100 m) of the ocean – the photic zone, and the concentration of nutrients varies considerably between different parts of the ocean (see page 18 on the seascape of the South-east Marine Region). Hence, the availability of light or nutrients, or both, generally controls the rate of photosynthesis and therefore the amount of energy made available for biological production in the rest of the ecosystem. This process, known as 'primary production' is illustrated in Figure 13.

Microscopic plants, known as phytoplankton, live in the surface waters of the ocean and are responsible for most marine primary production. Macroscopic marine plants, such as seagrasses and kelp, are important in coastal waters where light can penetrate to the ocean floor. Primary production in the South east Marine Region is explained in detail on page 51 in primary productivity.

Figure 13: *Microscopic marine plants – phytoplankton – turn energy from the sun, nutrients, and carbon dioxide into living plant material and oxygen. This 'primary productivity' supports almost the entire oceanic food web.*





Management considerations

Primary production by phytoplankton is highly variable in space and time. Patchiness in phytoplankton concentration influences the distribution and survival animals that feed on it: larvae, larger grazers such as zooplankton and small fish) and their higher predators.

Mobile higher predators often move toward areas of high production. The size and distribution of phytoplankton populations in an area can change dramatically from month to month and year to year, due to natural processes. This high level of natural variability makes it difficult to unambiguously detect and attribute changes to human-induced causes.

Primary production can be affected directly by land-based sources, such as terrestrial runoff and discharge of sewage, that can either enhance primary production from photosynthesis by increasing nutrients, or impede it by reducing light or killing plants directly. These effects are likely to be confined to coastal waters, as mixing and biological processes will dilute them away from the source of input.

Energy flow and food webs

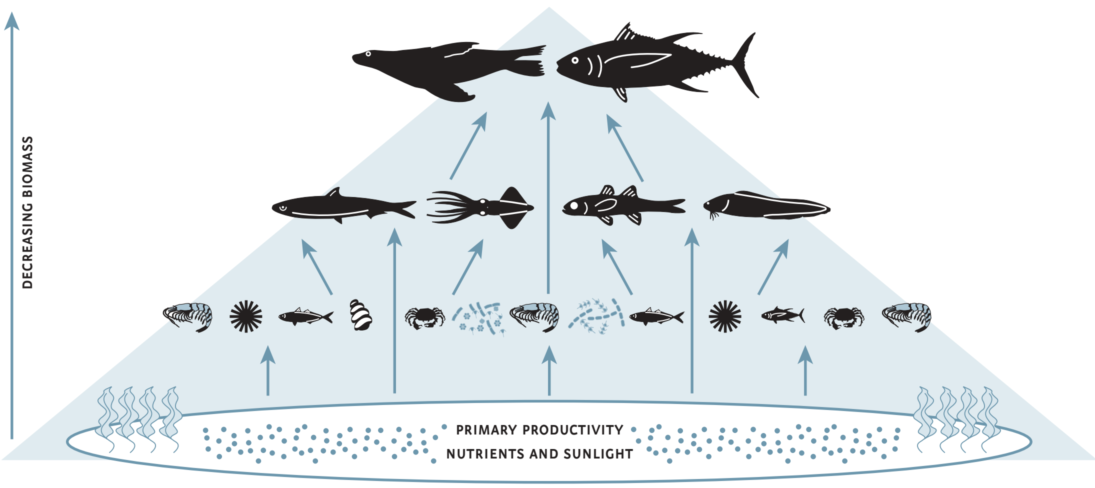
The flow of energy from primary producers to herbivores to higher level predators and back to primary producers in the form of recycled of nutrients is known as 'trophic dynamics'. As energy in the form of biomass (total mass of living material) moves up the food chain, some is lost to maintaining basic life processes of the individuals at each level. Consequently, there is generally a decrease in overall biomass at each successive level. This phenomenon is illustrated in Figure 14.

The species composition at each level and the feeding relationships between them are referred to as the "trophic structure", or food web. The trophic structure of ecosystems vary from very simple and direct (eg phytoplankton, krill, whales) to complicated and indirect (eg coral reef communities).

Individual species may have very specific or very general food requirements and may be more or less competitive with other species in obtaining their preferred food. Generally, a more flexible diet means reduced vulnerability to changes in the abundance of prey species.

Recent studies indicate that some ecosystems of the shelf and slope in the Region are controlled from the supply side (ie primary production, or bottom-up) and that competition between fish, seabirds and marine mammals for limited productivity plays a more important role than predation in controlling overall population sizes. This contrasts with other shelf ecosystems where predation is reported to play the

Figure 14: *A schematic representation of trophic structure – the flow of food energy (in the form of biomass) from primary producers (marine plants) to higher predators. The trophic structure varies with each ecosystem depending on levels of competition, predation, and biomass loss at each trophic level.*



major role. Scientists studying the habitats and diets of fish within the Region also suspect that the complex dietary relationships among many fish species may be more closely related to convenience than to taxonomic relationships. For example, the timing of daily feeding for a specific species may be related to the behaviour of either the predator or prey.

Identifying the trophic links in an ecosystem and measuring the flow of energy among trophic levels is a difficult and costly task and has not been the focus of the majority of research efforts in the Region. Consequently, our knowledge of the trophic structure and trophic dependencies among species is restricted to a few relatively well-studied areas. Improving this area of knowledge will be a priority for developing our capacity to understand ecosystem dynamics.

Other factors that will influence management include:

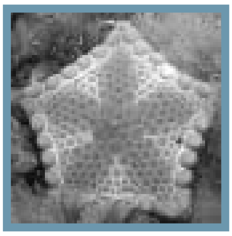
- trophic cascades (substantial shift in trophic structure due to removal of key functional group(s)) and loss of production related to environmental processes and human impacts
- historical decreases in population size of major predators (eg removal of top predators such as seals, whales, and tuna in commercial fisheries) and the effects this has had on the food webs in the Region
- changes in trophic structure resulting from nutrient loading, pollution and other habitat modification (eg plankton blooms due to terrestrial runoff)
- reduction in resiliency of 'managed' ecosystems – those ecosystem where humans have controlled the variability of particular species or aspects of the structural environment (eg flood control of rivers which flow into the ocean).

Population dynamics and life-history strategies

In the same way that different standards of living, birth and mortality rates result in human populations of different age, size and sex structure in different regions of the world, the same processes determine the size and structure of populations of marine species. Changes in the biomass and structure of a population of a species are known as population dynamics.

The processes that affect population biomass can be divided into those that relate to changes in the size of individuals currently in the population (individual growth and energy needs) and those that relate to changes in the total number of individuals in the population (births and deaths).

Population Biomass = Growth – Energy Needs + Births – Deaths



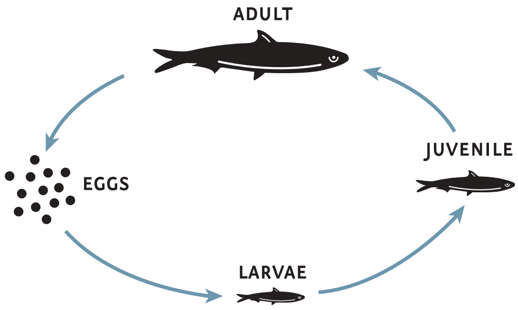
Marine life history strategies

Reproduction for most species of fish and marine invertebrates involves external fertilisation of eggs and a stage when the tiny young are referred to as larvae seen here in Figure 15.

As a consequence, eggs and larvae may be transported over large distances by ocean currents. If they encounter a suitable habitat they may settle there and advance to the next stage in their life cycle. A consequence of this method of dispersal is that eggs and larvae are exposed to the vagaries of environmental conditions along the way, and to predators against which they have little defence. As a result, the probability of eggs, larvae or juveniles surviving the journey can vary considerably, depending on the conditions at the time of spawning and along the way.

To ensure that enough larvae and juveniles surviving to maintain the adult population, adults produce thousands or even millions of eggs each spawning season. Year-to-year variations in the number of reproductively mature adults in the population and the conditions for larval survival mean that the number of juveniles that become mature in one year may vary by several orders of magnitude to that in the next. Consequently, the sizes of populations of species with this type of life cycle tend to have a high level of natural variation.

Figure 15: *A typical marine fish or invertebrate life cycle.*



Management considerations

The population dynamics, life cycles, and life history strategies of marine species such as fish are radically different from those of terrestrial vertebrates. This presents a number of challenges to resource managers who are trying to protect the viability of populations of marine species. Because of the natural variability in populations we will not be able to predict future birth rates or numbers of juveniles in a particular year with precision or accuracy for the vast majority of species. However, understanding individual survival strategies and overall population dynamics of many species can be used to develop adaptive management strategies that are able to deal with high year-to-year variation.

Dispersal and migration

The processes of dispersal and migration distributes energy, nutrients and biomass within an ecosystem and between ecosystems. Dispersal most often refers to the transport of larvae from spawning sites to juvenile nursery grounds, which may be localised or widespread. Many physical processes affect the dispersal and survival of larvae. Large-scale and local currents move the larvae, sometimes over long distances, and larvae will only survive if they encounter the right conditions along the way (temperature, light, etc). This dependence on complex, time-dependent physical processes means that the patterns and success of larval dispersal is largely unpredictable, and may vary from year to year.

Migration is distinct from dispersal in being active as opposed to passive. Many species undertake extensive migrations to take advantage of optimal conditions for feeding, breeding and general survival. Optimal conditions are determined by many factors including ocean currents, temperatures, and the presence of other species. Some migrations are horizontal, others vertical. Some migrations are carried out daily, others seasonally, and still others once in a lifetime as species move to different locations through different stages of their life-cycle. Migrations are often life-stage and sex dependent, in some cases because the migrations are related to breeding (eg whales). Scientists also think sex or age dependent migrations may reduce competition among individuals of the same species.

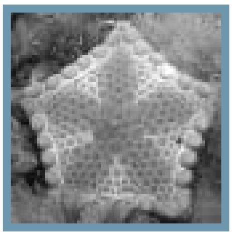
Dispersal and migrations together influence the age, sex and numbers of individuals in a population (stock structure) and the geographical range of a given population (biogeographical boundaries). This physical differentiation of various populations and stocks over time is related to evolution and species differentiation. Separate populations of species within the Region that may be influenced by migration and dispersal patterns include humpback whales (separate populations migrate up the west and east coasts of Australia) and eastern and western gemfish (found to the east and west of Tasmania, respectively).

Management considerations

The connectivity of the marine environment sets up multiple challenges to effective resource management, a prime example being that species and processes cross jurisdictional boundaries. For larval dispersal this means that spawning in one location (or management area) can effect the settlement and later maturity of individuals in a distant location (and different management area). Thus, impacts of human uses and management travel through the system and the health of one area relies on the health of other areas.

An important distinction between dispersal and migration is that migration can be more confidently predicted as it involves the use of particular habitats in space and time, eg feeding and breeding areas, and migration routes. Identifying these areas may enable effective management of human impacts on the habitats and the species using them.

Management of human impacts on dispersal is more difficult because the details of the dispersal change each year. The spawning habitats and juvenile nurseries can be protected, but the regional scale processes that determine larval dispersal and survival are highly variable. Management will need to incorporate the best information about these regional processes and their affects on particular species, and be as adaptive as possible to changes in yearly conditions.



Structural complexity

Physical structure determines the range of habitats available for plants and animals and influences physical and biological processes at a range of time and spatial scales through many mechanisms. The key elements of physical structure include depth, seafloor type space, water temperature and nutrient level, water movement and sunlight. Examples of biological structures include kelp forests, coral reefs, sponge gardens and marine snow (conglomerates where plankton aggregate).

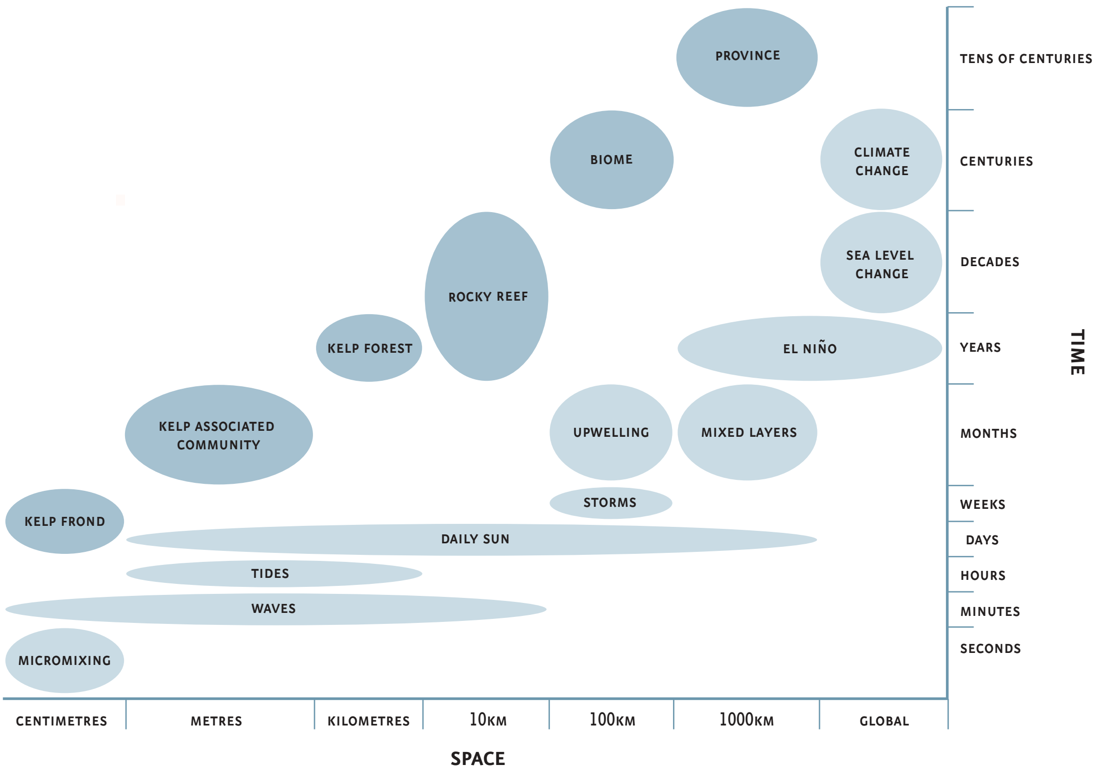
Notable features of the large-scale structure of the environment in the Region include the wide, shallow Bass Strait; steep, canyoned continental slope; isolated seamounts; Macquarie Ridge and Island; the dynamic suptropical front and powerful Southern Ocean; high wave energy and high seasonal variability in currents. Smaller-scale structure varies throughout the Region and the most important structural components in each general ecosystem type are described below. Examples of small-scale structural features include: kelp forests (up to 35 m high) which influence local currents and provide a habitat for a complex community of other species, or the different species that live on reef habitats compared with soft sediment species.

Multi-scale, complex processes

The physical and biological processes that produce environmental structure operate at a range of scales in space and time. Figure 16 illustrates the range of scales for selected oceanic processes (light shading) and biological structures (dark shading). These structuring processes are dynamic and affect each other.

Processes on all scales influence each other in a non-linear fashion – in other words, a two-fold change in one process can cause in a five-fold change in another. The result is that many processes are dynamic, variable and respond to environmental and human induced impacts in unpredictable ways. Changes on the scale of centimetres occur against the background of changes on the global scale, and changes over a period of minutes occur within the context of century-long

Figure 16: *Examples of the range of space and time scales in the marine environment. Light shading indicates examples of physical processes in the ocean environment. Dark shading shows examples of biological structures – with their placement on the time axis based on the dominant processes shaping the structures. (eg, At the Province spatial scale, the dominant process is evolution, which happens over 10,000s of years; at the kelp frond scale, processes include cell growth and predation, which happen over hours, days and weeks). Figure adapted from Gunderson, Holling* et al. *1995.*



trends. Nevertheless, fast, small-scale processes that occur at critical times and places can sometimes change the outcome of slow, large-scale processes. For example, rapid, unusual changes in local water conditions can cause blooms of toxic algae that can completely transform marine ecosystems through their release of toxins, causing changes that can last for many years.

A constantly changing web of interactions

All of these processes and their interactions are constantly changing. The physical environment transforms as tides change by the hour, weather changes by the day, ocean currents change by the season, and events such as underwater landslides and wild storms can happen at any time. Some changes are regular and predictable; others are catastrophic. Still others, such as sea level change, are subtle, long-term, and difficult to even observe with out decades of monitoring. Biological time-dependence is superimposed on these physical changes. The numbers of individuals oscillate due to complex population dynamics, while individuals change their behaviour throughout the days, seasons and years.

Management considerations

Much of the structural complexity of the marine environment and it's role in shaping populations and ecosystems is poorly understood. The Subtropical Front, for example, moves over five degrees of latitude between seasons and the details of the large Antarctic currents were described for the first time in the Region in 1997. This complexity in space and time complicates our efforts to understand marine ecosystems and manage our impacts. We must manage adaptively, constantly incorporating new information into flexible and robust management decision systems.

Some key references and further reading:
(Bax & Williams. 2000), (Bruce, et al. 2002), (Gunderson, et al. 1995), (Harris, et al. 1988), (Mcauley, et al. 2001), (Nybakken. 1993), (Underwood & Chapman. 1995).

Large-scale processes in the South-east Marine Region

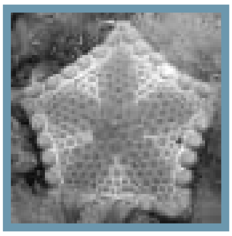
Primary productivity

Most primary productivity in the ocean requires not only sunlight, but also key nutrients such as nitrogen, phosphorus, silicon and iron. The nutrients in the thin photic zone are quickly taken up by phytoplankton. Deeper water masses are relatively rich in nutrients. Colder water masses also tend to have higher levels of nutrients than warmer waters, and waters entering the sea from rivers carry nutrients from the soil on land. Consequently, the places where the deeper waters rise toward the surface (upwelling zones), rivers discharge into the sea, and cold water masses mix with other water masses are areas of high productivity.

While these localised sources provide the nutrients to support plankton growth, other physical processes influence of primary production. These include many mixing processes, such as tides and internal waves, as well as the mixed layer – a thin layer of surface water which is mixed to relatively uniform temperature and salinity by interactions between the atmosphere and ocean.

Mixed layers in temperate regions typically follow a seasonal cycle, deepening as surface waters cool and sink during winter and reforming at a shallow depth as the surface water warms in spring and summer. The winter mixing brings nutrients up to the surface while spring and summer warming and sunlight encourage plankton growth and the nutrients become depleted. This cycle is shown in Figure 17.

All of these complex, time-dependent physical interactions result in patchy nutrient availability and plankton growth. Biological temporal change is overlaid on the physical complexity; the uptake of nutrients by the plankton varies through daily and seasonal cycles of photosynthesis and growth.



Energy transfer

Primary productivity in the surface layers supports food chains both directly and through the production of detritus. In a photosynthesis based food chain, zooplankton feed phytoplankton (single-celled algae) growing in the top 100 m, and higher predators feed on these zooplankton. The type and size of phytoplankton in a particular area can influence the type of food chains that are established.

Where phytoplankton are large, larger zooplankton feed on them and may be eaten directly by small fish – in this way food energy is transferred to higher predators efficiently. Where phytoplankton are small, there may be more links in the food chain – their uptake and use of available light and nutrients may be more efficient, but energy transfer to higher predators will involve more steps. As a result, there is a greater loss of energy between primary producers and higher predators.

Detritus consists of fecal pellets, molted crustacean exoskeletons, ungrazed phytoplankton and other 'waste' material. In a detritus based food chain, detritus falling from the surface layers supports life in the deeper waters. One interesting component of detritus is marine snow (mucus-like aggregates formed from secretions from a variety of plankton) which is usually 0.5 mm to 1 cm in size, but can be as large as 100 cm. Scientists now believe phytoplankton stick to marine snow, rather than floating freely and spread out in the ocean. Zooplankton and other species feeding on the plankton gather near these floating food rafts and a large component of the detritus food supply may be marine snow that has dropped to the seafloor. Phytoplankton may also form aggregates independent of marine snow and gather on and around seaweed rafts.

Nutrients in the food chain

Compared to similar regions around the world, the open ocean surrounding Australia tends to be lower in nutrients. This is due to the low nutrients in coastal soils (mainly low in phosphates) and to the lack of major upwelling zones. For example, central Bass Strait waters are very low in nutrients, which means they have relatively low primary productivity.

Exceptions to these lower-nutrient conditions occur where local, seasonal upwellings bring deeper waters into the photic zone and the plankton reproduce rapidly, forming 'blooms'. These patchy, irregular events support entire food webs and attract major pelagic species, such as southern bluefin tuna. One example of increased primary productivity due to upwelling can be seen off the west coast of Tasmania in Figure 17.

A few upwellings occur consistently over the continental shelf and along shelf breaks throughout the Region. The Bonney upwelling, which is close to the Bonney Coast in south-eastern South Australia (between Cape Dombay and Cape Nelson), occurs as a result of prevailing south-east winds during summer and autumn, which draw up cold, nutrient-rich subantarctic waters. This type of upwelling is illustrated in Figure 17 in the top left box 'coastal upwelling'. The Bonney upwelling subsides at the onset of prevailing westerly winds during late autumn.

Further to the east, nutrient-enriched waters rise to the surface in winter at the shelf-break east of Bass Strait, which may be related to the Bass Strait Cascade (see page 18 on the seascape of the South-east Marine Region).

To the south, autumn shelf-break upwelling events are common along the east coast of Tasmania, as a result of the interactions of the Tasman Sea surface waters, the subantarctic waters, the eastern tail of the Zeehan current and the southernmost extensions of the East Australian Current. These 'frontal upwellings' are demonstrated in the middle upper box on Figure 17.

East Australian Current eddies also result in increased nutrients, and in fact represent southward-moving habitats, clearly distinguishable from the surrounding waters by the higher temperatures and salinity and the biota of tropical origin that become entrapped in the water masses. As the surface water isolated in an eddy cools down, it sinks, leading to a progressively deeper mixed surface layer that can reach 300 m depth. In this way, nutrients are brought up to the photic zone,

resulting in enrichment and diatom (*Pseudonitzschia* and *Rhizosolenia*) blooms. These are most common at the eddy centre and its western margin, where the eddy interacts with the continental shelf, as shown schematically in the upper right box on Figure 17.

The other significant source of nutrients for phytoplankton growth within the Region is the cold, nutrient-rich subantarctic water injected by the seasonal movement of the subtropical front. The front circles the globe and flows eastward from the south corner of Tasmania. It is a dynamic feature, and its position varies during the year and between years. Like other major fronts, it is a region of turbulence, mixing, nutrient enrichment and enhanced productivity. (see page 18 on the seascape of the South-east Marine Region).

The seasonal mixed layer in the Region is typical of temperate regions throughout the world. On the shelf south of Tasmania, river runoff intensifies stratification (the formation of distinct density layers) during the spring formation of the seasonal, shallow mixed-layer. This allows the isolated surface layer to warm more quickly. By summer, there is a stable, uniform layer over the shelf and offshore; by autumn the layer is cooling and deepening in a fairly uniform manner. The extent and uniformity of the mixed layer changes not only between seasons, but also between years. The cycle is shown along the bottom of Figure 17 – the depths of the layer are from a study on the shelf south of Tasmania, but the general cycle of deep mixing in winter and of nutrient depletion in summer is common to the temperate regions of the global ocean.

- Productivity depends on sunlight, temperatures, upwellings, mixing events, and mixed-layer dynamics
- Productivity is 'patchy' in space and time
- In the ocean, productivity is generally higher on the shelf than in the open ocean, but in the South-east Marine Region on-shelf productivity is relatively low and may depend on imports form offshore
- Productivity in the Region is highest at shelf-breaks, along fronts and around eddies at particular points in time.

Food supply

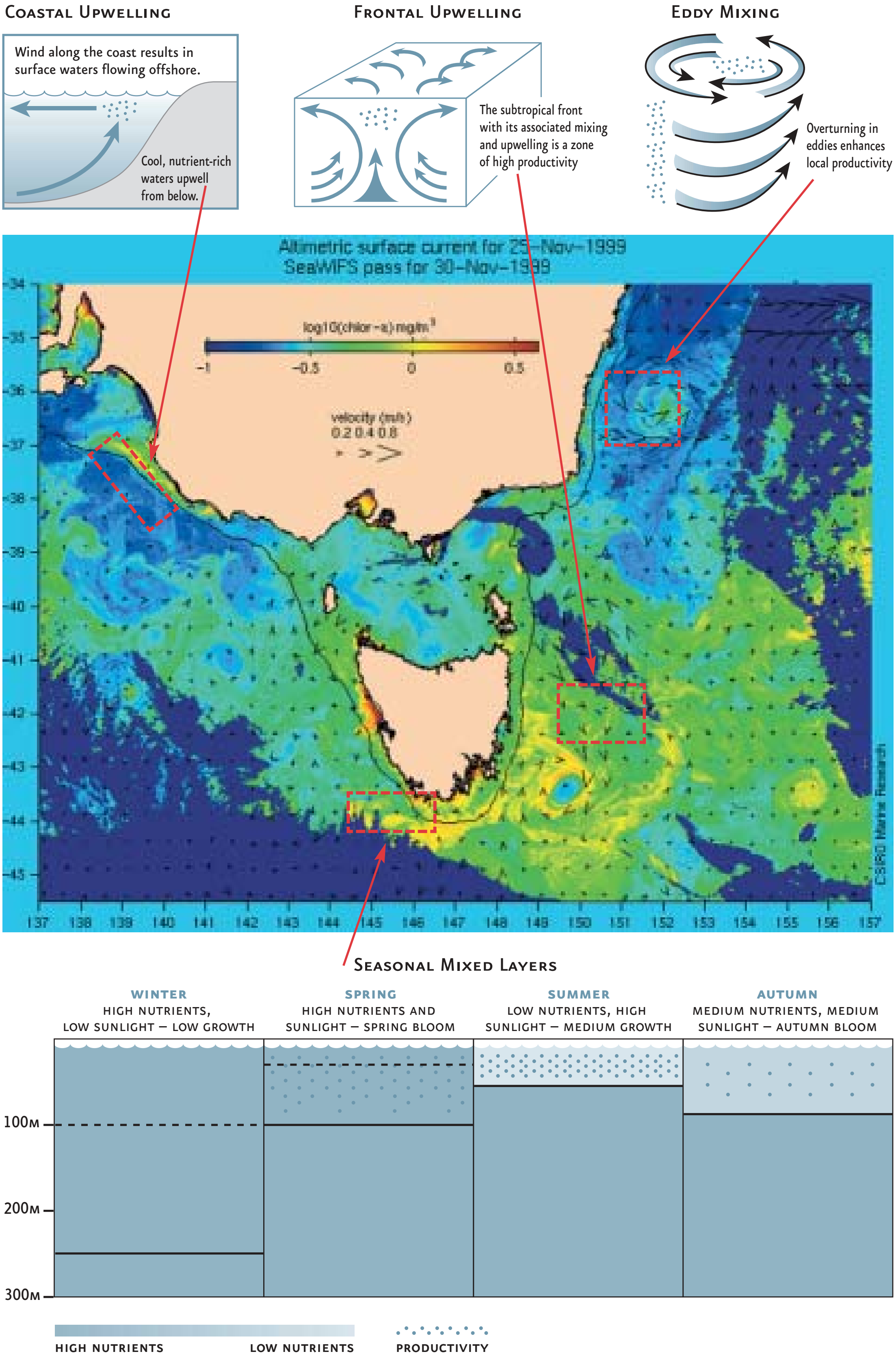
A study of the shelf ecosystem off southern New South Wales found that both pelagic and benthic trophic systems are fuelled by near-surface primary productivity. Thus, much of the shelf production may be imported advection of pelagic food, rather than being generated insitu by seagrasses and kelp forest along the coasts. This means the principal commercial fish species may be less dependent on seagrass detritus or other inshore sources for food energy than was previously thought. Nonetheless, seagrasses and kelp provide structural habitat and food for many species, supporting local food chains as well as species that feed on floating mats of detritus.

Some key references and further reading:
(Bax & Williams. 2000), (Bulman, et al. 2001), (Crawford, et al. 2000), (Furnas. 1995), (Harris, et al. 1987), (Harris, et al. 1991), (Gibbs, et al. 1991), (Griffiths & Brandt. 1983), (Hallegraeff. 1995), (Jeffrey & Hallegraeff. 1980), (Lewis. 1981), (Parslow, et al. 1996), (Schahinger. 1987), (Young, et al. 1996).

Dispersal and migration

Ocean ecosystems are connected in a variety of ways including links between the land and sea, shallow and deep waters and links between regions. This means that impacts in one area can effect large areas in complex and unsuspected ways. Migration and dispersal are two examples of such connections others include nutrient upwellings, surface circulation (eg East Australian Current) land-based pollution sources or outbreaks of disease in marine species.

Figure 17: *Satellite measurements of sea surface productivity. Blue-green colours indicate low levels of productivity; the East Australian Current imports a low-nutrient, low-productivity water mass into the northeastern part of the Region. Yellow-red colours indicate higher productivity; evidence of local plankton blooms can be seen in an East Australian Current eddy east of New South Wales, along the Bonney Coast of southeastern South Australia/western Victoria, and in the Subtropical Front around Tasmania. Reproduced with permission from David Griffin, CSIRO Marine Research.*



Larval dispersal survival

Larval dispersal is largely dependent on oceanographic processes such as currents, as many larvae have a limited capacity to control their large-scale movement. In the Region some of the most important currents for larval transport are the East Australian Current (and its eddies), the Leeuwin Current, the Zeehan Current, and Antarctic Circumpolar Current as well as smaller scale local currents and tidal motions (see Figure 11 on the seascape of the South-east Marine Region). Examples of larvae that are carried by currents throughout the Region include blue grenadier (larvae originating from western Tasmania found in eastern Tasmania) and jackass morwong (larvae spawned at the shelf break found 250 km offshore; dispersal linked to offshore oceanographic processes). An illustration of larval dispersal from a computer simulation is shown in Figure 18 (b).

Larval survival depends not only on being moved to suitable nursery grounds, but also on the suitability of other environmental conditions such as water temperature and food availability. These dependencies are not well understood, but environmental effects on distribution and movements appear important for a number of commercial species in the Region. Various environmental mechanisms also affect timing of spawning. Some fishes in the Region are thought to spawn in only one or two specific locations (eg eastern gemfish near Crowdy Head, New South Wales); and larval dispersal plays a vital role in spreading individuals from this single location.

Figure 18 (a): *Ocean currents and water temperature at 1.5 m depth during January, April, July, and October. Temperatures are from shipboard observations normalised over a grid. Currents are from a computer model driven by averaged observed winds and temperatures. Figure provided by CSIRO.*

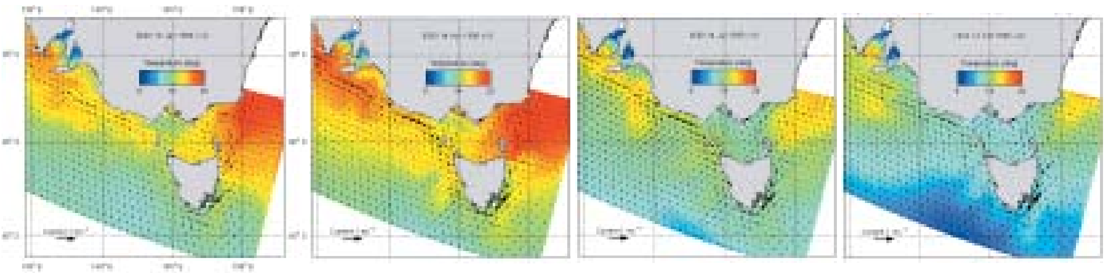


Figure 18 (b): *particle trajectories at 1.5 m depth in a numerical model of ocean currents, details above.*

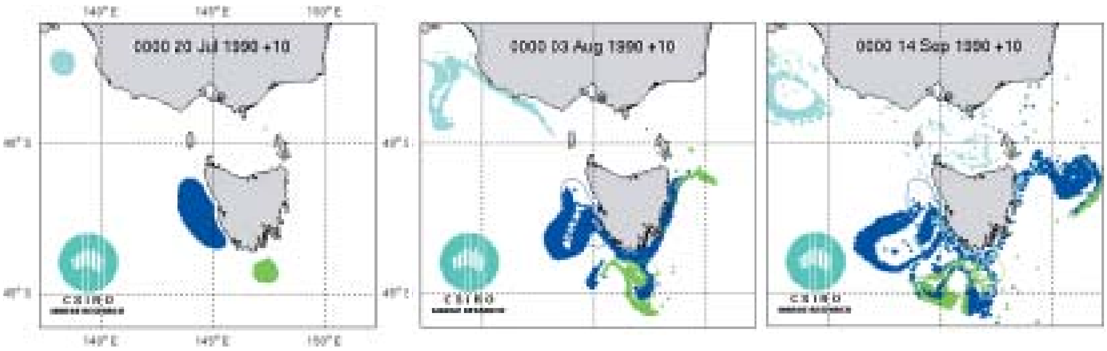
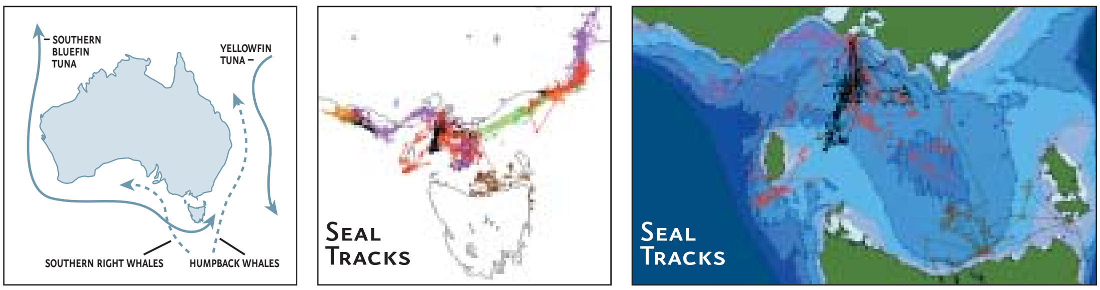
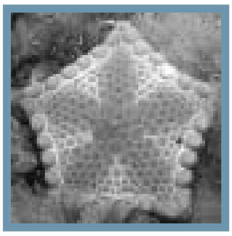


Figure 18 (c): *Left box – schematic of typical migration paths for tuna and whales around Australia. These Conceptual Models will be further refined and provide a basis for future targeted modelling work in support of regional marine planning.*





Different species spend differing amounts of time as dispersed larvae. Species having particularly long larval stages in the Region include jackass morwong (8-12 months) and southern rock lobster (12-24 months). Some species can self-propel to various depths to find amenable conditions for survival or dispersal. Researchers think that southern rock lobster larvae use vertical movement and water mass or depth signals to trigger development into the next life cycle stage. Other environmental factors such as upwelling, wind frequency and storm events may also trigger this transformation. The ecology of larvae of many species in the Region is not well known, and the environmental factors controlling survival and dispersal are even less well understood.

Migration

Marine species migrate in many ways and for many reasons. The following examples provide a sample of this variety.

Many whales migrate through the Region each year to key habitats for feeding, mating and calving. Humpback whales feed in the Southern Ocean in summer and migrate north in autumn for winter breeding in warmer water in western and eastern Australia. Southern right whales visit the south coast of Australia in summer, while blue whales and pygmy blue whales come in winter.

Other species that enter and leave the region annually during breeding and feeding migrations include: southern bluefin tuna, tropical yellowfin tuna, school shark, australian fur seal, new zealand fur seal, australian sea lion, albatross and shearwaters (eg muttonbird). Figure 18(c) shows some of these migration patterns.

Examples of single-sex or life-stage migrations in the Region include seals and sea lions (females and males undertake different foraging migrations) and school sharks (individuals migrate from South Australia to the Bass Strait as part of their life cycle). Life-stage migrations may cross the boundaries of the Region and take species considerable distances from it. An extreme example is provided by one of the freshwater eels that migrates from Victorian streams to breed in the Coral Sea.

Some species with broad distributions in the Region are known to migrate to specific spawning areas during particular seasons. Examples include blue warehou, blue grenadier and eastern gemfish.

Other fish species migrate in relation to environmental characteristics (such as water temperature). For example, fishery data in the region indicate seasonal vertical and horizontal movements of jackass morwong and upper-slope dogfish.

Along with seasonal, annual, life-cycle migrations, some species make more frequent daily migrations. Many species migrate from deep waters offshore of the continental shelf up to the surface waters to feed at night.

Some key references and further reading:
(Bruce, et al. 2002) and references therein, (Gill. 2000), (McAuley, et al. 2001), (Prince. 2001).

- Dispersal and Migration are two examples of connectivity within the marine environment that link areas and propagate impacts over large areas in unpredictable ways
- Dispersed larvae will only survive if they encounter the right conditions along the way (temperature, light, etc)
- Species migrate to take advantage of good feeding and breeding conditions, determined by ocean currents, temperatures, and presence of other species.
- We can predict regular spawning aggregations, which are the source of the larvae
- Larval dispersal is dependent on currents, storms, tides, and other oceanographic processes
- The details of dispersal are therefore unpredictable and vary each year
- Migration is an active process, largely independent of large-scale currents and is therefore more predictable once we have observed species behaviour
- Both horizontal and vertical migrations link ecosystems within the Region and connect the Region with distant ocean and coastal areas.

Ecosystem examples

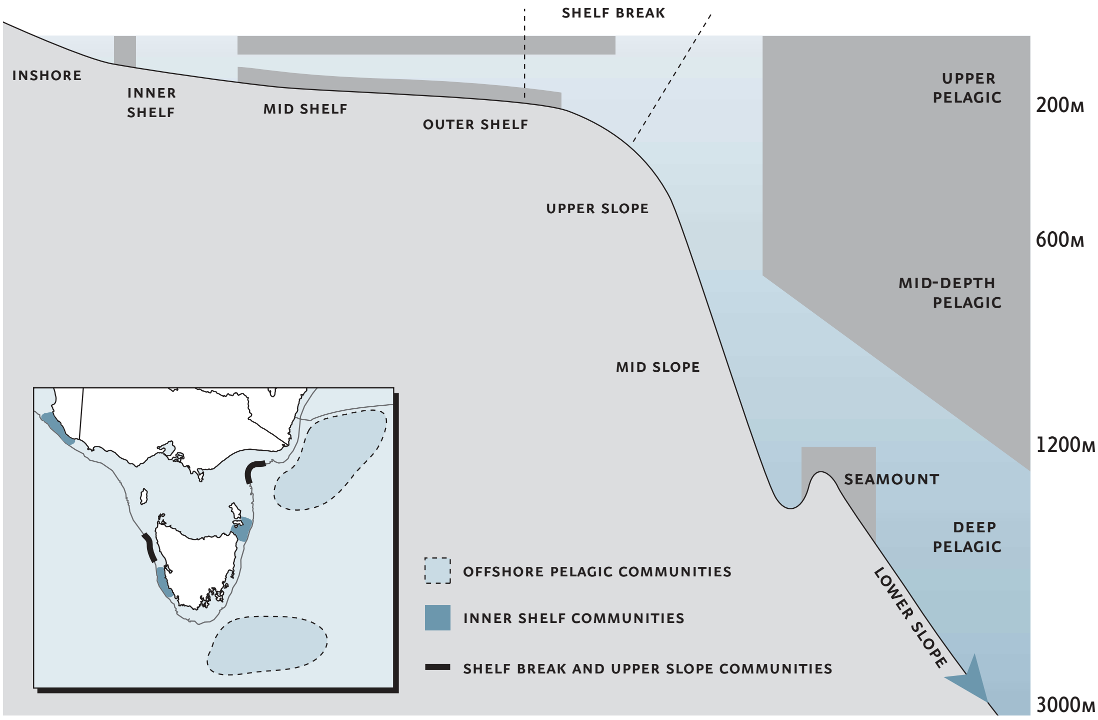
Here we briefly describe some of the ecosystems types that occur within the Region:

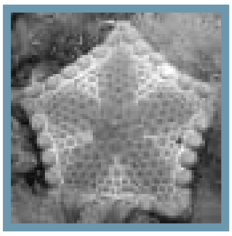
- Benthic inshore and inner shelf (between 0 and 60 m)
- Benthic mid and outer shelf (between 60 and 200 m)
- Benthic slope (200 – 3500 m)
- Pelagic – ie open ocean – over the shelf, shelf-break, and slope

Relevant terrestrial environments

These subdivisions reflect current knowledge about the structure and function of each type of ecosystem (explained on page 45 on ecosystem links and functions) and are identified in Figure 19. In addition to describing the broad ecosystem types, we present draft Conceptual Models for the following ecosystem examples: rocky reefs of the inner shelf, benthic shelf, seamounts of the mid slope, pelagic shelf, pelagic over the slope and Macquarie Island as a relevant island associated ecosystem. Where appropriate, the areas corresponding to these ecosystem types are highlighted in Figure 19. The general descriptions and the Conceptual Models draw on published research and the advice of the Ecosystem Function Working Group. These Conceptual Models will be further refined and provide a basis for future targeted modelling work in support of regional marine planning.

Figure 19: *General ecosystem subdivisions for the Region based on current understanding of ecosystem structure and function (eg division of the shelf into inner, mid and outer regions). Highlighted areas show the ecosystem types which are developed in ecosystem Conceptual Models in the following sections.*





Inshore and inner shelf ecosystems (0–60 m depth)

The inshore zone, as we define it here, encompasses all marine environments between the low tide mark and 20 m depth. It includes a variety of subtidal (permanently submerged) habitats, but does not include the zone between the low and high tide marks (the intertidal) although aspects of ecological links between intertidal seagrass beds and inshore areas are briefly considered.

The inner shelf zone continues down from 20 m to 60 m depth. It differs from the inshore area primarily in being less influenced by wave energy and tidal movements and having lower light levels in restricted wavelengths reaching the seafloor through the water column.

The fauna and flora that inhabit the inshore and inner shelf zones are the best known of marine organisms because they are the most accessible. However, our purpose is not to summarise this extensive knowledge, but to outline the main natural 'drivers' (processes with strong influence) that determine the structure and functioning of these environments and to introduce some of the processes that link inshore and offshore ecosystems. Some sources of information with more details on these environments and their inhabitants are provided at the end of the section. Alongside these natural 'drivers', the history of use and activities on marine systems has a substantial role in determining their structure and functions as we observe them today. For example, a six-year project monitoring protected and unprotected marine areas along the Tasmanian coast has revealed major differences in key indicators of ecosystem health, for example density of rock lobsters and macroalgae, pointing to a substantial influence of human activities in shaping these inshore reef systems.

In the northwest end of the Region parallel reef systems shelter seagrass beds – an example of wave energy and physical structure influencing species assemblages.

The northeast corner of the Region has a steep and narrow inner continental shelf (at its narrowest, near Montague Island, the whole shelf is only 17 km wide) and numerous estuaries, lagoons and inlets that shape the coast. Northward counter-currents to the East Australian Current generated by trapped coastal waves dominate these environments. These waters are cooler (14°–24°C) than the areas adjacent to the north and have faunal assemblages clearly distinct from their northern neighbours. This is an example of water temperature and local currents influencing species assemblages.

As a result of its unique geological origins, the marine environment of Macquarie Island consists predominantly of hard bottom types. The shallow water habitats are those typical of subantarctic islands and support extensive and luxurious growths of seaweeds – a total of 103 benthic species have been recorded, mostly red and brown algae. Large stands of the brown alga *Durvillaea antarctica* reach down to about 3 m depth along the less exposed east coast, but thrive in deeper waters – up to 15 m – along the west coast. They provide shade and shelter for numerous other species, including echinoderms and other macroinvertebrates, which inhabit the spaces among its holdfasts. Thanks to their hollow internal structure, the fronds of *D. antarctica* that become detached by the waves float across the ocean for long distances, regularly reaching the shores of Tasmania. Foliose red algae usually dominate a transition zone between the bull kelp and the deeper canopies of the giant kelp, *Macrocystis pyrifera*, the dominant species at depths between 2 and 20 m. Sponges, tunicates and hydroids inhabit darker surfaces and overhangs at these depths, while sunlit but more protected areas are dominated by the green alga *Codium subantarcticum*. Sparse areas of coarse sand and gravel can occur between boulders.

The main drivers of the inshore ecosystems

Drivers of the inshore and inner-shelf ecosystems include: wave and tidal motion, bottom type, light penetration (which depends on depth and turbidity), water temperature, salinity, terrestrial inputs/runoff and nutrient levels. All of these drivers change over short distances, especially between the shoreline and 20 m depth, resulting in strongly defined zones that support different assemblages of marine animals and plants in a variety of habitats.

In general, the Region's coastline is exposed to strong wave action; the shores of western Tasmania have the highest mean annual wave power anywhere in Australia. While the coasts of the western part of the Region receive high-energy waves all year round, albeit with seasonal patterns in intensity, the east coast is affected primarily by frequent but erratic storm events. At smaller scales, exposure to wave energy varies with local winds, currents and storms as well as the nature of the coastline. Sheltered bays, headlands and seabed features provide local protection from waves.

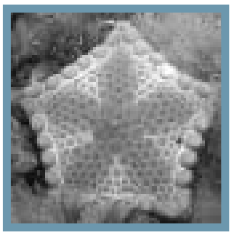
For example, the inner continental shelf of the westernmost part of the Region has parallel platform reef systems at depths of around 10 m. These systems shelter the inshore habitats, favouring the growth of seagrass beds and other communities that would otherwise be unable to withstand the extreme wave energy levels typical of this coastline.

Along with wave exposure, the amount of light that reaches the seafloor strongly influences the type of community inhabiting the seabed. Where light levels are high, marine plants such as kelp and seagrasses thrive and grow rapidly, dominating the benthic community and providing structural support for a variety of marine animals. Decreasing light levels with depth or turbidity, on the other hand, result in invertebrates becoming the dominant and structuring component of the seabed community. This is the case, for example, of the Region's sponge gardens, where large sponges of various forms and sizes shape the local seascape and provide shelter and substrate for a variety of other animals.

Light penetration in the Region is affected by small-scale patterns, such as the proximity to estuaries and water-mixing dynamics. The high tannin content in the runoff that drains to the south and west of Tasmania prevents the light from penetrating far below the surface. As a result, the communities on shallow (<10 m) reefs affected by this runoff are more typical of deep reefs elsewhere (below ~30 m). In these areas few plants grow below 5 m, allowing extensive growth of macroinvertebrates such as sponges, octocorals and ascidians, which are usually found at greater depths.

A patchwork of habitats

Another important driver of these ecosystems is bottom type. The proportion of hard to soft substrate influences species assemblages and their distribution. For example, the absence of near-shore reefs close to the mouth of the Murray and along most of eastern Victoria has influenced the distribution of inshore fish species in southern Australia.



Rocky reef habitats have been the subject of numerous studies investigating their structure, species composition and ecological processes. Well-studied rocky reef habitats in the inshore areas off New South Wales exemplify variety and zonation patterns that are typical of inshore habitats in the entire Region (although the particular species of flora and fauna would be different in other areas).

Seven types of habitats have been identified in the shallow subtidal rocky reefs of New South Wales. The fringe habitat on shallow, exposed reefs has assemblages of species including the kelp *Ecklonia* radiata and the *macroalgae Sargassum* and *Cystophora*. No one kelp species is dominant, in contrast with deeper habitats. The organisms usually found in the fringe habitat include the ascidian *Pyura stolonifera* and sea urchins, particularly *Heliocidaris* species, as well as turfing red algae. In the other rocky reef habitats, one of the species that co-habit the fringe habitat is often dominant. The *Pyura* habitat, for example, is dominated by this ascidian on the small rocky reefs. Other rocky reef habitats include *Ecklonia* forests (*Ecklonia radiata* is the most widespread kelp species in temperate Australia), *Phyllospora* forests, turf habitat, deep-reef habitat and the barren habitats.

Deep-reef habitats occur below 20 m depth and are characterised by high cover of a variety of sessile invertebrates. Both encrusting and erect, branched sponges and soft corals are common in this habitat, together with ascidians and echinoderms. All of these habitats represent the multiple influences of waves, light, bottom type, depth, and water temperature influencing species assemblages that then structure the environment for each other.

Although the soft sediments of the inshore and inner shelf, and the biota they sustain, are less well researched than the hard substrates, there is evidence that they may be high in both species richness and biomass of fishes and invertebrates. For example, the muddy and sheltered sediment flats on the western inner-shelf and the Disaster Bay area support high numbers of branching sponges and associated species.

Marine meadows

A sheltered area of soft, sandy sediments is the ideal environment for temperate seagrass species. Seagrass beds are therefore particularly common in estuaries and protected bays where some form extensive meadows. These rich and complex habitats are often made up of one or more species of seagrass. The distribution of individual species is strongly determined by the main currents in the Region. The warm Leeuwin and East Australian Currents, in the west and east respectively, allow the growth of warm-temperate *Posidonia* and *Amphibolis* species. Outside the influence of these currents, cool-temperate species of *Halophila*, *Zostera* and *Heterozostera* dominate. At a local scale, the main determinants of seagrass occurrence and distribution include tidal exposure, wave energy, salinity, turbidity and substrate stability.

Seagrass habitats are dynamic – their distribution and extent can change quickly, even between seasons. Seagrass species differ in their ability to recolonise areas after disturbances such as storms. In the Region, the extent of seagrass habitats around Tasmania has declined considerably over the past few decades. Although many areas showed little or no decline, decreases occurred throughout the State, especially near urban development or agricultural activities.

Considerable declines in seagrass cover have also been observed in South Australia (although mainly within the Great Australian Bight, which is outside the Region) and Victoria (at Western Port seagrass beds have declined by up to 70% during the 1970s, and are only now showing signs of slight recovery). These changes in seagrass growth are believed to be driven primarily by human induced increases in sedimentation and eutrophication.

Seagrass beds are highly productive habitats, supporting a broad diversity of organisms. Functionally, they are one of the main means of transferring nutrients from terrestrial systems to the marine environment. The extent to which the energy and matter produced by seagrass meadows transfers to other parts of the ocean is uncertain. Recent studies of the role of seagrass beds in sustaining fisheries in southern Australia found that most of the energy produced by seagrasses flows on to higher levels of the food chain as detritus. Epiphytes live on seagrass and are consumed by crustaceans, and so on to small fish and, finally, larger fish; only one or two fish species eat seagrass blades directly. Rafts of seagrass detritus transported offshore by storms may be a major indirect dietary source for the larvae of blue grenadier (*Macruronus novaezelandiae*) adjacent to the inshore areas of western Tasmania. Seagrasses also indirectly influence productivtity by providing nursery grounds for some fishes.

Some key references and further reading:
(Andrew. 1999), (Edgar & Barrett. 1999), (Andrew & O'neill. 2000), (Edgar & Shaw. 1995), (CSIRO. 1996), (2002) (Poiner & Peterken. 1995), (Rees. 1994), (Shepherd, et al. 1989), (Underwood, et al. 1991), (Zann. 1995), (O'Hara. 2001), (Butler & Jernakoff. 1999; Thresher, et al. 1992), (Barrett, et al. 2001), (Jordan, et al. 1998).

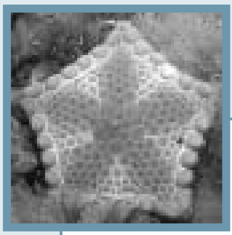
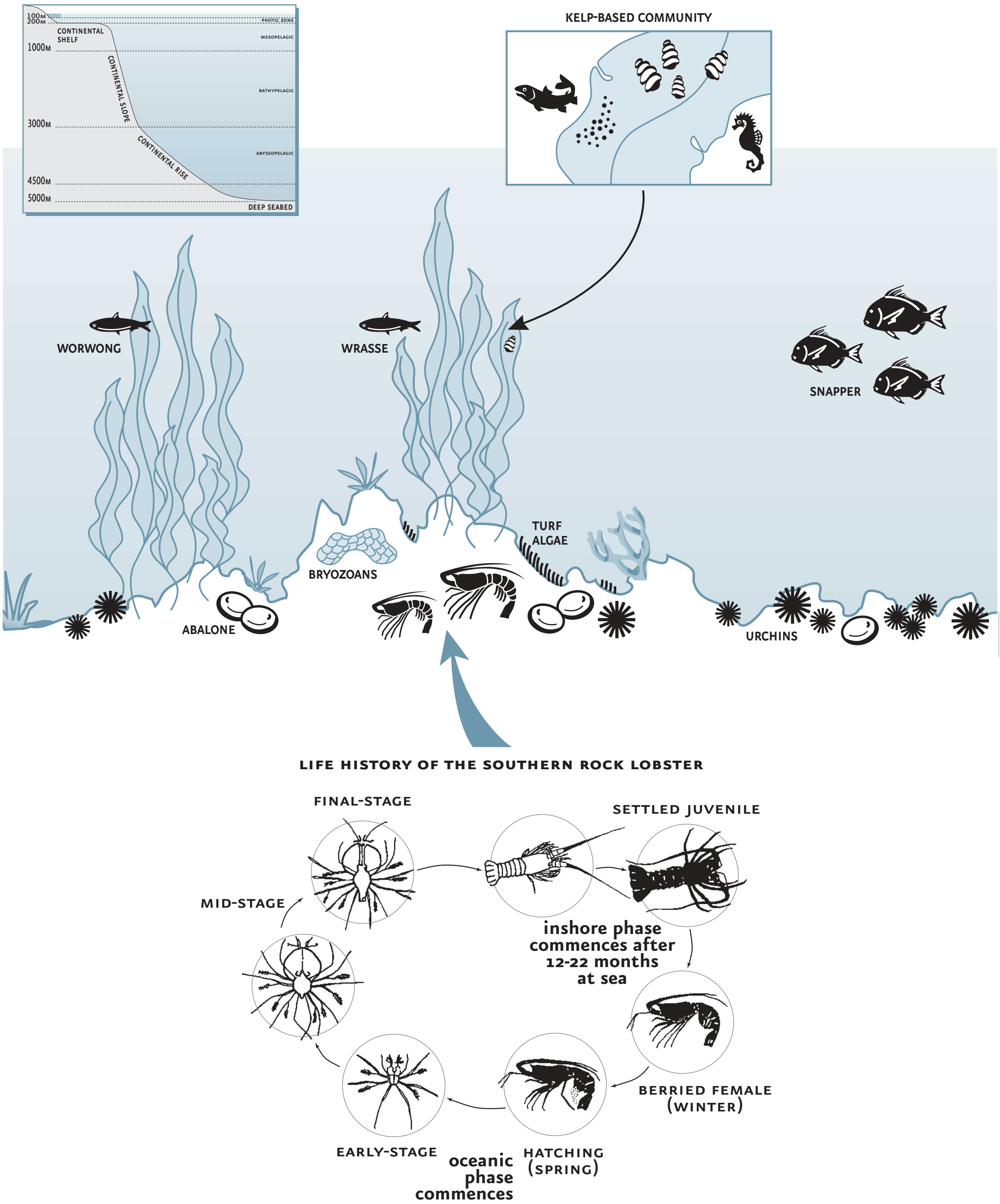


Figure 20: *DRAFT inshore rocky reef conceptual model.*



An example of an inshore ecosystem: Rocky reefs

Key ecosystem features and functions

- Macro-algae (kelps) are the main source of primary productivity and provide a variety of intricately structured habitats
- Competition for space a major drive among sessilebenthic community
- This food energy moves to other animals through direct and detritus food chains
- Wave energy, bottom type and depth, light penetration and terrestrial inputs are important drivers and influence species assemblages and the availability of nutrients for primary productivity
- Movement of flora and fauna on- and off-shore links the shallow and deeper ecosystems, eg rock lobsters

Structural complexity and rocky reef inhabitants

The structure of inshore rocky reefs is influenced by bottom type and depth, light, wave intensity, terrestrial runoff and water temperature. These factors affect which fauna and flora will live there (such as kelp) and further structure the environment. The result is a highly diverse, highly structured environment. This conceptual model illustrates two important communities that are found in the region: 'barren' habitats and bull kelp forests – the particular ecosystem functions shown in Figure 20 include: structural complexity, multiple sources of productivity, energy flows through detritivores and onshore-offshore links through life histories.

Dense bull kelp (*Durvillea potatorum*) forests are typical of the southern parts of New South Wales, which are at the north eastern end of the Region and are also found at higher latitudes, along the exposed Tasmanian coasts in particular. Together with the towering fronds and richness of species in the giant kelp forests (*Macrocystis angustifolia* and *M. pyrifera*), they give rise to some of the most spectacular and fascinating habitat types in the Region. Just as on land tree species can form different types of forests, in the ocean, kelp species that vary in size and morphology give rise to a variety of forests that differ mainly on the basis of the type and number of 'layers' formed. The large kelps that inhabit mainly the colder Tasmanian waters (eg *D. potatorum* and *M. pyrifera*), for example, are unique in the Region in that they form large areas of floating fronds in which many animals find refuge and feed. On the other hand, kelp forests where frond density allows good levels of light to reach the substrate are characterised by a rich and diverse 'understorey' of encrusting or foliose algae.

In shallow 'barren' habitats there are no kelp, but high densities of sea urchins. It appears the sea urchins, particularly *Centrostephanus rodgersii*, create these habitats by grazing at night on leafy algae, including newly settle kelp plants. Where *C. rodgersii* is not as common, 'barren' habitats may not be as widespread. However, in Tasmanian inshore waters 'barren' habitats may be formed and maintained by *Heliocidaris erythrogramma*, perhaps the most common urchin in temperate Australia.

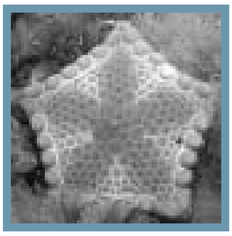
Besides kelp and urchins, many species are common inhabitants of the rocky reef in the Region, for example abalone, rock lobster, bryozoans, seahorses, snapper and larvae and juveniles of many fish and invertebrates.

Energy flows

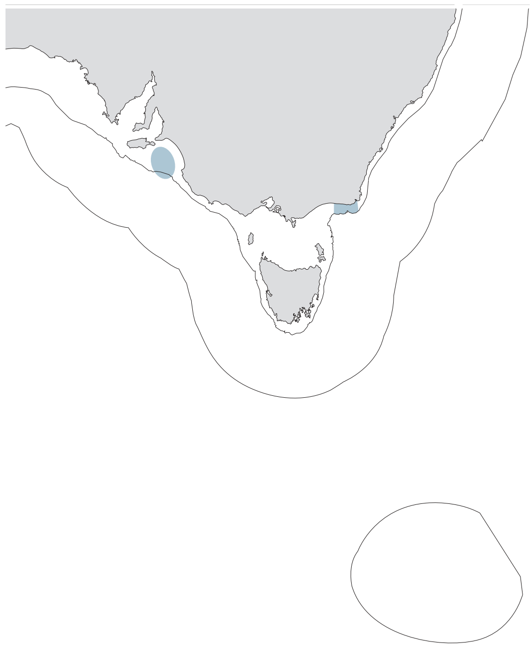
Inshore rocky reefs are areas of high primary productivity. Macro-algae are more important here than further offshore where phytoplankton predominate. Food energy from the kelp on the rocky reefs flows to other species through direct food chains and detritus chains – detritivores are a vital part of this process.
An example is black-lip abalone, which may feed on fragments of kelp, that have become detached from the fronds, as well as a range of other algae.

Linking the shallow to the deep

The southern rock lobster is an example of a species whose life history links the inshore areas with offshore. The rock lobster larvae travel vast distances on open ocean currents and return to shallow areas as they mature.



The mid and outer continental shelf ecosystems (60–200 m)



The mid and outer shelf zone spans depths between 60 m and the edge of the continental shelf. The 200 m depth contour is, by convention, used as the seaward margin of the shelf, below which the slope begins, although in the Region this varies from approximately 150 m to 220 m. The depth at which the shelf starts to rapidly descend towards the ocean floor depends on the local geomorphology and is typically shallow at conyon heads and where the shelf is narrow.

This section describes the benthic and demersal ecosystems of the shelf; pelagic ecosystems are described on page 74 in pelagic ecosystems.

The width of the continental shelf ranges from 17 km off southern New South Wales to hundreds of kilometers in Bass Strait and off the Murray mouth. The shelf includes many local geological and hydrological features, such as a variety of rocky outcrops of diverse geological origin and many canyons that descend beyond the continental slope depths, cutting into and molding the shelf break. This complex geology affects local currents, especially near the shelf-break where upwellings play a vital role in the ecosystems.

The Lacepede shelf – adjacent to the Coorong coast – is characterised by a mosaic of 1–2m high hard limestone banks, scattered across a gently undulated ground of either soft sandy bottoms or coarse gravels. Common invertebrates, more abundant on outcrops and gravelly bottoms, are sponges, octocorals, crabs and crinoids as well as holoturians, bivalves and bryozoans on soft sediments.

On the shelf off eastern Victoria, the diversity of topographical features is high and may influence the type of organisms that establish at a certain location. For example, hard substrates can be found in the form of low relief limestone and sandstone reefs in the Gabo reef complex; cemented sediments in the 'Flower Patch'; and granite bedrocks in the Point Hicks Reef.

Main drivers of the shelf ecosystems

The mid and outer shelf benthic environments are still poorly understood, in terms of both their physical and biological characteristics. Most current knowledge comes from studies of commercial fisheries. One of the better studied shelf areas is between the north-east tip of the region (roughly at the latitude of Bermagui on the New South Wales coast) and the latitude of Wilson's Promontory in Victoria. This area, part of the South-east Fishery is where the association of fish communities with seabed types and the significance of specific habitats for fishery production have been investigated.

The occurrence and abundance of biological communities on the mid- and outer continental shelf change considerably with increasing depth and depend on the type of substrate that dominates specific sites. Importantly, hydrodynamic patterns, both at large and local scales, also influence the distribution of benthic and demersal species across the Region.

Most of the continental shelf in southern Australia consists of extensive sediment flats (sands, muds and gravels) with outcrops of consolidated materials. Seafloor sediments are generally coarse and made up mainly of bryozoan, mollusc and foraminiferal skeletons, with an almost complete lack of sediments of terrestrial origin. An exception is the shelf near the Murray mouth, in the north-west of the Region, where sediments washed out of Australia's largest catchment dominate the seafloor. The type and size of sediments, the degree to which they are sorted (by size) and the extent to which they are consolidated into hard surfaces all have a strong influence on the number and type of organisms that live on these flat bottoms.

Currents structure the sediment flats of the mid- and outer-shelf, forming ripples and sorting sediment grain sizes. In rippled sediments, the troughs are usually filled by coarser grains, rubble and broken shells. The resulting patchwork of sorted and unsorted sediments and rippled and non-rippled seafloors influences species assemblages and ecosystem dynamics. For example, parts of eastern and western Bass Strait are covered in large underwater sand dunes (north of Flinders Island these average 7 m in height and 415 m in length). These dunes are mobile and when they move into a new area they completely restructure the biological communities.

Whether the seafloor is made of soft sediments or hard substrate dictates which types of organisms will be able to settle and live in an area. Some organisms require hard surfaces to which they can attach themselves. The shell of a dead mollusc can be an anchoring point, but extensive communities of hard substrate fauna can occur only where the area for attachment is large enough. In the south-east part of the South-east Fishery, about 10% of the seafloor is made up of either reefs, which offer a broad surface for attachment, or broken ground, which support individuals in smaller patches. In other parts of the Region, the proportions of hard ground, broken-ground and soft ground may vary considerably from this. For example, rocky surfaces are possibly more widespread in the western section of the Region, although the percentages of different bottom types are not well known in this area.

Sometimes species that are usually characteristic of hard substrates are found in soft sediments. This may indicate the importance of coarse or loosely consolidated sediments in supporting animal communities that require hard surfaces for anchoring themselves to the bottom. These findings highlight the difficulty in characterising habitats based on sediment characteristics identified by remote sensing.

Patches of muddy sediment flats of different sizes support large numbers of bioturbators, particularly in areas of high nutrients. Bioturbators are infauna, such as echinoderms and worms, that dig in and feed upon sediments and the organic matter on them. Their way of life results in continuous and substantial reworking of the top layer of sediments, which is important in maintaining nutrient cycling. This cycling brings nutrients from the sediment into the water column and maintain the health of the soft bottom communities. These nutrients support primary productivity in the surface layer as the water near the bottom is mixed upwards; this mixing links the benthic and pelagic shelf communities as the nutrients play a significant role in the functioning of the pelagic systems.

Epifauna (such as polychaete worms) are scarce in coarse sediment areas and flats swept by strong currents. In these flat landscapes, occasional dispersed limestone reefs or artificial substrates such as shipwrecks provide structural complexity and spatial refuges for a range of invertebrates and fish species.

This structural complexity influences the distribution of fish species and results in assemblages of fish species that are associated with particular bottom types. Each of these different fish assemblages of the continental shelf are generally rich and diverse, containing typically up to 80 species – some of these are included in the ecosystem conceptual models below and details on commercially important species are included in Appendix C (Southeast Marine Region commercial fish species). This spatial complexity in benthic communities and fish assemblages suggests that the trophic pathways and other functional links will vary at smaller scales within the shelf ecosystem.

In the eastern section of the Region extensive areas of the mid-shelf are now littered by the shells of an introduced marine species: the New Zealand screw shell. These shells tend to aggregate, together with coarse debris, in the troughs of sand ripples created by the currents to a depth of 60 m, or by other mechanisms, such as tidal flows in deeper waters and provide hard substrate for colonisation by other invertebrates This is an example of a biological process influencing both physical (eg sediment mobility) and biological processes (eg distribution of species).

Some key references and further reading:
(Bax & Williams. 2000), (Blaber & Bulman. 1987), (Bulman, et al. 2001), (Edgar. 2000), (Harris, et al. 1991), (Koslow & Gowlett-Holmes. 1998), (May & Blaber. 1989), (Williams & Bax. 2001; Williams & Koslow. 1997), (Young & Blaber. 1986).

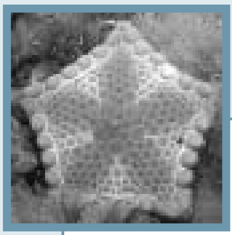
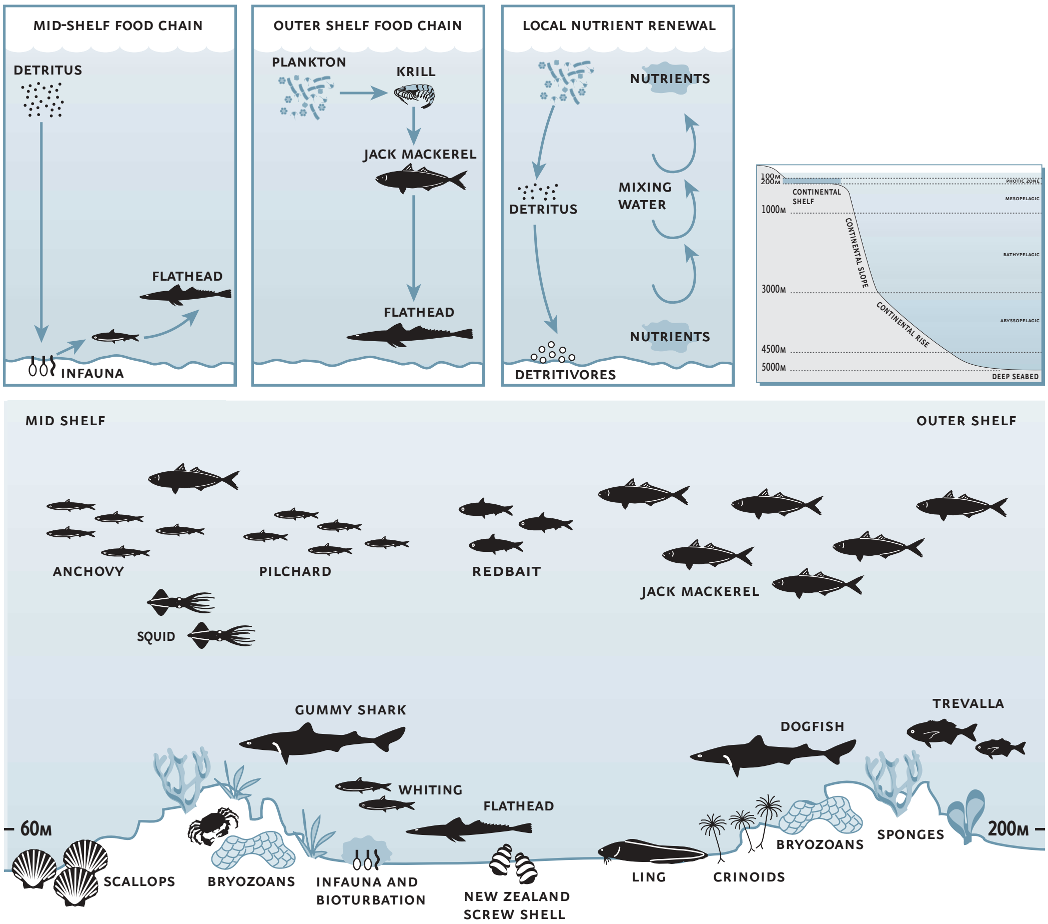


Figure 21: *DRAFT conceptual model of benthic & demersal continental shelf ecosystems.*



Key ecosystem features and functions

- Food energy from pelagic to benthic via detritus and vertical movement of demersal species.
- Local nutrient cycling through falling detritus, renewal by detritivores, and physical mixing back up to surface
- Assemblages of species depend on latitude, depth, substrate type and water currents
- Shelf communities may depend on food energy from further inshore (seagrass detritus) and further offshore (movement of species onshore from the shelf-break).

An example of a continental shelf ecosystem: soft and hard grounds

The picture of the continental shelf habitats that emerges from our preliminary knowledge is of a mosaic of habitats that provide varied seabed surfaces for a variety of animal assemblages. The structure and distribution of the geological features, besides being important for benthic communities, also influence the distribution and abundance of demersal fish species. Recent research indicates that bottom topography influences local currents, which in turn influences local feeding conditions and composition of fish assemblages. Hard grounds provide both attachment sites for benthic organisms and structural complexity that promotes the diversity of both attached and mobile fauna, and refuge for reef-associated animals.

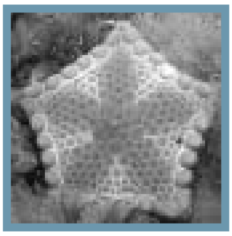
Another example of structural complexity is the formation of sponge dominated communities, which include sea whips and encrusting animals. The composition of these communities varies on the shelf depending on the local conditions, some areas have relatively simple and distinctive communities, such as those with large stalked crinoids on cemented sediments and bryozoan reefs.

Food from offshore

In addition to structural complexity, other ecosystem processes include the type and amount of primary productivity, the cycling of nutrients to support primary productivity and the flow of food to higher predators. Recent research indicates that transport of primary and secondary productivity from inshore and offshore to different parts of the shelf is important, and that links between the benthic and pelagic systems on the shelf are extensive.

A large study of demersal fish communities on the shelf off southern NSW found that many benthic or demersal species relied on pelagic prey, while others relied on benthic prey (study from 25 m – 200 m). Even within the same family, species took prey from different sources. Of 70 species, over half relied on benthic prey, while 18 of the 28 commercial or abundant species, relied on pelagic prey. This means that pelagic production undperpins a significant proportion of the productivity of the demersal fishery. Researchers suggest that benthic prey are more common food for fishes in shallower water and fishes of deeper waters further out on the shelf, are more generalist, and opportunistically feed on pelagic prey. A similar dependence on pelagic prey was found in a study on the upper mid slope off eastern Tasmania and in studies of similar regions around the world.

The relative importance for shelf communities of benthic and pelagic primary productivity is not clear and may vary with local conditions. Both detritus and direct food chains carry surface primary productivity down to the benthic communities, as illustrated in the two boxes on the top left of Figure 21. A recent study of links between primary productivity and fishery productivity in the South East Fishery found that the main source of productivity supporting the fishing grounds of the continental shelf is the oceanic plankton and micronekton brought to the shelf by physical processes including upwelling events near the shelf break. In contrast, seagrass detritus drifting offshore from the inner-shelf may be the main source of production for the food chain supporting larvae of blue grenadier, the principal mid-water predator off the western Tasmanian coast. Local primary productivity is supported by nutrients that are cycled from the seafloor sediments back into the water column by bioturbators. These nutrients are brought toward the surface by local mixing events such as internal waves and convective overturning, this full-water column local nutrient cycling is quite different from the nutrient cycling further offshore.



The continental slope ecosystems (200 – 3500+ m)

Many seamounts dot the slope in the Region, especially south of Tasmania, where there is an extensive field of about 100 seamounts. They are a unique geological feature in the region, and possibly in the whole Australian continental margins. Other more isolated seamounts include those in the South Tasman Rise, the East Tasman Plateau and the organge roughy spawning hill off St Helens, Tasmania. Some of the seamounts of south-east Tasmania are currently protected, following the declaration of an Interim Marine Protected Area in 1995.

We know little of the biological communities of the slope habitats around Macquarie Island. The continental slope drops quickly to great depths, with very steep rocks and boulders, coarse and unconsolidated debris on smoothly undulating substrate, and ridges of rocky outcrops. Recent surveys reported a quite barren seabed inhabited by benthic organisms mostly characteristic of hard substrate.

Five types of community appear to inhabit different depth zones and seafloor types. Between 200 and 500 m, the seafloor consistes of unconsolidated shell substrate and is dominated by bivalves, brachiopods and ascidians, and without sponges and octocorals. The South Macquarie Ridge to a depth of 1000m is rich in filter-feeding organisms and dominated by octocorals, while the Northern Macquarie Ridge has a low abundance of species that are rare or not found elsewhere, with the most common being a stony coral and a holoturian. The deepest sites (>1000 m) are sparsely inhabited by small sponges and some species typical of soft sediment bottoms.

From the edge of the continental shelf, at a depth of approximately 200 m, the continental slope drops to 2000 m. Below the slope, the continental rise continues down to the abyssal seafloor at 4000 – 5000 m. Until very recently, the continental slope of Australia was virtually unexplored, and we knew little about its appearance and inhabitants. Over the last few years, however, surveys across the continental slope have given us a snapshot of a surprisingly diverse environment One distinctive element of the slope environment in the Region is seamounts – a conceptual model of seamount is included in this Section.

Main drivers of the slope ecosystems

Continental slopes are dynamic environments; environmental conditions along the slope can vary considerably over short distances. Particularly along the southeastern continental margin, the slope is very narrow and the seafloor drops from 200 m to ~4500 m within a horizontal distance of 20–65 km. Water parameters and properties at the seafloor vary dramatically with depth down the slope, creating some seabed habitats that are rich in species and support large biomasses. Moreover, far from being a uniformly sloping and consistent environment, the slopes eascape is uneven, with many features such as canyons, seamounts and deep fractures influencing local hydrodynamics and supporting diverse biological communities.

Habitat identification and description on the slope will require considerable further work, but preliminary information is available from the recent survey undertaken by the CSIRO on behalf of the National Oceans Office. Seventeen sites in the Region, including sites on the continental slope, were surveyed by swath mapping, direct sediment and biological sampling and video recording.

Generally, the upper slope sediments are of biological origin and derived largely from the shelf and water column. The seafloor below 1500 m, consists mainly of chalky foraminifer shells, as observed in the deeper reaches of the Big Horseshoe Canyon and on the slope off Flinders Island. The lower slope shows evidence of sediments and detritus coming from shallower areas higher up on the slope. This may be a considerable component of the energy input to these environments as infauna (such as worms) can feed upon organic matter in the sediments and other species feed on the infauna.

In a study that investigated fish communities inhabiting the water column above a 500m deep slope bottom, abundance and composition of demersal fish species appeared to be uniform through the year, while the pelagic fish communities varied considerably both in biomass and in species composition in different seasons. Generally, the benthic fish communities were low in biomass but rich in species, while the opposite was true for the pelagic communities (which have fewer species, but many individuals). The demersal fish communities of the upper slope had a different composition from those near the shelf break area and those from the mid-slope.

In broad biogeographic terms, a distinct mid-slope demersal fish community can be defined between the Great Australian Bight and Chatham Rise (New Zealand). In terms of demersal fish communities, the mid-slope can be further subdivided in three depth strata (shallow, intermediate and deep), and some differences in species composition can be attributed also to longitudinal gradients, particularly between the east and west coasts of Tasmania. These demersal assemblages along the mid-slope of southeastern Australia are probably affected by the Antarctic Intermediate Water; a water mass restricted to this depth range (800–1200 m). Further information on these species assemblages in provided in Appendix B (Interim Bioregionalisation of deep water environments of the South-east Marine Region).

The invertebrate fauna of the slope are predominantly mud-dwelling species, but some sessile (attached to the substrate) species are found on rock outcrops. At depth, most soft bottoms are characterised by smooth sediments except in those areas that are swept by strong deep currents, where they can become rippled. The composition of benthic invertebrate communities on the slope shows some of the same depth and broad biogeographic patterns as demersal fish. Hard substrates on the slope appear dominated by sponges and, occasionally, colonial stony corals. Our knowledge of the invertebrate communities of the slope and deeper environments is very limited due to the lack of surveys using sampling gears designed for sampling invertebrates.

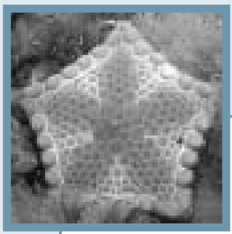
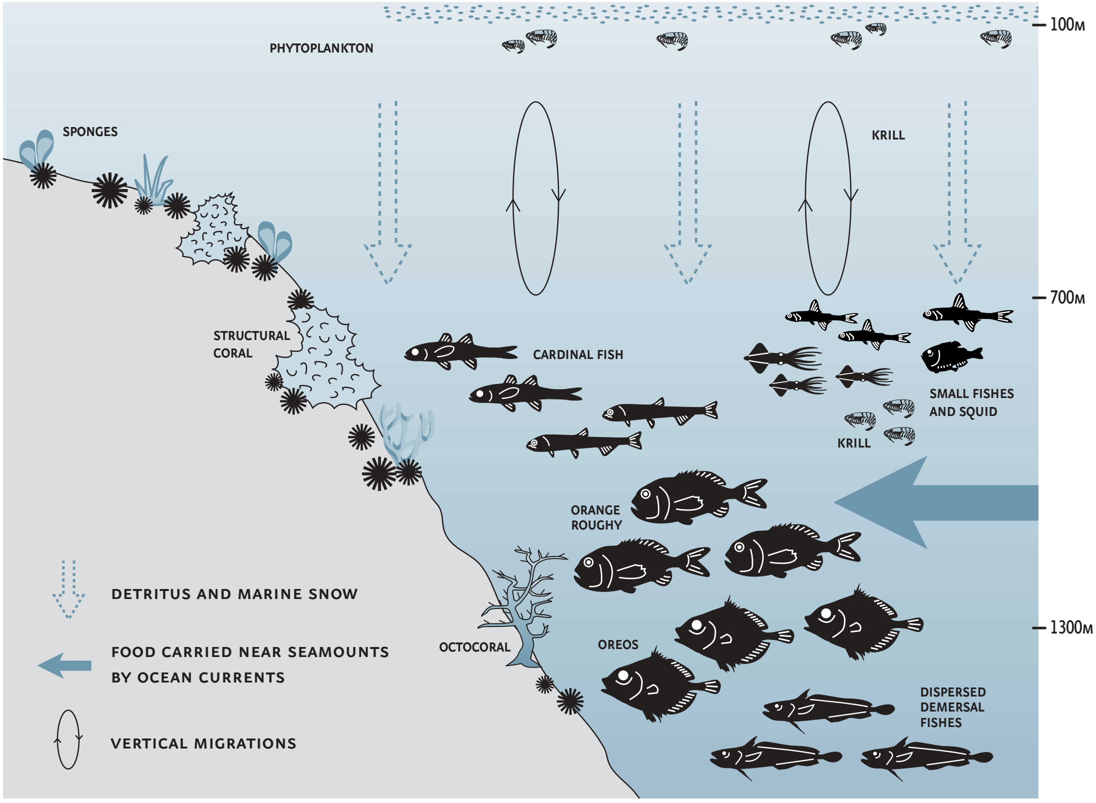


Figure 23: *DRAFT conceptual model of seamount ecosystems.*



Key ecosystem features and functions

- Food energy for active seamount-associated fish comes primarily from 'trout in the stream' dynamics – locally-intensified currents concentrate food from a larger ocean area and funnel it past the seamounts

- Detritus, marine snow, and overlapping vertical migrators transport food energy from the surface above the seamount to the deeper communities below

- Benthopelagic (bottom and near-bottom) fish communities contain 'high-energy' and sedentary species that rely on different trophic pathways to meet energy requirements

- Some species endemism, extreme longevity and late sexual maturity of fish species means these communities are highly vulnerable to disturbance and have low sustainable yields.

Example of a continental slope ecosystem: Seamounts

The seamounts off southeastern Tasmania arise from waters 1000–2000 m deep. They are between 200 and 500 m high and cone-shaped with a base diameter of several kilometres. They are home to rich assemblages of animal species, many of which are quite different from those that live on the surrounding soft-sediment bottoms. Two broad benthic community types have been identified on these seamounts: coral-dominated communities in the shallower waters to about 1300 m depth; and below, echinoid-dominated communities.

The dominant coral the colonial *Solenosmilia variabilis*, constitutes 30–90% of the biomass of fauna collected from the shallower communities. *S. variabilis* is a slow-growing and long-lived coral, which is therefore particularly vulnerable to disturbance. The matrix formed by this coral supports a variety of filter-feeding epifauna, including solitary corals, hydrocorals, octocorals, brachiopods sponges and bivalves as well as motile taxa, such as crustaceans and ophiuroids, which find refuge in the lattice-like coral skeletons.

The deeper echinoid-dominated communities are less diverse; they are primarily detritus-feeding fauna. The biomass is lower than that of coral-dominated communities, and between 25 and 95% of the biomass are sea urchins and other echinoids. Many of the benthic fish on the seamounts are either rare or likely to be undescribed. They include, among others, two species of an Antarctic family of moray cods, and several species that probably belong to the poorly known genera *Cataetyx* (Bythitidae) and *Paralaemonema* (Moridae). Other fishes are well-known because they are fished commercially, including orange roughy and oreo dory.

Multiple paths of energy flow

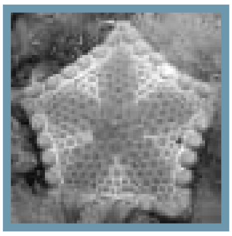
Seamounts amplify the flow of the usually slow deep-sea currents, creating unique deep-sea environments with low sedimentation rates and distinctive benthic communities dominated by filter feeders. Their food, in the form of detritus and small organisms, is transported to the seamounts by currents. Other current-borne food in the form of larger plankton and micronektonic fishes, squids and crustaceans maintain the large aggregations of oreos and orange roughy that form around seamounts. Other sources of food come from the rain of detritus falling from the productive water layers above and by the smaller mesopelagic fishes that migrate to shallow depths at night to exploit the wealth of plankton in the photic zone.

Deep ocean life histories

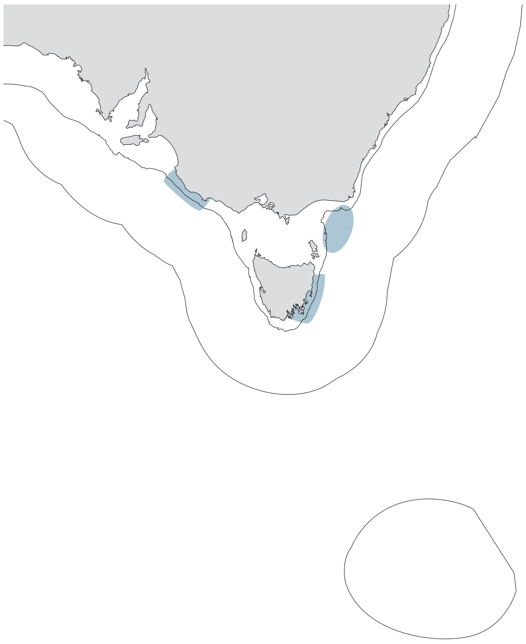
The fishes associated with seamounts have life histories that contrast strongly with many of the species despersed over the deep seabed and through the overlying water column. Many of the seabed species are rather sedentary, while bathypelagic fishes (living in the deep water column) remain suspended, often hundreds of metres off the bottom, moving only to feed or flee from predators. These fish typically have slow metabolism and tissues containing low proportions of fat and protein but high in water content (which reflects their very low energetic requirements). They are usually widely dispersed and in areas little affected by strong currents. Their body shape is often extreme, either eel-like so that they can move effortlessly, or almost spherical, to float and drift in gentle currents.

In contrast, seamount species include fishes such as orange roughy that have relatively high metabolism and denser muscle that enable them to live and catch prey in the dynamic currrents characteristic of seamounts. Fulfilling their high-energy needs, however, is done at the expense of growth (which is very slow) and reproduction efficiency. Another life history trait of seamount-aggregating fish is their extreme longevity (orange roughy and oreos may live for over a hundred years), which makes them highly vulnerable to over-fishing.

Some key references and further reading:
(Commonwealth of Australia. 2001), (Bulman, et al. 2001), (Koslow, et al. 1994), (Bruce, et al. 2002), (Koslow. 1996), (Koslow. 1997).



Pelagic ecosystems



Each summer and autumn, the Bonney Upwelling, in south-east South Australia, supplies nutrients for a local bloom of algae that attracts a variety of marine life from tiny juvenile fishes to southern bluefin tuna and blue whales, the largest marine animal alive today. Other upwellings occur locally along the coast of South Australia, south of the Murray mouth and near the Murray Canyon.

The interaction of the East Australian Current eddies with the shelf is an example of the dynamic, rich shelf-break environment. There is a very high abundance of phytoplankton, zooplankton and small fish at the western edge of warm-core eddies as they encounter the edge of the shelf off southern New South Wales. The phytoplankton at the eddy edges are mostly diatoms, which are typical of the shelf region, especially near upwellings. These local blooms of primary productivity attract secondary feeders, which in turn attract the top predators – fishery data confirm that high numbers of yellowfin tuna gather to feast at this moving table. The warm-core eddies are distinguished by a mix of shelf and offshore zooplankton, mainly copepods and pelagic decapods. Larvae of tropical benthic organisms are also associated with the eddies and may result in the temporary establishment of small populations further south than their usual distribution range.

Off eastern Tasmania, the subtropical front waters and local upwellings over the shelf result in phytoplankton blooms and masses of krill grazing on the tiny marine plants. Jack mackerel feed on the krill and southern bluefin tuna aggregate at these sites to feed on both the abundant krill and jack mackerel. These feasts are brief; before long the nutrients in the water are depleted, plankton growth slumps, and the giant southern bluefin tuna continues its long travels.

The fluid environment

Vast numbers of marine organisms gather and interact in the open ocean – in many cases never descending to the seafloor. Pelagic ecosystems support a multitude of life forms, from unicellular algae, which generate most of the primary production in the ocean, to large fish, marine mammals and seabirds. Most species move constantly through the water, some searching slowly for food, some journeying over half a kilometre up and back from the deep to the surface each night to feed, some migrating thousands of kilometres each year between breeding and feeding grounds.

The variability of pelagic communities makes them extremely difficult to study. However, research into their dynamics has increased recently, mainly prompted by the need to better define what constitutes a sustainable use of fishery resources and aided by new technologies that make the task easier. By sampling oceanographic characteristics, plankton and other species in the waters above the shelf and the slope, researchers have learned that the composition of pelagic communities changes with distance from shore, and with increasing depth.

The shelf-break, in particular, where the relatively flat shelf slopes rapidly away toward deeper waters, marks a well-defined transition between the type and characteristics of the fish species that live on and off the shelf; the three communities (shelf, shelf-break, and offshore over the slope) are noticeably different from each other. For example, the total biomass of mid-size fishes over the shelf-break east of Tasmania far exceeds the biomass over the slope or shelf. This enhanced productivity results from mixing at shelf-break fronts, the large-scale currents that run along the shelf-break, and internal waves encountering the shelf. Ecosystem Conceptual Models on Pelagic Shelf and Pelagic over the Slope ecosystems are included in this Section.

Beyond the shelf-break, fish assemblages are associated with specific depths. These layered communities are, however, linked by physical and physical processes. Near the ocean surface, where the masses of phytoplankton transform solar energy into food, high densities of small planktonic animals gather to graze on the microscopic algae, in turn feeding surface pelagic fish, seabirds and marine mammals. Below the photic zone, the pelagic species need to gather their food from less direct food chains, or by migrating to and from the surface regions. Different life styles and body shapes have evolved in response to the requirements for survival in the dark deep ocean (see seamount conceptual model on page 70).

Main drivers of the pelagic ecosystems

Species assemblages that inhabit the open ocean are strongly influenced by the water masses and currents. The distribution of cold, nutrient-rich subantarctic waters; warm, nutrient-poor tropical waters and the mixed subtropical waters effects the broad scale distribution of species. For example, the subtropical convergence, which extends eastward from south of Tasmania, shifts seasonally and from one year to the next, thus creating marked seasonal changes in temperature, nutrients and primary productivity. These may be the primary cause of large fluctuations in fish biomass and species composition observed in this part of the Region.

Embedded within these broad-scale oceanographic patterns are smaller-scale processes that create more localised and ephemeral, but highly productive, pelagic habitats. Two such processes are the dynamics of the seasonal mixed-layer and upwellings (for details on these processes in the Region, see page 51 on large-scale processes). Typically, mixed-layer dynamics support a spring and autumn phytoplankton bloom, on which the pelagic communities of the Region depend for food supplies. The numbers of zooplankters and fishes show seasonal pulses, peaking in spring and autumn as they graze these extensive floating pastures.

Upwellings in the Region support the food chains of pelagic communities at smaller scales and in a less predictable fashion than the continental-scale upwellings of eastern oceanic boundaries around the world. In temperate Australia, a number of upwellings or other nutrient-enriching events contribute to locally productive pelagic habitats. Examples include the upwellings of rich subantarctic waters east of Tasmania, the seasonal upwellings along the Bonney Coast and eastern Bass Strait, and mixing within warm-core East Australian Current eddies. Seasonal, storm-induced upwellings and the local upwellings at the leeside of headlands can also have an effect.

Some key references and further reading:
(Edyvane & Baker. 1998), (Bax & Williams. 2000), (Bulman, et al. 2001), (May & Blaber. 1989), (Griffiths & Brandt. 1983), (Jeffrey & Hallegraeff. 1980), (Parslow, et al. 1996), (Poore, et al. 1994), (Williams & Koslow. 1997), (Williams & Bax. 2001), (Williams, et al. 2001), (Young, et al. 1993), (Young, et al. 1996), (Young. 1998).

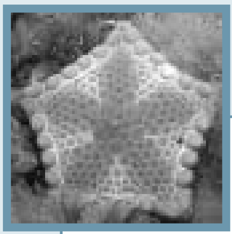
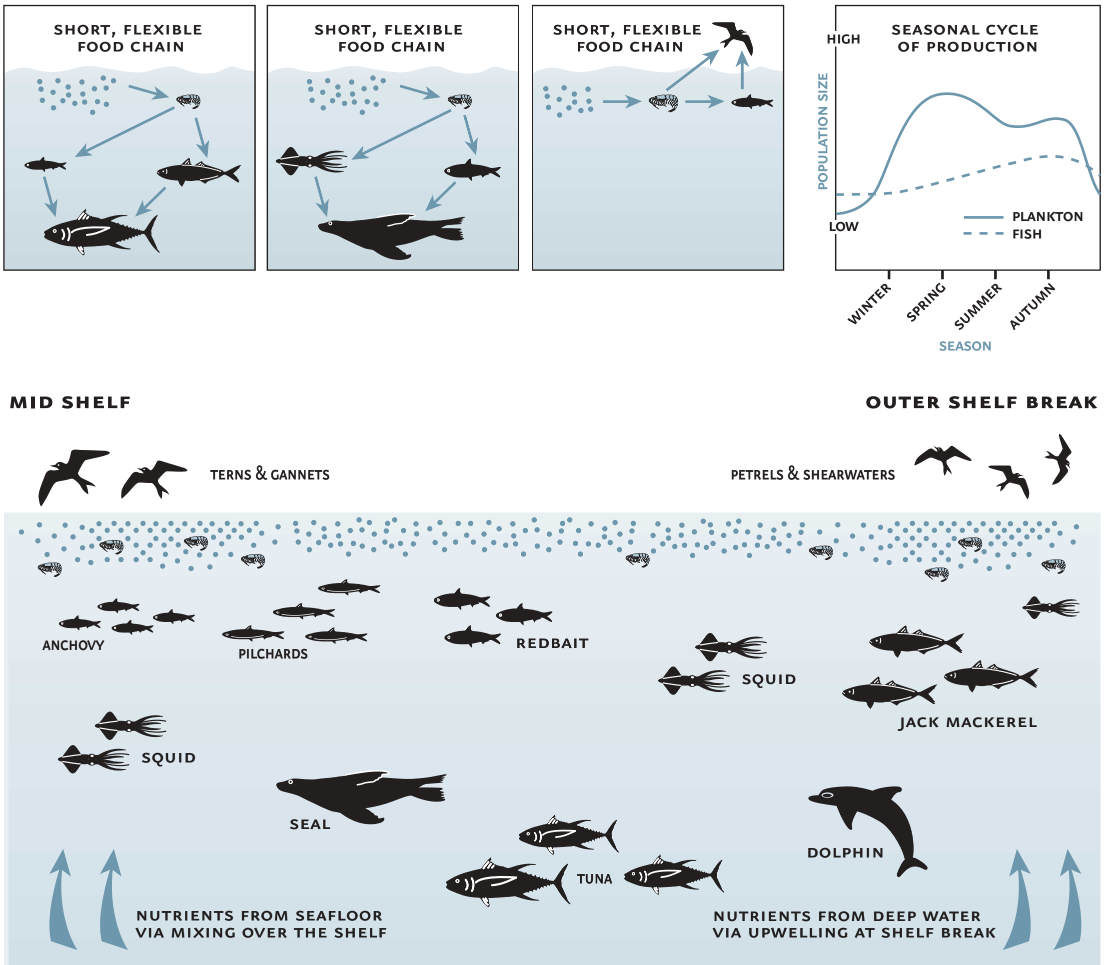
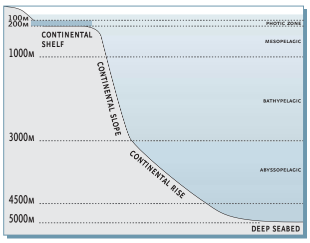


Figure 23: *DRAFT conceptual model of pelagic shelf ecosystems.*





Key ecosystem features and functions

- Many short, flexible food chains based on large, surface-layer plankton
- Nutrients from local and deep water sources
- Energy can move efficiently to higher predators through some short food chains
- Large phytoplankton and krill are important and have large seasonal fluctuations in abundance
- Biomass is spread throughout trophic levels.

An example of a pelagic ecosystem: The water column above the shelf

The waters over the shelf are influenced by the broad-scale oceanographic patterns, but of the open-ocean water masses, only the surface waters less than 200 m deep wash over the shelf. The large-scale surface currents tend to run along the edge of the shelf above the shelf break (eg the Zeehan Current) or just offshore of the shelf (eg the East Australian Current). Seasonal changes in these currents influence the habitat available for species in these ecosystems. At a smaller scale, shelf waters are influenced by evaporation and precipitation; local currents – which arise from daily tides interacting with local coastlines and bathymetry; and storms, waves and other ephemeral features including river runoff in some places. All of these processes contribute to a well-mixed water column over the continental shelf. There are however, periods in summer and autumn when offshore currents, such as the East Australian Current, flood the shelf resulting in a strongly stratified water column.

The shelf inhabitants

The phytoplankton of the continental shelf are dominated by the larger species, especially diatoms. Their populations fluctuate widely due to seasonal blooms. Large zooplankton – mainly crustaceans – feed directly on the phytoplankton as well as on algae, detritus and other zooplankton. The krill *Nyctiphanes australis* is especially prominent over the shelf in the Region. Many of the other species in these ecosystems (including fish, squid, turtles, marine mammals, and seabirds) are highly migratory. Fish species range from small fish such as pilchards and anchovies, through mid-size fish such as jack mackerel and cardinal fish, to large fish such as bluefin tuna and sharks. The most common seabirds are terns, gannets, petrels and shearwaters, and the mammals are seals, sea lions, whales and dolphins.

Energy flows

Phytoplankton provide most of the primary production for the pelagic shelf community. Other forms of primary production may contribute varying amounts throughout the Region, including seagrasses and kelps which grow inshore and float out over the deeper shelf providing a detvital food source. Nutrients come from both local mixing and offshore upwelling events. Although the relative importance of benthic and pelagic productivity for pelagic shelf communities is unknown – and is likely to vary across the Region – recent research over the north east area of the Region has indicated that pelagic shelf species depend heavily on offshore pelagic productivity.

The shelf community is distinguished by many short food chains. For example, large phytoplankton are eaten directly by large zooplankton, which are in turn eaten by large fish. This results in an efficient energy flow.

The food chains are also characterised by flexibility in diet, seasonal and interannual variability, and changes in feeding times and in food at different life stages. Many species switch between prey types, depending on what is available. For example, pilchards, jack mackerels, whales, southern bluefin tuna and terns all feed directly on the krill at times and feed on krill predators at other times. This means the shelf system is not characterised by tight or obligatory predator-prey relationships.

This web of feeding relationships appears to be controlled from the bottom up: nutrients, phytoplankton blooms and associated pulses in zooplankton control the growth of higher predators, rather than these predators limiting numbers of primary producers from above. Consequently, the repercussions of changes in primary productivity are felt throughout the food chains.

Shelf ecosystems are also characterised by many higher-level predators, including fishes such as dogfish, dories, ling, flathead, rays and large sharks, marine mammals and seabirds although there is no single most important, or keystone, predator.

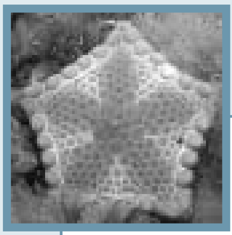
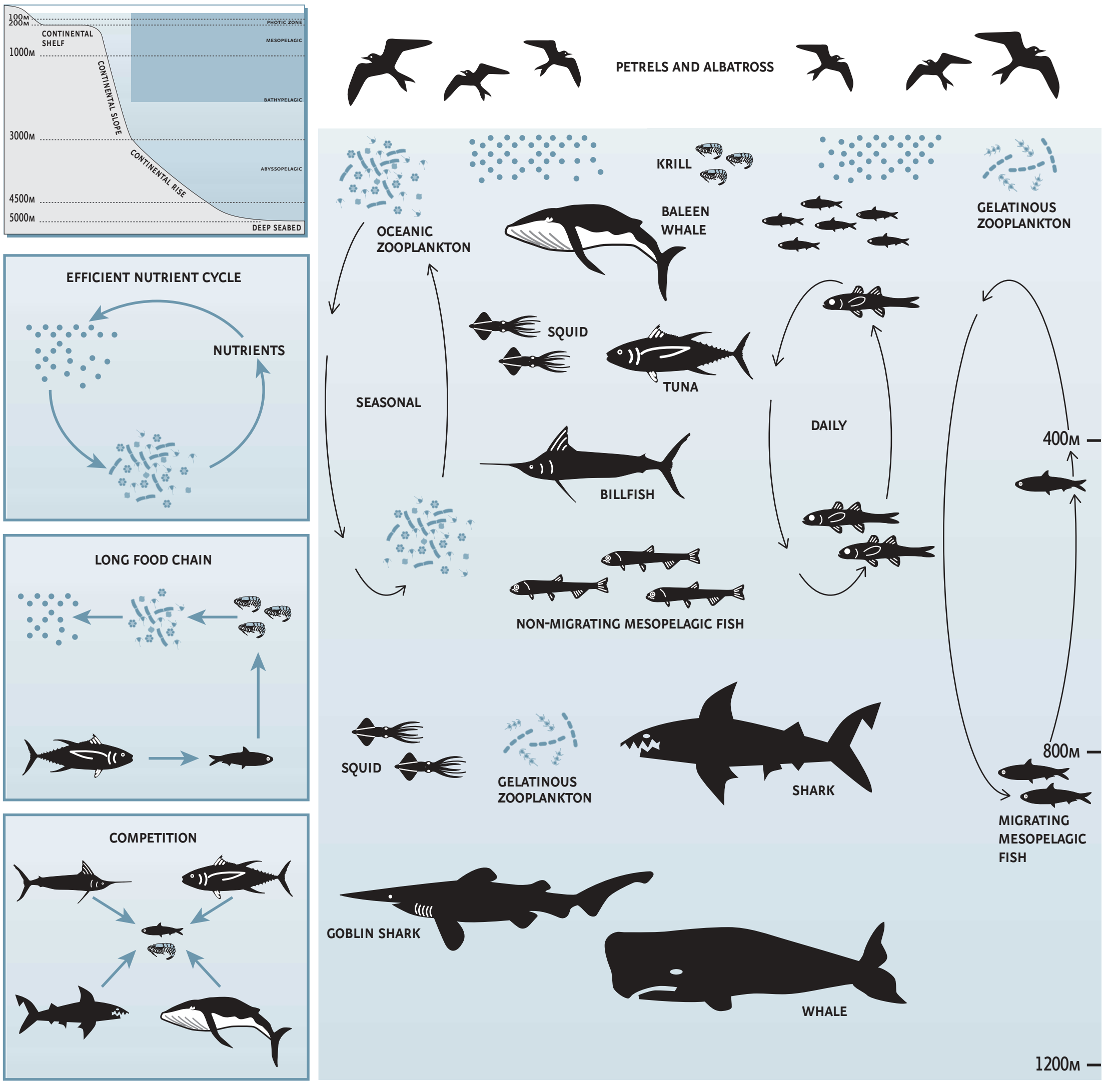


Figure 25: *DRAFT conceptual model of pelagic offshore ecosystems.*



An example of a pelagic ecosystem
The open ocean above the slope

Key ecosystem features and functions

- Long food chains based on small, surface-layer phytoplankton
- Nutrients are patchy – low in general, high in particular locations – and may be efficiently recycled in a surface plankton loop
- Energy moves inefficiently to higher predators due to many steps in food chains
- Production in surface photic zone feeds species in greater depths via falling material (detritus) and vertical migration of predators and prey
- Large proportion of biomass is in the high trophic levels – competition is high and many species migrate (horizontally) over large distances.

A fluid environment

Offshore of the shelf where the ocean rapidly deepens, oceanic water masses exert their influence most strongly. The Region's open-ocean ecosystems exist throughout these depths: surface layers dominated by East Australian Current and Leeuwin waters (<250 m); middle layers of Subantarctic Mode Water (300–600 m) and Antarctic Intermediate Waters (800–1200 m); and deep waters of various origins. Distinct fish assemblages inhabit these water masses, although many species move between water masses on large-scale horizontal migrations and daily or seasonal vertical migrations.

Patchy nutrients and patchy productivity

Large expanses of the open ocean can be considered deserts in terms of their primary productivity. Although light can penetrate to considerable depth in clear oceanic waters, nutrients are sparse and limit primary productivity, especially in the warm sub-tropical waters of the Region. Subantarctic waters refresh nutrient levels in the Region with the irregular, meandering Subtropical Front carrying nutrients north, and supporting extensive, but patchy, plankton blooms in the Region's open ocean. Offshore phytoplankton species have evolved to capitalise on these occasional enrichments – they can recycle nutrients by transforming the methane emitted by zooplankton into the nutrients they need for photosynthesis.

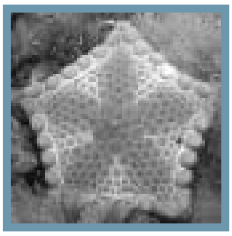
Open ocean inhabitants

Surface waters host complex communities of phyto- and zooplankton and the many species of fish, squid, mammals and seabirds that feed on them. Below the photic zone live mid-depth species, including some zooplankton, and squid, fishes and large mammals, such as the sperm whale. Some of these are vertical migrators, journeying up to shallower waters each night to feed, while others live permanently in the deeper waters.

Phytoplankton species in the open ocean pelagic ecosystems are generally smaller than those over the shelf. Zooplanktons – (krill, copepods, decapods and gelatinous zooplankton) feed on phytoplankton, zooplankton and other material. Some of the zooplankton species, such as copepods, migrate vertically on a seasonal cycle and in doing so transport food and nutrients from the surface to the deep and vica versa. Krill is a particularly important food source for larger species, and the size and distribution of krill populations of can fluctuate considerably seasonally and inter-annually. Most of the mid-size fishes and squid are different species from those found over the shelf. Many move between overlapping vertical levels to feed on zooplankton, smaller fishes and squid. Their preferred depths generally vary with the stage of life-cycle, and migratory patterns may vary seasonally and with breeding condition. Except for those caught commercially, many of the species from these ecosystems are not well understood. Myctophids (lanternfish) are the most common and diverse fish group – at least 48 species have been found in the Region. Larger species (including tuna, oceanic sharks, billfish, dolphins, and seabirds such as petrels and albatrosses) travel over the shelf and open ocean waters on large-scale feeding and breeding migrations (see page 53) . Competition for food between these species is thought to be high.

Energy Flows

The Region's open-ocean ecosystems revolve around food chains that are long relative to those over the shelf: small phytoplankton are eaten by small zooplankton, which are in turn eaten by larger zooplankton or small fish. The top predators are therefore at higher trophic levels than they are over the shelf and energy transfer is less efficient. These food chains are also flexible – species adjust their diet based on food availability, which varies with location, depth and season. Energy flows from the surface to the depths by way of vertical migrations and sinking detritus, and in and out of the Region by way of migratory predators (eg southern bluefin tuna and whales).



Coastal and island habitats of seals and seabirds

Many animals in the Region rely on both terrestrial and marine environments, so their distributions, movements and terrestrial habitat requirements are important considerations in planning human activities in the Region. Seabirds and seals play an important part in the functioning of the Region's ecosystems. Many are top predators, and most of them belong to high trophic groups. By making long migrations, sometimes crossing several oceans, these predators export and import energy and organic matter from and to the Region's ecosystems. By consuming large quantities of fish and squid, some species also interact directly and indirectly with the human uses of the Region's resources. The terrestrial habitats within the Region that serve as breeding sites play a key role in the population dynamics of many of these species.

Islands in Bass Strait and around Tasmania provide a variety of breeding and haul-out (non-breeding) habitats for three of the nine species of seals that are found in the Region. The Australian fur seal, the most common species, breeds in large colonies on rocky islands and exposed reefs in Bass Strait forming large, territorial colonies when breeding and is also commonly found along the NSW coast. The New Zealand fur seal breeds in colonies on south Tasmanian islands, particularly Maatsuyker Island and the adjacent Walker and Little islands, where the breeding animals use boulder coves and caves. They are found to occur at these islands year-round, but are most abundant between December and January. There are also colonies of New Zealand fur seals establishing in Bass Strait at Kanowna Island, the Skerries and at Lady Julia Percy Island and NZ fur seals which breed on Kangaroo Island in South Australia forage in the Region. There are haul-out colonies throughout the year, but mostly in autumn and winter on several islands and along the Tasmanian coast, mainly in the south-west.

The southern elephant seal was once common on King Island, and, fossil records show it was widely distributed around the Tasmanian shores. This species was hunted to local extinction by the early 19th century. A colony may be re-establishing on Maatsuyker Island. Non-breeding animals tend to occupy pelagic habitats for most of winter. Within the Region, the Australian sea lion is found on The Pages, east of Kangaroo Island in South Australia, this is the largest colony for the species.

Example of a coastal and island habitats of seals and seabirds: Macquarie Island

Physical influences

Strong seasonal and interannual (4–5 yr) patterns in the paths of the major fronts (Subantarctic Front, antarctic polar front) influence sea surface temperatures and productivity around the island. The bathymetry of the Macquarie Ridge has a strong effect on local oceanography, the bottom is generally steep and rocky with little 'shelf', mostly slope. The location of the island means extreme (windy, cold) weather and strong waves. The island itself is a large wind-swept plateau bounded by steep escarpments.

Inhabitants

Many seabirds and marine mammals migrate to Macquarie Island every year to breed and moult. The annual visitors include some 86,000 breeding seals and over 3 million seabirds, most of which are penguins. These migratory species join other species that are permenant residents on the island. Seals and seabirds are the dominant higher predators of the island associated ecosystem at Macquarie and feed on squid, shallow- and deep-water fishes, and crustaceans.

The island is home to six species of seals, two of which visit the island only occasionally (Hookers sea lion and the leopard seal) and one only in summer from northern latitudes (New Zealand fur seal). The most common seal on Macquarie Island is the southern elephant seal. Population size of this species on the island during the breeding season (between September and October) reaches about 85,000 (of which ~19,000 are females), or one seventh of the world's population. They breed mainly on the northern part of the island, on the most extensive beach areas, and spend their autumn and winter at sea foraging in the pack ice of the Antarctic region.

Antarctic and subantarctic fur seals are the main breeding fur seals on Macquarie Island. Non-breeding male New Zealand fur seals are know to frequent the island also. The breeding population of fur seals on Macquarie Island were eliminated by sealers by about 1830 (around 200,000 are estimated to have been harvested for oil and skins). No breeding occurred on the island until 1955 – over 130 years since the end of fur sealing. The original fur seal species composition is unknown, but the three species currently found on the island extensively hypridise.

Nutrient sources, primary productivity and energy flows

The vegetation on the island consists mostly of herbfields and moss cushions in the more exposed areas, and tussock grasslands and Macquarie Island cabbage (*Stilbocarpa polaris*) on the slopes of the scarps. Thick, deep kelp forests protect the coast from much of the wave energy and also provide habitat for many invertebrates and other marine species. When kelp fronds break off they can form detritus rafts which can act as both protection and a food source for organisms in offshore areas. There are strong seasonal and inter-annual patterns in planktonic primary productivity around the Island with a recent study finding that total consumption by toothfish, marine mammals, and select seabirds is around ten times higher in summer than in winter. Competition exists between top predators including seabirds (penguins, petrels) and mammals (seals, killer whales).

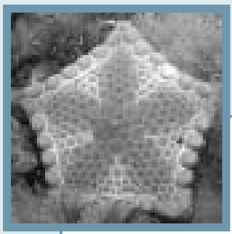
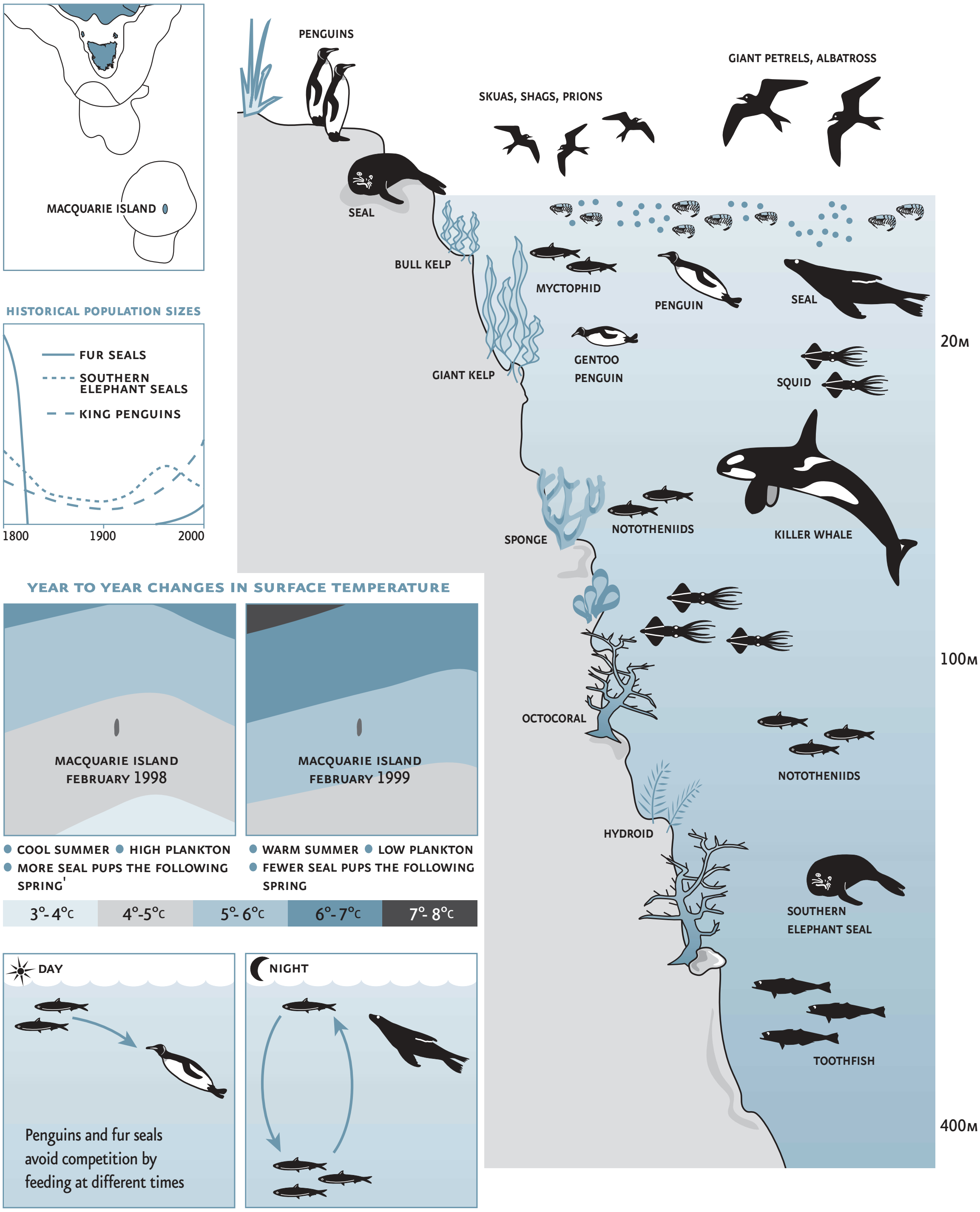


Figure 26: *DRAFT Ecosystem Conceptual Model, Macquarie Island.*



Key ecosystem features and functions

- Strong seasonal and interannual patterns in paths of the major fronts (Subantarctic Front, Antarctic polar front) influence sea surface temperatures around the island
- Bathymetry of Macquarie ridge has strong effect on local oceanography & bottom is generally steep and rocky with little 'shelf'; mostly slope
- Thick, deep kelp forests protect subtidal environemnts from much of the wave energy and provide habitat for many invertebrates and other marine species
- Food energy is imported and exported from the local area through long migrations of higher predators
- Land mass provides breeding, moulting and resting sites for marine mammals and birds, dominated by few species with large population sizes
- Strong link between variation in oceanographic conditions (Subantarctic front, Antarctic polar front) and condition and breeding success of marine mammals and seabirds.
- Several of the marine mammal and bird populations are recovering from historically low population sizes following banning of harvest.
- In this system many species live/breed in one environment and feed in another, meaning they 'link' the two and are sensitive to changes in both.

Energy flows

Krill (euphasiids), mid-depth fishes and squid are very important in the Macquarie Region food chain and food energy is imported and exported from the local area through long migrations of higher predators. In many ecosystems species eat and live in same environment, but many species in Island ecosystems such as Macquarie Island live/breed in one environment and feed in another, meaning they 'link' the two and are sensitive to changes in both.

Some key references and further reading:
(Butler, et al. 2000), (Goldsworthy, et al. 2001), (Hull, et al. 1997), (Selkirk, et al. 1990), (He & Furlani. 2001).

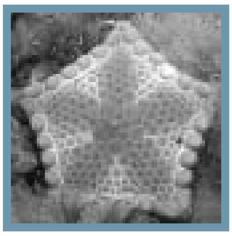
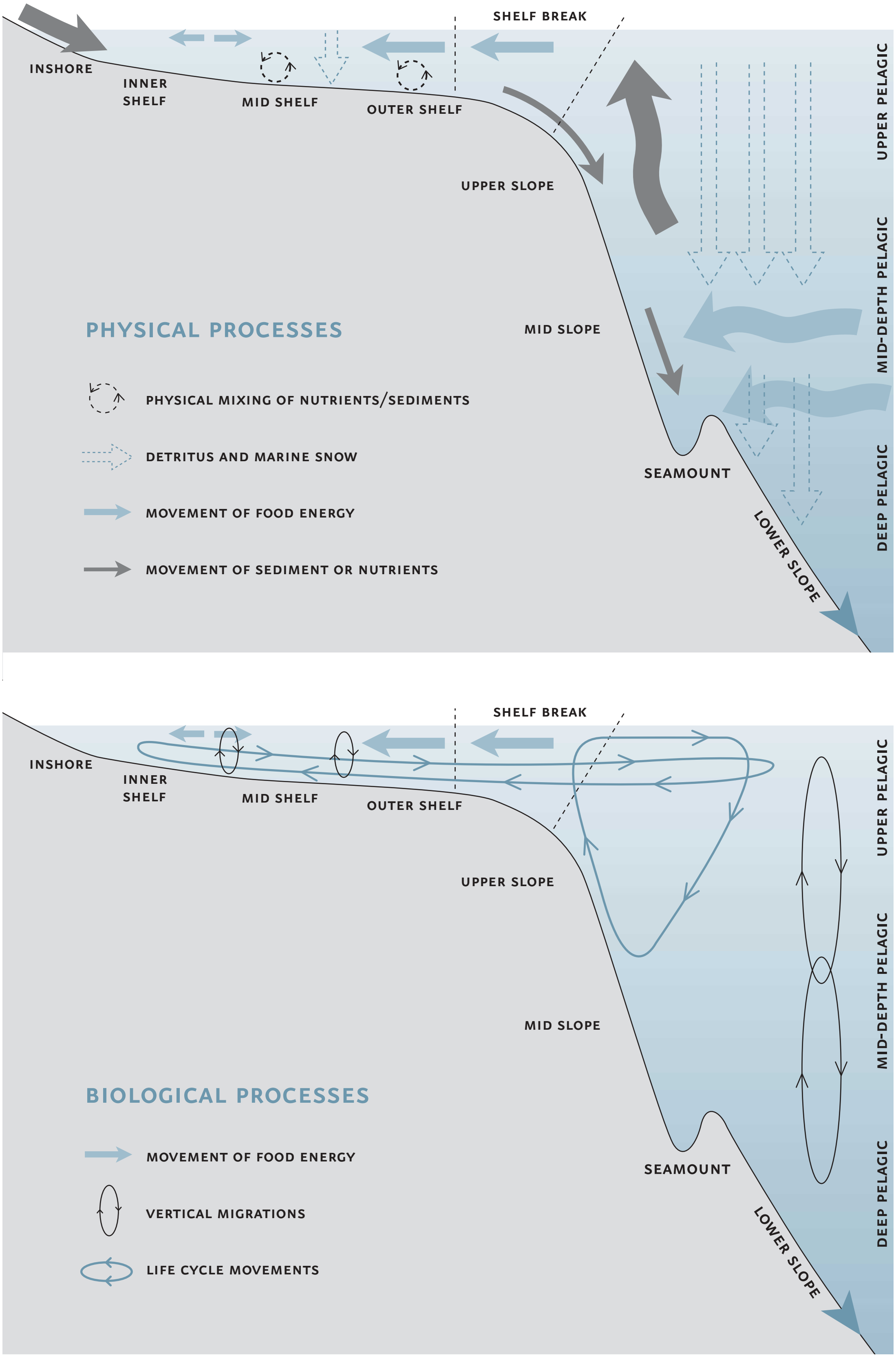


Figure 27: *Regional Links between marine ecosystem types, physical processes (top) and biological processes (bottom).*



Regional links

The conceptual ecosystem models described in the preceding sections occur throughout the Region. We have defined the ecosystems on the basis that the physical and ecological processes that drive them and determine their dynamics are more consistent within them than between them (eg terrestrial sources of input can have a significant direct effect on inshore ecosystems but are unlikely to have direct effects on an offshore pelagic ecosystem).

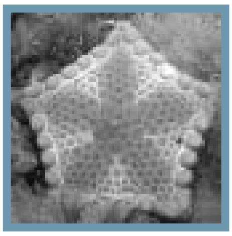
Nevertheless, these systems are obviously linked in by a variety of biological and physical processes and at a range of scales (ie with other ecosystems within the region and with others outside the region). Some of these links have been described above. Here we briefly examine the relative importance of the links among them under three broad headings: land/ocean links, seafloor/water column links and onshore/offshore links.

Land-ocean links

In near-shore environments terrestrial inputs link the land to the ocean through river runoff and human inputs. River runoff carries sediment and associated nutrients into the marine environment and also introduces fresh water to near-shore areas (the potential effects of human land-based inputs to the marine environment are described in the report *Impacts – disturbing the balance* assessment report). Inshore and inner-shelf ecosystems further link the land and ocean – seagrasses and other macro-algae transfer nutrients into edible food energy, and at least some of this productivity is carried offshore through various food chains. Another land/ocean link arises through the life histories of animals that live at sea and breed on land, including many seabirds and seals.

Seafloor-water column links

Links between the seafloor and water column are different in various parts of the Region. Shallower areas – inshore and some shelf environments – are well-mixed. Nutrients and food energy are transferred from the surface to the bottom and the ecosystems are closely linked (this is termed benthos-water column coupling). Further offshore the links between the water-column and the seafloor are less direct, although still important. Surface productivity reaches the deeper areas through direct food chains (overlapping vertical migrations of predators) and detritus (plankton and associated material falling to the deep). Nutrients from deeper waters and the seafloor reach the surface through local upwelling events. The processes linking the seafloor to the water column in deeper water occur over longer time periods than those in shallower water.



Inshore-offshore links

Large-scale structures and processes such as bathymetry and ocean currents link inshore and offshore environments, as do migrations, species movements, and import/export of food energy. These processes and movements occur on many scales and in different ways throughout the Region.

Initial studies over the continental shelf of the region suggest that food energy links are mainly offshore to onshore, rather than onshore to offshore. These links include supply of nutrients, importation of phytoplankton or zooplankton, and movement of other species onto the shelf. There are also other links between these communities, including life-cycle links such as those species whose adults live inshore, while their larvae travel vast distances offshore (eg rock lobster). Researchers are beginning to identify some general patterns within the species assemblages in the Region; for example, recent work on the shelf off New South Wales and eastern Tasmania indicates that many fish species move offshore onto the deeper parts of the shelf as they grow older. Such patterns are extremely difficult to identify in the complicated and difficult-to-observe pelagic communities The cross-shelf movement of fish as they age may also play an important role in the food webs of these communities. The prey of older individuals of some species differ from the prey of younger individuals. Food resources may be partitioned in different ecosystems between species and between age classes of a single species.

Some key references and further reading:
(Bax & Williams. 2000), (Bruce, et al. 2002), (Kloser, et al. 2001), (Young. 1998), (Jordan. 1997).

Chapter 4 Ecological basis for planning in the South-east Marine Region

Recognising the links within and between marine ecosystems and between the land and the ocean, and incorporating this knowledge into planning and management arrangements for ocean use, are central to developing ecosystem-based regional marine plans (see box).

Australia's Oceans Policy encourages a change in approach to oceans planning and management by recognising that our knowledge of the marine ecosystem is incomplete and will continue to improve, and that therefore we need to design management that is robust to uncertainties in our knowledge base and can adapt to new information.

Australia's Oceans Policy provides clear policy guidance for the development of ecosystem-based regional marine plans. In the context of maintenance of ecosystem integrity and development of ecosystem-based regional marine plans, these include:

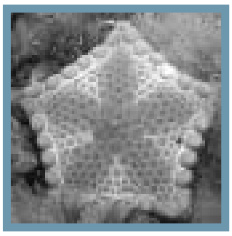
- The ecological links between the land and oceans, as well as within and between ocean ecosystems, must be taken into account in ocean planning and management.
- Maintaining natural ecosystem structure and function should be used to develop agreed objectives and indicators for ecosystems and resource uses, on the basis of the best available information on the assessment of:
    - natural levels of spatial and temporal variability and the sensitivity or resilience of the ecosystems likely to be affected by proposed uses
    - the extent and levels of change in ecosystem components or impacts on ecosystem integrity likely to arise from proposed uses and other impacts, singly or in unison
    - levels of induced change considered acceptable
    - levels of change in ecosystem characteristics considered incompatible with maintenance of ecosystem health or recovery within a reasonable period
    - gaps or uncertainty in information on resources, uses or ecosystem processes, and the capacity to monitor, detect and assess change in indicators of ecosystem health.

(Oceans Policy, Vol 1. P37)

Applying our understanding

The Biological and Physical Assessment has provided the ecological foundations for developing ecosystem-based planning and management arrangements for the Region:

- the Interim Bioregionalisation – the first step in developing planning, management and monitoring arrangements based on our current knowledge of the ecological structure of the Region
- the Conceptual Models – an overview of our current understanding of the key processes that drive the dynamics of the different ecosystem types in the Region and what that tells us about their potential vulnerability to different human activities.
- the synthesis of our current knowledge – describes the diversity of plants and animals that comprise the ecosystems of the Region, how they differ in different parts of the Region, and the current status of species of conservation or resource significance.



Each of these components develops our understanding of the ecosystems of the Region.

The Interim Bioregionalisation serves multiple purposes in the regional marine planning process. It will be used to:

- provide a nested spatial framework (or operational planning and management boundaries) for identifying management options for the Region that reflect the ecosystem's characteristics
- select the appropriate spatial scale on which to base further analysis of information from the assessments for the Region so that they relate logically to ecosystem characteristics
- provide a spatial framework for setting management targets and assessing the state of the ecosystem as part of the performance assessment.

Together, the Interim Marine and Coastal Regionalisation for Australia (IMCRA) and the Interim Bioregionalisation cover the entire South-east Marine Region, from the coast to the Exclusive Economic Zone boundary. The way that these two regionalisations complement each other and can be applied in regional marine planning will need to be considered when we are developing management options. IMCRA currently provides the national and regional planning framework for developing the National Representative System of Marine Protected Areas, and it is likely that the planning units based on the Interim Bioregionalisation will have similar application for the deeper waters of the Region. However, additional work may be required to understand how the bioregions are linked and depend on each other, and to refine knowledge of the region's habitats (Levels 4–7 in the spatial heirarchy) to further assist the process of identifying and selecting potential marine protected areas.

The Interim Bioregionalisation, however, does not provide the complete picture. Our knowledge of the structure of the ecosystem must be combined with our knowledge of its dynamics. This will help us to understand how the different areas in the Region are linked to, and depend on each other.

This understanding will be critical for decisions on how to maintain the health of the marine ecosystem, from identifying areas that may be suitable for Marine Protected Areas to suggesting how a resource use should be managed in the absence of understanding of potential impacts.

The ecosystem Conceptual Models provide a basis for building an understanding of the ecosystem function of the Region. The models:

- identify key internal processes and ecosystem attributes of each type of ecosystem that can be used to develop ecosystem objectives and indicators
- identify likely functional links between ecosystems in the Region
- Identify some of the likely functional links between the land and the ocean in the Region
- define objectives and indicators for the ecosystems of the Region.
- provide a foundation for formal ecosystem modelling as dictated by planning issues and development of educational material

In the next phase of the planning process the ecosystem Conceptual Models will be used to:

- analyse the range of potential impacts and evaluate the risks posed to the ecosystems of the Region (in conjunction with the Interim Bioregionalisation and the outcomes of the Impacts on the Natural System and Uses assessments)
- develop issue-specific models to assist in the assessment and evaluation of planning options (where appropriate – ie for priority planning issues – and possible – ie sufficient information and understanding
- identify how the impacts of human use are likely to propagate through the different ecosystems in the Region
- identify key uncertainties in our understanding of the function of ecosystems that are likely to affect the effectiveness of management of use in the Region

Defining planning and management boundaries

The next steps in developing an ecosystem-based regional marine plan are to define planning and management boundaries and develop objectives and indicators for ecosystems, to be used in performance assessment and management feedback.

Ecosystem-based management requires a move away from boundaries based on jurisdictions and sectoral patterns of use to planning based on the characteristics of the ecosystem. Defining operational planning and management boundaries for regional marine planning based on ecosystem characteristics will be a significant step towards ecosystem-based management.

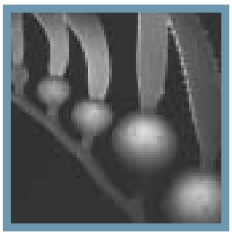
While the information obtained from this assessment will inform each of these steps, they need to be developed in conjunction with information from the other assessment streams and with the direct participation of all stakeholders.

The Interim Bioregionalisation does not translate directly into operational planning and management boundaries, but is a fundamental input to designing planning, management and monitoring for the South-east Regional Marine Plan.

Other information including current use patterns and existing management and institutional arrangements, will be used in defining appropriate (and possibly hierarchical/nested) planning units.

There are a number of considerations in developing operational planning and management boundaries. One of the ways to achieve adaptive management in regional marine planning will be to maintain the Interim Bioregionalisation as separate from the planning units. The plan will incorporate a feedback mechanism that is triggered when new knowledge has management implications, so that the plan can be adapted to improved knowledge about the marine ecosystems (eg by changing the planning units). The feedback mechanism will be a set of decision rules that relate a growing information base to management of the Region. This approach would allow for continuous improvements in the Interim Bioregionalisation without requiring a major shift in management (unless determined by the feedback mechanism).

As well as designing units that allow for adaptive management, we also want to design units that are robust to the fact that ecosystem boundaries are rarely (if ever) hard, but are more accurately described by gradients between core areas with similar characteristics. The application of these in the Regional Marine Plan will help us to develop management strategies that reflect the complex and connected nature of the marine ecosystem.



Developing objectives and indicators for ecosystems

Objectives and indicators for ecosystems are key ingredients in developing ecosystem-based regional marine plans. The Conceptual Models provide a foundation for developing objectives and indicators for the ecosystems of the Region. There are two distinct components to developing these ecosystem objectives:

• developing objectives for regional marine planning

• developing operational objectives and indicators.

The first requires stakeholders to articulate their desired objectives for the ecosystems from managing human activities in the Region. Regional marine planning objectives should be a concise statement of what we are aiming to achieve through the regional marine plan and they should relate logically to the higher goals of *Australia's Ocean Policy*. As these objectives depend on what people collectively value about the ecosystems and resources they provide, we need to provide an opportunity for all stakeholders to participate in this process to ensure the shared values are translated into objectives for the plan in a clear and transparent manner.

In considering the regional marine planning objectives, it will be important to recognise the current state of the ecosystems relative to their unused state and agree on concrete definitions of terms such as 'rebuild', 'maintain', 'natural' and 'sustainable'. These definitions provide a bridge between those things that we collectively value about the ecosystem of the Region and tangible characteristics or attributes of the ecosystem that can be measured.

The second step involves taking the desired regional marine planning objectives and developing operational objectives for the relevant components of the ecosystem and indicators that can be used to measure them. An operational objective is an objective that has a direct and practical interpretation in the context of management and against which performance can be evaluated quantitatively. Operational objectives should articulate the relationship between specific system attributes (eg Population size of siginificant species) and the relevant higher level regional marine planning objective. This articulation should include a statement of:

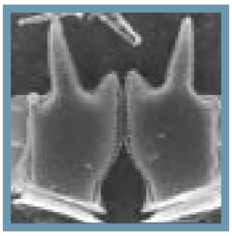
• the indicator for the objective

• the reference point for the objective

• the acceptable level of risk that the objective is not met

• the time interval of the assessment period.

While defining the ecosystem objectives and reference points is largely a technical task, it will be essential that the relationship between each desired RMP objective and the relevant operational objective be clearly communicated to stakeholders. It will be equally important to acknowledge that the first cut of these operational objectives for ecosystems will be 'best guesses' and that this is an essential first step in an iterative process of building our knowledge and more effective management.



Appendix A: IMCRA Meso-scale Bioregions in the South-east Marine Region

The following descriptions of the Australian Marine and Coastal Regionalisation of Australia (IMCRA) bioregions within the South-east Marine Region are reproduced verbatim from IMCRA version 3.3, CoA, 1998.

Twofold Shelf (TWO)

Climate

Moist cool temperate with warm summers and a tendency towards winter-spring rainfall.

Oceanography

Water temperatures reflect the influence of warmer waters brought into Bass Strait by the East Australian Current, with the southern section of the Twofold Shelf being considerably warmer in summer than other more southerly Tasmanian regions. Along the New South Wales section coastal oceanographic circulation is influenced mainly by northwards settling coastally trapped waves generated in Tasman Sea waters, although inshore a northerly flowing tongue of Bass Strait water is generally present. The median density of the seawater in this area in 26.43, with a quartilic range of 0.09. Intermittent upwellings occur along parts of the east Gippsland coast. Wave energy is relatively low, particularly in the broader shelf area in the Gippsland Basin. Stalled low pressure systems in the Tasman Sea during summer create higher wane energy at this time. The wave climate in the New South Wales section is characterised by a range of typical breaker heights between 1.0 and 2.0 m, and a low relative frequency of peak wave energy fluctuations, with a peak of wave energy occurring in February.

Geology and geomorphology

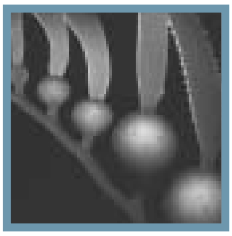
The New South Wales and northern Victorian sections are bordered by the Lachlan Fold Belt and the Victorian coastline is dominated by Quaternary dunes and dune sediments and associated sandy shorelines (mainly Ninety Mile Beach). The continental shelf is relatively narrow in the northern section, becoming much broader (and shallower) in the southern area of the Gippsland Basin. Changes in shelf width are associated with marked changes in coastline orientation, from east facing in the north to south-south-east facing in the south. Orientation in the Victorian section varies from south-east to Lakes Entrance, south to Rame Head and then south-east to the New South Wales border. North of this, the coastline faces general east southeast. The continental shelf shows a very steep inshore profile, with a less steep inner (20–60 m) to mid (60–120 m) shelf profile, and a generally flatter outer shelf plain (120–160 m) south west of Cape Howe. Seaward the sediments are poorly sorted, with a median of 92% sand and 8% gravel; they are composed of organic material, with a median of 64.5% calcium carbonate.

Biota

The fauna is characterised by distinctive species assemblages of reef fish, echinoderms, gastropods and bivalves. Reefs are generally dominated by warm temperate species that occur commonly in southern New South Wales; particularly the large urchin *Centrostephanus rodgersii*, which removes macroalgae from shallow reefs, creating a coralline algal encrusted habitat.

Estuaries

The larger estuaries in this region occur in the south, including the Gippsland Lakes, Sydenham Inlet and Mallacoota Inlet. (See also VES – Victorian Embayments).



Freycinet Bioregion (FRT)

Climate

Cool temperate, meso thermal climate with cool wet winters and warm summers.

Oceanography

Mean water temperature 17°C in summer, 12°C in winter. Experiences significantly elevated temperatures on occasions when warm core eddies produced by the East Australian Current move inshore. Submaximal wave exposure. Moderate (1.5 m) tidal range.

Geology and geomorphology

Predominantly granite coastline, which is interrupted by classic sedimentary sequences. Coastal embayments present in Mercury Passage and Oyster Bay. Narrow continental shelf.

Biota

Fish species richness moderate compared with other Tasmanian regions, plant species richness moderately high. A number of warm temperate species common in New South Wales but rare in Bass Strait recruit in variable numbers each year, including the fish *Parma microlepis*, the sea urchin *Centrostephanus rodgersii*, the crustaceans *Austromegabalanus nigrescens* and *Penaeus plebejus*.

Estuaries

Nineteen moderate size barrier estuaries and drowned river valets. Numerous coastal lagoons including six of moderate size.

Flinders Bioregion (FLI)

Climate

Cool temperate, meso thermal climate with cool wet winters and warm summers.

Oceanography

Mean sea-surface temperature varies from 20°C in summer to 13°C in winter. Submaximal wave exposure which is highly variable especially on Wilsons Promontory with wave energy of 18 4 kW/m on the western side to 4 kW/m on the eastern side where it is protected from the dominant southwest swell direction. Tidal characteristics (velocities and amplitudes) vary markedly across the region as determined by the geometry of the eastern entrance to Bass Strait. Tidal range varies from 2–3 m with the greatest range occurring between the islands in the southern part of the region.

Geology and geomorphology

Predominantly granite (Wilsons Promontory, Flinders and other islands) and unconsolidated clastic sediments. Rocky headlands and promontories are prevalent with long sandy beaches between. Located on the continental shelf on the eastern entrance to Bass Strait. Low offshore slopes and extensive offshore reef systems often present in the south but shores plunge steeply onto sandy sea floor to the north around Wilsons Promontory.

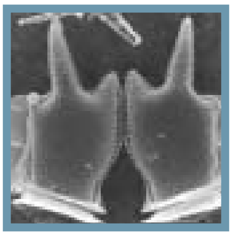
Biota

Fish and plant species richness both high, when compared with Tasmanian regions. The biota is typical of the Bassian Province, with warm-temperate species commonly found in New South Wales also present in low numbers.

Estuaries

Most estuaries are in the Furneaux Group, which has nine moderate-size estuaries and numerous coastal lagoons. Shallow Inlet, the only major lagoon west of Wilsons Promontory, lies at the northern end of the region.

(See also VES – Victorian Embayments).



Bruny Bioregion (BRU)

Climate

Cool temperate, meso thermal climate with cool wet winters and mild summers.

Oceanography

Mean water temperature 17°C in summer, 10°C in winter, with larger annual temperature ranges in sheltered embayments. Submaximal wave exposure. Microtidal (1 m range).

Geology and geomorphology

Predominantly dolerite and sandstone strata. Dissected coastline with large embayments protected by peninsulas. Embayments generally shallow (<25 m) with flat seabeds; exposed shores drop quickly into deep water because of extremely narrow continental shelf.

Biota

Fish species richness low compared with other Tasmanian regions, plant species richness extremely high. Contains an unusually large component of endemic species, including fishes *Forsterygion gymnotum*, *Brachionichthys hirsutus* and *Brachionichthys politus*, the sea stars *Patiriella vivipara* and *Smilasterias tasmaniae*, and the algae *Aeodes nitidissima* and *Cirrulicarpus polycoelioides*.

Estuaries

One large drowned river valley (Derwent) and 20 moderate size barrier estuaries and four large coastal lagoons.

Davey Bioregion (DAV)

Climate

Cool temperate, meso thermal climate with cold winters and very high rainfall.

Oceanography

Mean water temperature 17°C in summer, 11°C in winter. Maximal wave exposure. Microtidal (1m range).

Geology and geomorphology

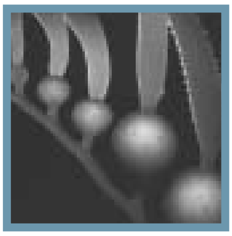
Quartzitic coastline with numerous rocky headlands separated by sandy beaches. Narrow continental shelf.

Biota

Fish species richness low, plant species richness moderately high. Contains the most extensive stands of giant kelp (*Macrocystis pyrifera*) remaining in Australia, and is the only location where the striped trumpeter (*Latris lineata*) is regularly recorded. A number of endemic species, including new species of fish, molluscs and cnidarians, appear restricted to the Port Davey embayment within the region.

Estuaries

One large drowned river valley (Bathurst Harbour) and five moderate size barrier estuaries grading into drowned river valleys.



Franklin Bioregion (FRA)

Climate

Cold temperate, meso thermal climate with cold winters, cool summers and extremely high rainfall.

Oceanography

Mean water temperature 17°C in summer, 12°C in winter. Maximal wave exposure. Microtidal (1 m range).

Geology and geomorphology

Diverse geological coastal strata with turbidities predominating in south and sandstones/mudstones and granites in northern section. Rocky headlands separated by very long sandy beaches. Narrow continental shelf.

Biota

Fish diversity extremely low, algal diversity moderately low. Differs from other regions primarily by low species richness. No plants or animals recognised to be characteristic.

Estuaries

One large drowned river valley (Macquarie Harbour) and 15 moderate size drowned river valleys grading into barrier estuaries.

Boags Bioregion (BGS)

Climate

Cold temperate, meso thermal climate with cool wet winters and warm summers.

Oceanography

Mean water temperature 19°C in summer, 12°C in winter. Moderate wave exposure. High tidal range (3 m range) and strong tidal currents at eastern and western extremities.

Geology and geomorphology

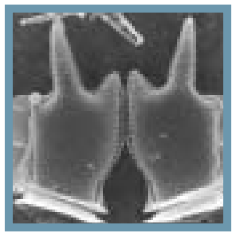
Highly diverse geological strata, including granite and dolerite in east, basalt and quartzwacke in central region and sandstone and quartzite in west. Gradual offshore bathymetric slope into central Bass Strait.

Biota

Fish diversity high compared with other Tasmanian regions, algal diversity moderately. Differs substantially from other Tasmanian coastal waters by possessing large beds of the seagrasses *Posidonia australis* and *Amphibolis antarctica*, and a number of dominant species on reefs that are rare or absent further south, including the macroalgae *Cystophora monilifera* and *Sargassum varians*, the sea star *Plectaster decanus*, and the fishes *Parma victoriae*, *Meuschenia hippocrepis* and *Meuschenia flavolineata*.

Estuaries

One large drowned river valley (Tamar) and 21 moderate size barrier estuaries grading into drowned river valleys.



Central Bass Strait Bioregion (CBS)

Climate

Not applicable.

Oceanography

Tidal velocities vary from <0.05 ms^{-1} in the central area to as high as 0.5 ms^{-1} at the margins where the islands and promontories form the western and eastern entrances to Bass Strait. Water mass characteristics are complex and vary seasonally representing the mixing of the different water masses present on the western and eastern sides of the Strait. Mean water temperature 19°C in summer, 13°C in winter. Submaximal wave exposure.

Geology and geomorphology

Large marine basin contained within the continental shelf, with water depth varying from about 80 m at its centre to 50 m around the margins. Soft sediment substratum consisting of silts and muds.

Biota

Diverse infaunal biota, consisting predominantly of crustaceans, polychaetes and molluscs.

Estuaries

Nil.

Central Victoria Bioregion (CVA)

Climate

Moist temperate with warm summers.

Oceanography

Amplitudes and phases increase eastwards. Semi-diurnal constituents dominate over diurnal constituents. Generally eastwardly decreasing velocity for the M2 semi-diurnal constituent. Other semi-diurnal and diurnal velocities fluctuating but slowly increasing eastward. Mean annual sea-surface temperature is approximately 15.5°C representative of Bass Strait waters. Moderate wave energy (9–18 kW/m) can be divided into Cape Otway to Point Lonsdale (9 kW/m) which faces south-east and is protected from the dominant swell direction; and Point Lonsdale to Wilsons Promontory (18 kW/m), which faces south-west and receives some of the south-westerly swell.

Geology and geomorphology

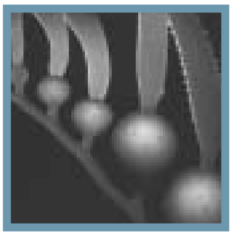
Dominated by cliffed shorelines in Quarternary, Tertiary and Mesozoic sediments. Contains the western-most occurrence of granites and granodiorites. Orientation changes from facing south-east (Cape Otway to Point Lonsdale) to generally south-west facing (Point Lonsdale to Wilsons Promontory). Pronounced variations in orientation (over 90) in the Venus Bay area. Very steep offshore gradients to the 20 m contour (1:50) and steep to the 50 m contour (1:100). Minor flattening out between the 20 and 50 m contours in the region offshore from approximately Port Philip Heads to Cape Paterson.

Biota

Marine fauna and flora are typically cool temperate. Sheltered rock platforms are covered in a mixed algal assemblage including various green (eg *Codium*, *Caulerpa*), brown (eg *Cystophora*, *Sargassum*) and red algae. This assemblage continues into the shallow subtidal (5–20 m) on south-east facing coasts such as off Point Lonsdale and the Bunurong. The more exposed coasts are fringed with *Durvillaea* with mixed *Phyllospora* and *Ecklonia* stands occurring on subtidal reefs. Small beds of *Amphibolis antarctica* seagrass occur on sand in sheltered locations. Many western species have their eastern distribution limit within central Victoria particularly between the Bunurong and Wilsons Promontory.

Estuaries

See VES – Victorian Embayments.



Victorian Embayments (VES)

Climate

Moist temperate with warm summers, pronounced west to east variation in catchment run off and seasonality.

Oceanography

Because of their small size fetch is limited with the greatest 60 km in Port Phillip Bay. The are large changes in tidal phase and amplitude within them compared with the open coast, with a maximum amplitude of 3.1 m recorded in Westernport. Large and rapid changes in tidally induced velocities also occur.

Geology and geomorphology

A variety of forms are evident from drowned river valleys to impounded drainage as a result of development of dune barrier systems. Depositional substrates dominant, with rock outcrops limited mainly to the margins. Tend to be basin shaped, the maximum depth is variable but is generally less than 20 m.

Biota

Victorian bays and estuaries contain a diverse range of biotic assemblages depending on their morphological and hydrological characteristics. Port Phillip Bay is a marine embayment fringed by seagrass beds, rocky reefs and sandy beaches. The benthic assemblages in the muddy central region are distinct from those in the sand to the west and east. Western Port Bay and Corner Inlet are large muddy estuaries with extensive mudflats and seagrass beds. The turbid waters in Western Port allow many subtidal animals to occur in relatively shallow water. The small narrow estuaries in western Victoria have an impoverished benthic fauna compared to those in the east which tend to be larger and better wind-mixed. The dominant seagrass species are *Zostera muelleri* and *Heterozostera tasmanica*, with large areas of *Posidonia australis* occurring in Corner Inlet/Nooramunga, and the east coast species *Zostera capricorni* reaching its southern limit in Mallacoota Inlet. The estuaries of eastern Victoria are distinguished from those in the centre and west by the presence of penaid prawns.

Estuaries

Various.

Otway Bioregion (OTW)

Climate

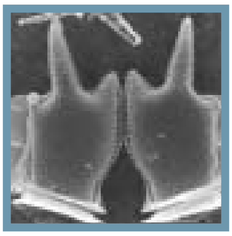
Cool temperate, meso thermal climate with cool, wet winters and warm, dry summers.

Oceanography

Coastline typically high energy, with wave energy dependent on the orientation to prevailing swell direction and cross shelf width. The western region is typified by a high deepwater wave energy, attenuated by a steep offshore-nearshore gradient and offshore reefs which provide for moderate to low energy conditions. Waters are cold temperate and typified by localised, regular, seasonal, cold, nutrient-rich coastal upwellings in the west of the region. Mean sea surface temperatures vary from 14°C in winter to 18°C in summer (decreasing to 11–12°C under the influence of the upwellings). The far eastern region (ie King Island area) is influenced during winter months by warm waters, making this region warmer than other Tasmanian waters at that time. Here also, summer water temperatures are cooler than elsewhere in the Bassian Province.

Tidal range is microtidal (ie ≈ 0.8 to 1.2 m range), though much of the area, however tidal ranges and velocities vary rapidly in that part of the region forming the western entrance to Bass Strait.

In the western region, two large unconfined aquifers (in the Gambier Limestones and Dilwyn Formation) discharge freshwater at the coast via beach springs and spring lakes.



Geology and geomorphology

Narrow, dominantly south-west facing, continental shelf, including the western entrance to Bass Strait. Small barrier coast dominated by a steeply sloping offshore gradient, dominated by bio-clastic carbonate sediments, and few coastal embayments. Coastal geomorphology comprises headlands of Pliocene-Pleistocene volcanic outcrops, and also Pleistocene dune rock cliffs, shore platforms and offshore reefs (which provide coastal protection), Tertiary sediments and, around King Island, Palaeozoic granite and associated sediments. Sandy beaches common in the western region (and around King Island), and also, within coastal embayments (ie Rivoli Bay, Guichen Bay) which are characterised by Holocene beach ridge plains, beaches and dunes. Cliffed shorelines common elsewhere.

Biota

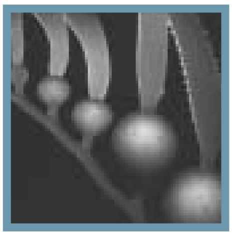
Marine fauna and flora are typically cold temperate (ie Maugean element of the Flindersian Province). Intertidal and sublittoral fringe on wave-exposed coasts dominated by the bull kelp, *Durvillea* potatorum. Rocky subtidal macro-algal communities are dominated by *Macrocystus angustifolia*, *Phyllospora comosa* and other large brown fucoid algae. For many macro-algal communities, this region forms the westward limit of a number of key species. Extensive areas of seagrass occur in the limited sheltered embayments, with smaller areas in the lee of reefs. Subtidal seagrass meadows dominated by *P. angustifolia* and *Amphibolus antarctica* in deeper waters. Rivoli Bay is the easterly limit of *P. coriacea* and *P. denhartogii*. Port MacDonnell is the easterly limit of *P. angustifolia*. Plant species diversity is very high, particularly among the red algae.

Fish and plant species-richness both high compared to other South Australia, Victorian and Tasmanian regions. This is the only recorded area within Tasmanian waters where several species more typically associated with South Australia occur (eg the queen morwong *Nemadactylus valenciennesi*). Coastal wetlands of national importance in the region include Butchers and Salt Lakes, Ewens Ponds, Piccaninnie Ponds and the coastal lakes of Lake Robe, Eliza, George, and St Clair.

Estuaries

No true rivers in the western region, but a few groundwater-fed creeks (eg Eight Mile Creek, Ellards Creek), and coastal salt lakes intermittently connected to the sea (eg Lake George). Six moderate-sized barrier estuaries on King Island and numerous coastal lagoons. See also VES – Victorian Embayments.

In Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments. June 1998. Version 3.3. Appendix 5.



Appendix B: Interim Bioregionalisation of deep water environments of the South-east Marine Region

The following information on the bioregionalisation projects and the resulting bioregions has been extracted verbatim from the project report for the Bioregionalisation analysis for the South-east Marine Region: integration of geological, oceanographic and biological data as the basis for bioregionalisation (Butler et. al 2002). A detailed explanation of the analytical methods used to integrate the data to develop the Interim Bioregionalisation can also be found in the project report.

Summary of Individual Bioregionalisation Projects

Production of a consistent, high quality bathymetric data grid for the South-east Marine Region

This project added approximately 400 000 new bathymetry data points to the Geoscience Australia (GA, formerly AGSO) bathymetry database for the continental shelf area to supplement data already entered from shelf, slope and rise to develop a consistent, high quality bathymetric data grid in the South-east Marine Region. Analysis of this map provided estimates of slope, aspect and geomorphological units. Project provider – Geoscience Australia.

Seabed characterisation of the South-east Marine Region (including seabed sample data)

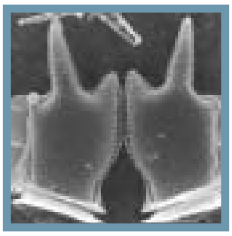
This project captured, analysed and interpreted existing seabed sediment data and other ship based acoustic survey results to provide maps of sediment distribution and seabed characterisation for the South-east Marine Region. The aim was to provide geological proxies for the occurrence of benthic habitats. Seabed sediment maps included carbonate content, mean grain size and sorting (standard deviation), percentage gravel, sand and mud content. The acoustic facies maps use the Damuth (1980) scheme and were based upon an assessment of available high frequency echograms (3.5 and 12 kHz) together with backscatter data collected by the various swath surveys. Geomorphological units were identified on the basis of bathymetry and a review of previous geological studies. Project provider – Geoscience Australia.

Upgrade of computer sediment model (GEOMAT)

Habitat types may be differentiated on the basis of the mobility of the substrate in response to oceanographic processes. The goal of GEOMAT is to predict the percentage of time that surficial sediments at shelf water depths (ie <200 m) are mobilised by surface swell waves and tidal currents on an annual basis. The aim is to provide geological proxies for the occurrence of benthic habitats. Project provider – Geoscience Australia.

Refine broad scale bioregionalisation (province and biomes)

This project was designed to confirm and/or amend the existing broad scale bioregionalisation (province and biomes) as a basis for the development of an Interim Bioregionalisation for the South-east Marine Region (allowing for additional refinement of provincial boundaries as necessary and development of biogeographical units if possible). It took into account existing data sets made available by Geoscience Australia, viz. Sedimentary basins, Tectonic elements, Crustal age, and Earthquake epicentres/magnitudes, as well as appropriate aspects of the data provided by the other projects listed here. Project provider – CSIRO Marine Research.



Upgrade deepwater nutrient, water properties and ocean current models

This project provided consistent, high quality models for deepwater nutrients and water properties based on the methodologies developed by Dunn and Ridgway (2001), as well as ocean current fields based on hydrodynamic model outputs (Bruce et al. 2001). Apart from their use in the Interim Bioregionalisation, these products could serve as core data sets for physical and biological studies within the South-east Marine Region, and to assist in identifying areas requiring specific management actions. The project provided:

- A gridded dataset of seasonal nutrient distributions (nitrate, phosphate, silicate) covering the South-east Marine Region at a resolution of 0.125° in latitude and longitude, and at 56 depth levels down to 5500 m.
- A gridded dataset of seasonal temperature and salinity distributions covering the South-east Marine Region at a resolution of 0.125° in latitude and longitude, and at 56 depth levels down to 5500 m.
- A dataset of seasonal dissolved oxygen distributions covering the South-east Marine Region at a resolution of 0.125° in latitude and longitude, and at 56 depth levels down to 5500 m.
- Maps of nutrient, temperature, salinity, and oxygen distributions showing the South-east Marine Region at selected times and depths.
- A dataset of seasonal currents covering the South-east Marine Region at a resolution of 0.2°, and at 37 depth levels down to 1900 m. These fields were output from a circulation model of the region.
- Maps of current vectors showing the South-east Marine Region at selected times and depths.
- An animation of seasonal near surface currents and temperatures in the South-east Marine Region.

Project provider – CSIRO Marine Research.

Rapid assembly of ecological fish data (community composition and distribution) for the South-east Marine Region

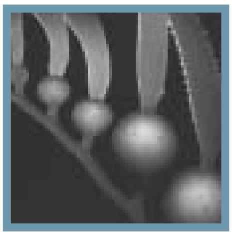
This project used information on the distributions of fish species, assembled from fisheries databases, fish collection databases, and published data to deliver:

- an assessment of provincial substructure (Level 1) within the Region
- an assessment of biomic substructure (Level 2) within the Region
- a matrix and classification of south-east regional fish species into their primary biomes, and
- a listing of metadata used to produce the regional maps.

Project provider – CSIRO Marine Research in partnership with Museum Victoria, Australian Museum and New South Wales Fisheries.

Rapid assembly of ecological data on key invertebrate groups of the South-east Marine Region

This project provided a database of collection data relating to key invertebrates from the South-east Marine Region shelf and slope. Echinoderms and decapods were considered key taxa in the marine invertebrate communities and reliable information could be rapidly assembled from existing data sets; pycnogonids (sea-spiders) were also included because their close association with hydroids and bryozoans meant that they would be indicators of a number of invertebrate community types and factors influencing community structure, and the pycnogonid data could be assembled in time to meet the project deadlines. Unidentified material from existing collections was identified and added to the data set. Project provider – Museum Victoria in collaboration with the Australian Museum and CSIRO Marine Research.



Bioregionalisation analysis for the South-east Marine Region: integration of geological, oceanographic and biological data as the basis for bioregionalisation

This project aimed to:

- analyse biological, geological and oceanographic data sets for the South-east Marine Region with the aim of developing an Interim Bioregionalisation appropriate for regional marine planning
- delineate bioregions of the outer shelf, slope and abyssal waters among and within each of the three Large Marine Domains of the South-east Marine Region, complementing where possible existing meso-scale IMCRA bioregions
- work in close consultation with the Bioregionalisation Working Group to refine the analytical approach, interpret the outputs and develop the Interim Bioregionalisation.

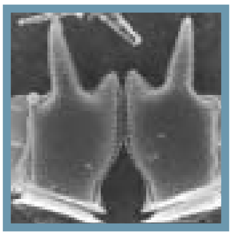
Project provider – CSIRO Marine Research and Geoscience Australia.

Descriptions of Bioregions

Level 1

Demersal Provincial Unit P1 incorporates the continental slope and abyssal plain west of Tasmania and the South Tasman Rise (STR) (Figure 2.1.5). The Provincial boundaries are recognised, on the upper continental slope, by the distributions of fish species parallel to the coast; there is a discontinuity in these distributions broadly west of the NW tip of Tasmania and in the deeper water by the underlying geologic structure of oceanic crust and plate age. In fact, it is likely that, when examined in a whole-continental context, this area will be found to be an biotone between two well-defined faunal provinces – one being our Province P2 in the South-east Marine Region and the other lying further to the north and west. Invertebrate data broadly corroborate this picture but are sparse and therefore do not give a clear pattern. Beyond the upper slope, the lower slope and abyssal plain contain several small, rotated blocks of underlying continental crust protruding above the sea floor. These blocks are remnant continental crust that has locally subsided during and after the separation of Australia from Antarctica. The sea floor of the abyssal plains has broadly east-west trending features that have been inherited from the underlying structure of the oceanic plates.

Demersal Province P2 incorporates the southern continental slope of Tasmania and the large continental block of the South Tasman Rise (STR). Its boundaries on the slope are determined by discontinuities in the distributions of fish species parallel to the coast; these are broadly corroborated by discontinuities in the much more limited data available on invertebrate animals. Beyond the slope, the province has been defined to incorporate the continental block of the STR, and the abyssal plain further south. The western boundary is the escarpment of the Tasman Fracture Zone (TFZ), its eastern boundary the eastern edge of the STR. The STR is geologically and biologically (fish) related to the western Tasmanian Margin (ie P1). East of the STR, the boundary curves eastward because the abyssal seafloor to the south is structurally related to the spreading of Australia from Antarctica, rather than the earlier opening of the south Tasman Sea. Consequently, the provincial boundary has been placed at the boundary between these two structurally different regions.



Demersal Provincial Unit P3 incorporates the continental slope (including Bass Canyon), East Tasman Rise (ETR), and abyssal plain east of Tasmania. The boundary with Province P2 is recognised, on the upper slope, by the distributions of fish species parallel to the coast; there is a discontinuity in these distributions broadly south of Hobart. In fact, it is likely that, when examined in a whole-continental context, this area will be found to be a biotone between two well-defined faunal provinces – one being our Province P2 in the South-east Marine Region and the other lying further to the north. Invertebrate data broadly corroborate this picture but are sparse and therefore do not give a clear pattern. Beyond the slope, this province includes the submerged continental block of the ETR, which locally subsided from Tasmania and the STR during the opening of the south Tasman sea approximately 80 million years ago. Beyond the continental slope, the sea floor of the abyssal plains has broadly N-S trending features that have been inherited from the underlying structure of the oceanic plates, and thus differs from associated regions in Provincial Units P1 and P2.

Level 2A

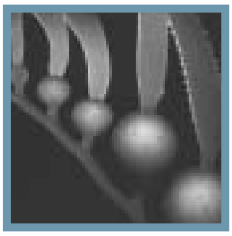
Level 2A (biomes) distinguishes the shelf (which is not covered in this report), Continental Slope, Abyssal Plains and features such as locally submerged continental blocks (ie STR and ETR).

We have identified 11 biomes in the South-east Marine Region:

The East Tasman Rise (ETR), located approximately 100 km southeast of Tasmania, is a 50 000 km^2 roughly circular fragment of locally subsided continental crust. The ETR rises from water depths of >3300 m to almost 700 m at the summit of the younger volcanic cone of the Soela Seamount. The eastern flank of the ETR forms a steep (14°) 1400 m high scarp that gives way to a gently rising terrace which intersects the base of the steeply-sided Soela Seamount. The ETR also contains several smaller parasitic cones, both on the flanks of the seamount and along the terrace. The morphology of the western flank is similar to the eastern flank, starting out flat but then becoming more rugged. Analysis of planktonic foraminifers and calcareous nannofossils contained in seafloor dredges indicates that the formation of the ETR may have involved multiple phases of subaerial and submarine volcanism. Fish fauna on the ETR is more akin to that of eastern Tasmania but poorly sampled; there has been limited fishing on the shallowest (<1000 m) portion.

The South Tasman Rise (STR), is a 200 000 km^2 fragment of locally subsided continental crust that rises from water depths of >4000 m to an elevation of 800 m. The STR forms a NW-trending broad dome approximately 1000 km long and 500 km wide that is characterised by a rough, irregular surface surrounded by gentle slopes. North of the STR, in water depths of 4000–1800 m, steep (>20°) northwest-oriented scarps bound topographic highs of rotated continental basement rocks. Basins separating these highs have shallow floors (0–2°) which form numerous channels extending over tens of kilometres into the ocean basin. On the northwest flank of the STR, perched basins are floored by hardgrounds, possibly comprised of manganese nodules. The TFZ, on the western flank of the STR, is comprised of a series of high relief ridges and troughs, with escarpments up to 2–3 km high. Previous deep seismic and geologic studies (eg Exon et al. 1997a) have confirmed that the TFZ separates high-standing continental rocks of the STR from low-standing oceanic crust underlying the abyssal plain to the west. Ichthyologically, the STR has more in common with western Tasmania (hence its inclusion in Province 2) but because of its shallow depth it has species of fish otherwise found on the upper continental slope. Its invertebrate fauna are poorly known.

The P1 Continental Slope contains numerous submarine canyons that connect the continental shelf from water depths of 300 m to the top of the continental rise at water depths of ~3500 m. The submarine canyons are characterised by straight axes and v-shaped cross-sections with relief of between 25 m and 200 m. In the canyons, the gradient of the longitudinal profile decreases down slope, causing them to coalesce on the rise to form wide, shallow channels, particularly in the south. Large (up to 180 km long pieces of continental crust protrude from the sea floor on the lower slope



(particularly near the boundary with Province 2). South of Cape Sorell, ~40% of the seafloor is exposed bedrock, which forms extensive WSW-trending canyons, escarpments and basement blocks with moderate to steep relief.

The P2 Continental Slope is characterised by rugged topography, with extensive rock exposure on the upper part of the slope, including jagged canyons (up to 250 m deep) and volcanic cones (up to 600 m high). Over the entire slope, small, localised areas containing ridges, pinnacles and valleys with relief of >100 m occur between extensive areas of moderately-graded, rough slopes and >70 volcanic cones. The seafloor on the lower continental slope contains numerous irregular, steep-sided ridges, separated by deep valleys. The axes of these ridges and valleys are aligned both parallel and sub-parallel to the TFZ, indicating that they probably were formed after folding of basement rocks, during strike-slip movement of the TFZ. Southwest of Tasmania, the continental slope is incised by an extensive network of linear to curvilinear submarine canyons that extend >60 km from the shelf edge to the base of the slope.

The P3 Continental Slope is a steep and rugged. The slope is incised with numerous submarine canyons that are up to 30 km long and >500 m deep and connect directly to the abyssal plain. The submarine canyons are more numerous in the north. East of Bass Strait, the continental slope also includes Bass Canyon, an ESE-trending funnel-shaped chasm 60 km long and 10–15 km wide at its mouth. The canyon has incised to a depth of >2 km and is bounded in the north and south by steep bedrock walls that attain 1000 m in height. The main canyon floor, located in water depths of >4000 m, is connected to the continental shelf by three large, deeply-incised tributary canyons and numerous smaller valleys. Erosion in the main canyon has exposed large vertical sections of the underlying continental crust.

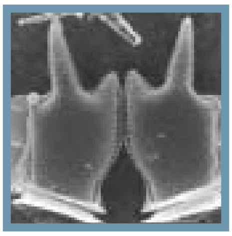
The P1 Abyssal Plain is characterised by gently undulating relief associated with irregular and faulted underlying basement blocks imparting a broad east-west trending fabric on the sea floor. The P1 abyssal plain is characterised by the accumulation of fine pelagic ooze, implying very little subsequent reworking by currents. However, the fauna on the P1 abyssal plain is virtually unknown, and the area is relatively poorly sampled.

The P2 Abyssal Plain is characterised by gently undulating relief associated with irregular and faulted underlying basement blocks imparting a broad east-west trending fabric on the sea floor. The seafloor of the south Tasman margin is characterised by foraminiferal/nannofossil ooze and foraminiferal sand.

The P3 Abyssal Plain is characterised by gently undulating relief, with numerous seamounts, located in groups and as isolated elevations in the seafloor rising up to 1000 m in height. In Bass Canyon, sediment transported down the canyon debouches at its mouth and spreads out onto the abyssal plain via a network of distributary channels.

The P4 Macquarie Ridge complex is characterised by and extensive kinked-linear to arcuate ridge complex extending more then 1500 km with a maximum relief of 1500 m, but rises above sea level in places (eg Macquarie Island). The ridge complex defines the boundary between the Australia and Pacific plates, and is comprised of oceanic crust that has been thrust up as a result of the weakly oblique strike-slip movement along the plate boundary. The ridge is steeply-sided and has an uneven and heavily dissected surface.

The P4 Macquarie Trench complex is a long, narrow, relatively steep-sided arcuate depression of the deep-sea floor to the southwest of the Macquarie Ridge. The trench formed from the buckling of oceanic crust associated with the strike-slip movement of the plate boundary, and is a section of oceanic crust that has been buckled downwards due to compression of the Australian Plate adjacent to the plate boundary. The Macquarie Trench is characterised on its western margin by gently sloping sea floor of exposed underlying oceanic crust and patches of relatively thin pelagic sediment. The steeper sides of the trench are characterised by gravity flows which deposit fine pelagic sediment in the bottom of the trench in water depths exceeding >6 500 m.



The P4 Macquarie Abyssal Plain is a broad region of mostly gently undulating topography, which also contains several seamounts and numerous rotated and faulted crustal blocks up to 50 km in length. To the east of the Macquarie Ridge, the abyssal plain contains a southeast trending chain of large steeply-sided seamounts and numerous smaller volcanic cones. The seamounts and volcanic cones have formed from local upwelling of mantle magma during the opening of the south Tasman Sea. The flanks of the seamounts are characterised by small cones, representing subsidiary volcanic vents. Large areas of the abyssal plain are exposed oceanic crust or warped crustal blocks protruding above the sea floor which have been locally uplifted by compression adjacent to the plate boundary.

Level 2b

The sub-biome level, level 2b, is identified by faunal patterns within biomes. In the South-east Marine Region at present, the only data set containing sufficient information to do this with some confidence is that on the distributions of fishes. Analysis of data on depth-distributions of fish species shows that there are distinct faunal groups in depth-ranges of 320–550 m, 850–1120 m, and 1600–2000 m. Between these bands are zootones or (since we are using the distributions of species as a surrogate for ecological patterns and processes) ecotones. These depth-related sub-biomes have been identified within each Province and within the level 3 units (below) as sub-areas A1, A2, A3. We consider the sub-biomes as nested within provinces in the hierarchical scheme. Thus, the fauna in Sub-Biome 3 (depth-range 1600–2000 m) in Provincial Unit P3 off eastern Tasmania is expected to differ from the fauna in Sub-Biome 3 in Provincial Unit P1 off western Victoria. For this reason, a different shade of yellow is used for Sub-Biome 3 in each of the three provinces in Figure 5.

Level 3

Level 3 (geomorphological) units identified for the Southeastern Continental Margin are shown in Table 1, and those for Macquarie in Table 2. In general, Level 3 units are considered to be nested within Level 1 and 2 units but in the case Level 2b units (Sub-biomes), a strict application of this nesting would have led to a proliferation of Level 3 units. Instead, we treat the Level 3 units as being (where applicable) subdivided by the Level 2b Sub-biomes, which are depth-bands (see above), as follows: A1 (320–550 m), A2 (850–1120 m), A3 (1600–2000 m) and B (2000 m to base of slope). For the Macquarie Province, no level 2 Biomes have been identified, due to insufficient biological data. There, as for the SE continental margin, Level 3 units are based primarily on interpretation of geomorphology. Data on ages of continental crust were examined to test for any variability in the seafloor and hence likely sediment drape. Fish data did not provide any breakdown of the region at this level. Invertebrate data identified a very general north/south split, but were not sufficiently detailed to provide units at either levels 2 or 3. Oceanographic data were not available in sufficient detail to refine the regionalisation for this region.

Table 1: *Level 3 (geomorphological) units identified for the Southeastern Continental Margin (EEZ waters adjacent to Tasmania, Victoria, part of South Australia and New South Wales). Where applicable, Level 3 units are subdivided by Level 2b units (Sub-biomes). These are shown in columns 4 and 5 or the table. The Level 2b Sub-biomes (see text) are depth-bands, as follows: A1, 320–550 m; A2, 850–1120 m; A3, 1600–2000 m; B, 2000 m to base of slope.*

Province 1	Region	Feature	Sub-biomes	Bottom Currents (cms^{-1}/Dir.)	Acoustic facies	Description
	1	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 20/NW; Max.: 40/NW-SE Mean: 20/SE; Max.: 40/NW	No acoustic facies data available	Extensively incised with submarine canyons spaced 14 to 17 km apart. In Area A, maximum currents diverge at 137°E.
	2	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 15/NE; Max.: 35/SE Mean: 15/NW; Max.: 40/S-SE	No acoustic facies data available	No submarine canyons.
	3	Continental Rise	N/A	Mean: 15/E; Max.: 20/E	No acoustic facies data available	Several rotated continental blocks between 11-30 km diameter.
	4	Continental Slope	Area A: A1, A2, A3 Area B	Mean: 20/E-SE; Max.: 25/NE Mean: 40/S-SE; Max.: 50/S-SE	Rough (Classes III)	Extensively incised with submarine canyons spaced every 15 km. In Area B, bottom currents are part of a clockwise gyre centred at 40.8°S and 141°E.
	5	Continental Rise	N/A	Mean: 5/S; Max.: 15 E	No acoustic facies data available	Several rotated continental blocks between 7 to 28 km in diameter.
	6	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 20/S; Max.: 35/S Mean: 20/S; Max.: 20/S	Rough (Classes III)	Extensively incised with submarine canyons spaced 7 km apart.
	11	Abyssal Plain	N/A	Mean: 15/Var.; Max.: 20/Var.	Rough (Classes III) SE corner only	Contains several continental blocks and 180 km long NW-trending ridge. Mean currents form an anti-clockwise gyre (flowing into Area 7B). Max. currents flow to the southwest (north of 43.6°) and northeast (associated with the clockwise gyre in area 7).
	13	Continental Rise/ Abyssal Plain	N/A	Mean: 15/E-S; Max.: 25/Var.	No acoustic facies data available	Mean currents modelled only for the northern part of this area (to latitude 45°S). Mean currents flow towards the east in the northernmost part of the area (north of 41°S) but towards the southwest in the area south of this latitude. Max. flows are complicated by an anticlockwise gyre centred at 39°S 138.6°E and other down-slope flows at 137.6°E and 141.8°E.

34	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 25/S; Max.: 45/S Mean: 15/S-N; Max.: 20/Var.	Smooth (Classes I & II) – A1, A2 and rough (Classes III) – A3 Smooth (Classes I & II)	Extensively incised with closely spaced submarine canyons, spaced 7 km apart.
Province 2					
7	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 30/S; Max.: 25/SE Mean: 20/Var.; Max.: 20/Var.	Rough (Classes III) Smooth (Classes I & II)	Extensively incised with submarine canyons spaced 14 km apart. Contains several rotated continental blocks. In Area A, mean currents form complex clockwise and counterclockwise rotating gyres.
8	Saddle	N/A	Mean: 20/Var.; Max.: 20/Var.	Smooth (Classes II) in west and equal Rough (III) and smooth (II) in east	Numerous protruding rotated continental blocks. Mean and Max. currents form a clockwise gyre located at 45°S 147°E.
9	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 20/N; Max.: 25/NW Mean: 15/N-NW; Max.: 20/NW	Rough (Classes III) Smooth (Classes I & II)	No submarine canyons. Contains several rotated continental blocks and a few seamounts.
10	Continental Slope	Area A: A1, A2, A3 Area B	Mean: 20/E; Max.: 20/Var. Mean: 25/S; Max.: 35/S	Rough (Classes III) Rough (Classes III)	Abundant seamounts, submarine canyons and small rotated continental blocks.
12	Ridge/Trench	N/A	Mean: 5/N; Max.: 10/S	Rough (Classes III)	Tasman Fracture Zone. Currents only associated with very north of area.
14	Continental Block	Area A: A1, A2, A3 Area B:	No current data available	Equally smooth and rough with pronounced N-S aligned rough area through centre.	Region of South Tasman Rise with extensive plateau areas. East boundary shifted to include acoustic facies classes IA and IIID indicative of flat plateau areas.
15	Continental Block	N/A	No current data available	Smooth (Classes II) – edges Rough (Classes III) – centre	Region of South Tasman Rise containing prominent ridges and swales.
16	Abyssal Plain	N/A	No current data available	No acoustic facies data available	Containing several small protruding continental blocks.
17	Continental Block	Area A: A2, A3 Area B:	No current data available	Smooth (Classes I & II) – north only.	~200 000 km^2 of locally subsided, broad low relief dome of the South Tasman Rise.
18	Continental Block	Area A: A3 Area B:	No current data available	Smooth (Classes I & II)	Contains submarine canyons spaced 30 km apart.
19	Abyssal Plain	N/A	No current data available	No acoustic facies data available	Contains some seamounts and numerous protruding continental blocks.

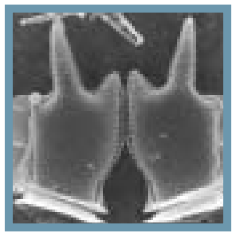
Table 1 *continued…*

Region	Feature	Sub-biomes	Bottom Currents (cms-1/Dir.)	Acoustic facies	Description
35	Continental Block	Area A: A3 Area B:	Mean: <5/Var.; Max. 10/Var. Mean: <5/Var.; Max. 10/Var.	Rough (Classes III) Rough (Classes III)	Domed continental block of South Tasman Rise with extensive plateaus and ridges rising above 2000 m isobath.
36	Continental Block	N/A	Mean: <1/Var.; Max. 10/Var.	Equally rough (Classes III) and smooth (Classes I & II) types	Domed continental block of South Tasman Rise with extensive plateaus and ridges below 2000 m isobath.
38	Continental Rise/ Abyssal Plain	N/A	No current data available	Smooth (Classes II)	Acoustic facies data only available for 5% of the area.
39	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 15/N; Max.: 20/Var. Mean: 15/N; Max.: 15/Var.	Smooth (Classes I) Rough (Classes III)	Contains submarine canyons, spaced 14 km apart, and several small protruding continental blocks. Canyons are incised and steep-sided cliffs. Boundary between 26 and 27 adjusted to include Class IIIA so that 26 includes all of this class.
Province 3					
20	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 25/S; Max.: 45/S Mean: 25/S: Max.: 35/S	Rough (Classes III) and equal rough (III) and smooth (I & II) types	Contains numerous submarine canyons spaced 15 km apart, but locally abundant at 6 km apart.
21	Saddle	N/A	Mean: 20/N-NW; Max.: 20 N	Smooth (Classes I) – south only	Low-relief surface containing several protruding continental blocks.
22	Continental Block	Area A: A2, A3 Area B:	Mean: 10/N-NW; Max.: 15/NW No current data available	Smooth (Classes I & II) No acoustic facies data available	East Tasman Rise, ~50 000 km^2 locally subsided block containing the Cascade Seamount (67 km in diameter). Max. currents part of a anticlockwise gyre located at 44.4°S, 148.2°E.
23	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 10/N; Max.: 20/S Mean: 20/S; Max.: 20/N	Rough (Classes III) – south and smooth (Classes I & II) – north Smooth (Classes I & II)	Few or absent submarine canyons. Includes broader 'flattened' area of Darcey's Patch.
24	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 5/Var.; Max.: 15/Var. Mean: 20/W-N; Max.: 20/ S	Rough (Classes III) Equal rough (Classes III) and smooth (Classes I)	Contains numerous, deeply-incised submarine canyons, spaced 16 km apart.

	25	Canyon	Area A: A1, A2, A3 Area B:	Mean: 15/Var.; Max.: 15/Var. Mean: 20/E; Max.: 15/E	Smooth (Classes I) for A1, A2 and rough (Classes III) for A3 Rough (Classes III)	Bass Canyon and associated continental slope
	26	Continental Slope	Area A: A1, A2, A3 Area B:	Mean: 15/N; Max.: 15/S Mean: 15/N; Max.: 20/S	Rough (Classes III) Rough (Classes III)	Extensive submarine canyons spaced 14 km apart and several continental blocks. Canyons have heavily-incised with steep cliffs. Boundary between 26 and 27 were adjusted to include acoustic facies classes IIIA so 26 includes all of this class.
	27	Continental Slope	Area A: A1, A2, A3 Area B:	No current data available No current data available	Rough (Classes III) No acoustic facies data available	Few submarine canyons.
	28	Abyssal Plain	N/A	Mean: 15/Var. See description.	No acoustic facies data available	Currents modelled only far north as 37°S. Var currents except for a 70 km wide eastward flowing jet that extends from the base of slope to ~151°E and has a mean of 20 cm/sec and a max. of 25 cm/sec., and a 70 km wide anticlockwise gyre up to 15 cm/sec (20 cm/sec max.) centred at 45°S 148.4°E.
	29	Abyssal Plain	N/A	Mean: <1/Var. Max. <5/Var.	No acoustic facies data available	Contains seamounts.
	30	Abyssal Plain	N/A	Mean: <1/Var. Max. <5/Var.	No acoustic facies data available	Contains seamounts.
	31	Abyssal Plain	N/A	Mean: <1/Var. Max. <5/ Var.	No acoustic facies data available	Contains seamounts.
	37	Abyssal Plain	Area A: A3 Area B:	Mean: 5/N; Max.: 10/N Mean: 5/N; Max.: 10/N	Equally rough (Classes III) and smooth types (Classes I & II) No acoustic facies data available	Contains numerous seamounts and continental blocks. Bottom currents modelled only north of 46.8°S.
Shelf						
	32	Continental Shelf				Not described as it overlaps IMCRA zones.
	33	Continental Shelf				Not described as it overlaps IMCRA zones

Table 2: *Level 3 (geomorphological) units identified for the Macquarie Ridge. There is only one province in the Macquarie Large Marine Domain. No level 2 Biomes have been identified for this province, and Level 3 units are based primarily on interpretation of geomorphology (see text).*

	Region	Feature	Sub-biomes	Bottom Currents (cms-1 / Dir.)	Acoustic facies	Description
Province 4						
	1	Oceanic Crust	N/A	No current data available	No acoustic facies data available	Low-relief undulating surface with E-W oriented ridges and swales. Small basin is present in the west.
	2	Volcanic Ridge	N/A	No current data available	No acoustic facies data available	Linear-arcuate narrow, steep sided ridge complex that locally rises above sea level (Macquarie Island). Top of ridge is deeper towards the south.
	3	Submarine Trench	N/A	No current data available	No acoustic facies data available	Broad (80 km). Contains some rotated and faulted oceanic crustal blocks up to 50 km in length.
	4	Abyssal Plain	N/A	No current data available	No acoustic facies data available	Contains several seamounts and numerous rotated and faulted oceanic crustal blocks.
	5	Abyssal Plain	N/A	No current data available	No acoustic facies data available	Undulating surface probably consisting of uplifted oceanic crustal blocks.
	6	Oceanic Crust	N/A	No current data available	No acoustic facies data available	Contains several seamounts.
	7	Abyssal Plain	N/A	No current data available	No acoustic facies data available	Contains an E-W trending chain of seamounts (<30 km diameter) and numerous smaller volcanic cones on their flanks. Largest seamount rises up to 390 m.
	8	Submarine Trench	N/A	No current data available	No acoustic facies data available	Broad (<80 km) but narrows considerably to the south.
	9	Basin	N/A	No current data available	No acoustic facies data available	NE trending basin (40 km long x 8 km wide), separates north and middle ridge systems.
	10	Abyssal Plain	N/A	No current data available	No acoustic facies data available	Undulating surface, possibly seamounts. Strong low-relief, E-W ridge and swale fabric.
	11	Seamount	N/A	No current data available	No acoustic facies data available	Single, steeply-sided (~23 km diameter).
	12	Saddle	N/A	No current data available	No acoustic facies data available	Narrow (<2 km) elevated saddle. Separates middle and south ridge systems.
	13	Volcanic Ridge	N/A	No current data available	No acoustic facies data available	Broad (<70 km) arcuate with peaks typically <3 000 m. Western flank characterised by W-SW corrugations. Several large volcanic cones occur on the eastern flank.
	14	Submarine Trench	N/A	No current data available	No acoustic facies data available	Broad (<20 km) with steep-sided cliffs and undulating floor. Separates western ridges from main volcanic ridge.
	15	Submarine Trench	N/A	No current data available	No acoustic facies data available	Broad (<50 km) steeply-sided to east where abuts Volcanic Ridge. U-shaped bottom profile in north and V-shaped in south. Trench bottom >6 000 m.
	16	Submarine Trench	N/A	No current data available	No acoustic facies data available	Narrow (<6 km) arcuate, bounded by steep cliffs. Comprises an undulating floor at depths of >4500 m.
	17	Oceanic Crust	N/A	No current data available	No acoustic facies data available	Undulating surface with some higher peaks. Probably formed by spreading ridge to south.
	18	Submarine Trench	N/A	No current data available	No acoustic facies data available	Narrow (~5 km) E-W trending, sinuous profile.
	19	Volcanic Ridge	N/A	No current data available	No acoustic facies data available	Narrow (~5 km) N-NW trending ridge up to 1000 m high. Forms southward extension of Macquarie Ridge.
	20	Submarine Trench	N/A	No current data available	No acoustic facies data available	Narrow (5–10 km) with ridged floor.
	21	Oceanic Crust	N/A	No current data available	No acoustic facies data available	Undulating surface with 40 km wide plateau on western flank.



Appendix C: South-east Marine Region Commercial Fish Species

This Appendix synthesises ecological information for 45 species of commercial significance in the South-east Marine Region. The information is based on a review of scientific and technical fisheries research literature. A comprehensive list of relevant literature is provided in the review report: Targeted review of biological and ecological information from fisheries research in the South-east Marine Region by Bruce et al. (2002), which can be can be obtained from the National Oceans Office website (www.oceans.gov.au).

Although the main focus of this review is the distribution, biology and ecology of individual species, some fishery and management aspects have been considered here to provide a broad context. However, comprehensive information of that nature is to be found in the report *Resources - using the ocean*.

The Table below outlines the species considered in this Appendix, the fisheries they belong to, and whether they are target or bycatch species in which they are caught.

The following acronyms are used in the table below and in this Appendix generally, to indicate the different fisheries of the Region.

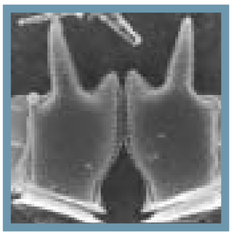
SE	South East Fishery
SETF	South East Trawl Fishery
SENTF	South East non-Trawl Fishery
SAF	Subantarctic fishery
SSF	Southern Shark Fishery
STR	South Tasman Rise Fishery (part of South East Fishery)
GABTF	Great Australian Bight Trawl Fishery
PTF	Patagonian Toothfish Fishery
ECTF	East Coast Tuna Fisheries
SRLF	Southern Rock Lobster Fishery
STCZ	South Tasman Convergence Zone

Other commonly used acronyms in this Appendix are:

AFZ	Australian Fishing Zone
CPUE	catch per unit effort
FL	fork length
GAB	Great Australian Bight
MSY	maximum sustaibable yield
STCZ	South Tasman Convergence Zone
TAC	total allowable catch

Table 3: *Species of commercial significance in the South-east Marine Region.*

	Common name	Species	Fishery	Target/Bycatch
1	Greenlip abalone	Haliotis laevigata	Abalone Fishery	T
2	Blacklip abalone	Haliotis rubra	Abalone Fishery	T
4	Yellowfin tuna	Thunnus albacares	ECTF	T
6	Southern bluefin tuna	Thunnus maccoyii	SBTF	T
7	Skipjack tuna	Katsuwonus pelamis	SBTF (GAB)	T/B
8	Ray's bream	Brama brama	SBTF	B
9	Blue shark	Prionace glauca	SBTF, ECTF, Recreational (NSW)	B/ T
10	Patagonian toothfish	Dissostichus eleginoides	PTF	T
11	Blue eye trevalla	Hyperoglyphe antarctica	SENTF, SETF	T
12	Jackass morwong	Nemadactylus macropterus	SENTF, SETF	T
13	Flatheads	Neoplatycephalus spp. Platycephalus spp.	SENTF, SETF	T
14	Pink ling	Genypterus blacodes	SENTF, SETF	T
15	School whiting	Sillago flindersi	SENTF	T
16	Jack mackerel	Trachurus declivis	SENTF, SEFT, TasF	T/B
17	Redbait	Emmelichtys nitidus	TasF (jack mackerel)	B
18	Striped trumpeter	Latris lineata	SENTF, SEFT, SSF, TasF	T/B
19	John dory	Zeus faber	SENTF, SETF	B
20	Hapuka	Polyprion oxygeneios	SENTF, SETF (Blue eye trevalla)	B
21	Orange roughy	Hoplostethus atlanticus	SETF, STRF	T
22	Oreos	Allocyttus niger A.verrucosus Neocyttus rhomboidalis Pseudocyttus maculatus	STRF, SBTF (GAB)	T/ B
23	Blue grenadier	Macruronus novazelandiae	SETF	T
24	Redfish	Centroberyx affinis	SETF	T
25	Blue warehou	Seriolella brama	SETF, SENTF	T
26	Spotted warehou	Seriolella punctata	SETF, SENTF	T/B
27	Royal red prawn	Haliporoides sibogae	SETF	T
28	Eastern gemfish	Rexea solandri	SETF	T
29	Western gemfish	Rexea solandri	SETF	T
30	Mirror dory	Zenopsis nebulosus	SETF	T
31	Silver trevally	Pseudocaranx dentex	SETF	T
32	Ocean perch	Helicolenus percoides, H.barathri	SETF	B
33	Skates	Family Rajidae	SETF, SAF	B
34	Dogfishes	Family Squalidae	SETF, SSF	T/ B
35	Gummy shark	Mustelus antarcticus	SSF	T
36	School shark	Galeorhinus galeus	SSF	B
37	Sawsharks	Pristiophorus spp.	SSF, SEF	B
38	Elephant fish	Callorinchus milii	SSF, SEF	B
39	Snapper	Pagrus auratus	Snapper Fishery, Recreational	T
40	Southern calamari	Sepioteuthis australis	Southern Sqid Fishery	T
41	Southern rock lobster	Jasus edwardsii	SRLF	T
42	Scallop	Pecten spp.	Tas & Vic Scallop Fisheries	T
43	Australian salmon	Arripis trutta, A.truttaceus	Tas & New South Wales Fisheries	T
44	Pilchard	Sardinops neopilchardus, S.sagax	Vic & SA Fisheries	T
45	Blue sprat	Spratelloides robustus	Other clupeiod fisheries (e.g. pilchards)	B



Greenlip abalone *Haliotis laevigata*

Distribution

Greenlip abalone are members of the family Haliotidae. Endemic to Australian waters, they occur from Corner Inlet (Victoria) across southern Australia to Cape Naturaliste (Western Australia), including Tasmania, primarily in depths of 10 m–30 m.

Fishery profile

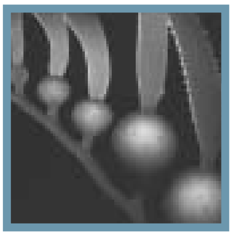
Abalone are managed on a State basis by individual quotas and a total allowable catch (TAC). The main areas of the fishery are in Tasmania and South Australia where the fishery is subdivided into various zones. Management is based on both input (number of licences, minimum legal size) and output (quota) controls. The fishery is subdivided into State-based management zones, which have differences in quotas and legal sizes. Abalone occur as metapopulations (isolated populations of adults requiring recruitment from other populations to persist) as a result of their short larval life, limited dispersal and limited movements. Management of the fishery is generally aimed at maintaining metapopulations at sustainable levels, allowing adequate recruitment and maintaining genetic diversity. In South Australia, catches declined from 1,200 t in 1968 to approximately 250 t in 1974 and increased slightly to 500 t in 1984. Catches have been stable at approximately 400 t since 1990. The annual recreational catch is estimated to be approximately 13 t (4.6% of TAC). Recent independent diver surveys suggest a significant decrease in abundance at two of the four sites regulary surveyed in South Australia and significant decreases in juvenile abundance at some sites. No trends in abundance were apparent at other sites. Declines in the percentage of sub-legal sized abalone (suggestive of sustained low recruitment levels) have been detected at most survey sites.

Biological & ecological profile

Greenlip are patchy in their distribution and tend to cluster in areas of suitable habitat such that populations can be separated by tens of kilometres. Movements are limited in adults (in the order of tens of metres). Aggregations of greenlip abalone have been reported to be genetically different with genetic variation increasing with geographic distance between populations. Greenlip are broadcast spawners and spawn once per year from late October to March-April, although spawning can be more restricted in some regions. Fecundity can vary between individuals, populations and years and may be related to food supply. Larval life is short (5–10 days) and influenced by water temperature. Local hydrodynamics play a major role in dispersal of larvae and stock structure. Larvae settle preferentially on areas of crustose coralline algae although post-settlement survival may be higher in such habitats and mask more widespread settlement patterns. Newly settled abalone feed on diatoms and other microscopic algae. By two to three years of age, diet changes to a predominance of drift algae. Juvenile abalone are preyed upon by fish (usually wrasse), crabs, octopus, rays and rock lobster.

Key knowledge gaps and uncertainties

Both greenlip and blacklip abalone are the target of illegal fishing, however the extent of the illegal catch is difficult to determine. Recent work on genetic fingerprinting of abalone species has assisted in identifying components of the illegal catch. The effects of population size and male to female ratio on the spawning success need to be better understood, as well as the implications for stock assessments of regionally variable condition and growth. Further work on ageing is required.



Blacklip abalone *Haliotis rubra*

Distribution

Blacklip abalone are members of the family Haliotidae and are endemic to southern Australia. They occur from Coffs Harbour (New South Wales) around the south coast to Rottnest Island (Western Australia), in primarily shallow waters to 10 m in depth.

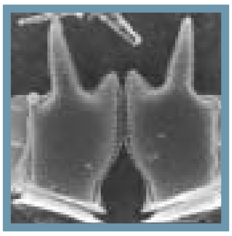
Fishery profile

Abalone are managed on a State basis by individual quotas and a total allowable catch. The main areas of the fishery are in Tasmania and South Australia where the fishery is subdivided into various zones. The fishery in South Australia is divided into three management zones, which are further subdivided into fishing areas. Management is based on both input (number of licences, minimum legal size) and output (quota) controls. The fishery is subdivided into State-based management zones, which have differences in quotas and legal sizes. Abalone occur as metapopulations (isolated populations of adults requiring recruitment from other populations to persist) as a result of their short larval life, limited dispersal and limited movements. Management of the fishery is generally aimed at maintaining metapopulations at sustainable levels, allowing adequate recruitment and maintaining genetic diversity.

Recreational fishers take both blacklip and greenlip abalone although blacklip is the main target due to its generally shallower distribution. In South Australia, blacklip catches increased from 270 t to over 500 t from 1968 to 1972. Catches then declined steadily to 250 t in 1975 and 1978. Catches have been relatively stable at 500 t since 1981. There have been no significant trends in CPUE across the South Australia fishery since quotas were introduced. In Tasmania, total catches have fluctuated over the course of the fishery. Peak catches occurred in 1984 (4500 t) prior to introducing individual quotas and a TAC. The TAC was originally set at 3806 t but was progressively reduced to 2100 t in 1989. Regional differences occur in the susceptibility of populations to fishing pressure as a result of regional variability in recruitment success. Highly significant differences in growth rates between north and south of Tasmania (abalone growing faster and larger in the south) lead to large differences in size at maturity. These differences also result in harvesting of some immature fish, although they are above the minimum size limit in the south and stunted populations that do not reach the size limit in the north. Size limits on the east coast of Tasmania may be too small to allow abalone to undergo two breeding seasons before entering the fishery.

Biological & ecological profile

Movements of abalone are limited. Aggregations occur in preferred habitat (eg in regions of coralline algal covered boulders) and abalone may reaggregate at such sites after periods of fishing. Timing of spawning varies with the region, ranging from autumn-winter to spring and autumn in some areas. Sexual maturity in blacklip abalone is dependent on age rather than size. As for the greenlip abalone, larval life is short (five to ten days) and influenced by water temperature. Local hydrodynamics play a major role in dispersal of larvae and stock structure. Recruitment can vary both regionally and from one year to another. This has been linked to reductions in coralline algal cover as a result of habitat changes. Recruitment failure has also been observed in unfished populations. Larval settlement is highest on coralline algae and newly settled abalone feed on diatoms and other microscopic algae. Juvenile abalone are preyed upon by fish (usually wrasse), crabs, octopus, rays and rock lobster. Abalone and sea urchins may play an interdependent role in structuring the algal habitat in their environment. Various parasites and commensals may influence the growth rate and mortality of abalone.



Key knowledge gaps and uncertainties

Aggregations occur in areas of preferred habitat and these are targeted by the fishery. Aggregations at the same sites re-form after fishing via movements to preferred habitat by larger individuals. Catch rates and size structure of catch can thus remain relatively stable masking depletion of stock and making interpretation of catch statistics difficult. Ageing of abalone requires further research, particularly at large sizes. There is the need to define the ecosystem effects of depletion of abalone – including implications of changes in abalone-urchin dynamics. The reasons behind observed behavioural differences leading to non-emergent (cryptic) and emergent specimens are not understood. The rates of natural mortality and the recruitment variability in several areas are not known.

Broadbill swordfish *Xiphias gladius*

Distribution

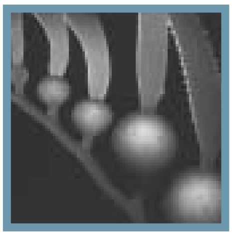
Broadbill swordfish are distributed throughout the tropical and temperate waters of the world. The broadbill swordfish has the most extensive range of all billfishes with a global distribution between 50°N and 50°S. Broadbill swordfish inhabit all Australian waters beyond the edge of the continental shelf. They represent a significant bycatch of the tuna longline fleets.

Fishery profile

Based on the trends in CPUE of the Japanese longline fishery, four stock units are believed to occur: one off Japan, in the north western and central Pacific, the second, off Baja California Peninsula, the third, off the western coast of South America and the fourth off the eastern Australian coast and north of New Zealand. Japanese longliners harvested an average of 660 t of broadbill swordfish per year in the Australian Fishing Zone from the 1950s until 1997. Broadbill swordfish catch by the Australian longliners has increased from an average of less than 30 t before 1996, to 1754 t in 1997. High market values for broadbill swordfish have stimulated a global commercial fishery that harvests more than 50 000 t annually. World broadbill swordfish landings in 1997 were ~97 698 t. In 1999, 2513 t were reported taken from the Australian Fishing Zone. Although broadbill swordfish are a bycatch of the tuna fisheries, in 1996/97 many longliners relocated from New South Wales to southeast Queensland where they used night-set squid baits to target broadbill swordfish and big-eye. As a result, landings of broadbill swordfish increased to 2373 t in 1998. It is of concern that current Pacific-wide catches of broadbill swordfish exceed the estimates of MSY from production model-based assessments. The International Commission for the Conservation of Atlantic Tunas considers that the south Atlantic swordfish have been fished at levels that exceed the MSY in most years since 1990. Some fisheries targeting broadbill swordfish in other regions of the world have shown initial rapid expansion followed by collapse or substantial decline.

Biological & ecological profile

Broadbill swordfish migrate vertically in response to light, being near the surface at night, at maximum depths of more than 600 m at local noon, and rapidly migrating up or down in the water column during sunset and sunrise respectively. Broadbill swordfish are able to easily penetrate thermoclines and are not limited in depth distribution by them. For example, they have been observed to undergo a temperature change of 19°C in the course of 2.5 hours. Despite their ability to tolerate a wide range of temperatures, abundance and distribution is generally associated with surface waters >18°C and <30°C. Broadbill swordfish activity appears to be influenced by the presence of anoxic waters. Larvae occur in all tropical seas including the Atlantic, Pacific, and Indian Oceans and the Mediterranean Sea. Spawning grounds may be associated with areas of upwelling. Broadbill swordfish are frequent batch-spawners, where temperature is above 24°C. Fecundity ranges between 1 to 30 million eggs, depending on the size of individual females. In the



south Pacific, the peak spawning season appears to be December through January. Broadbill swordfish attains a maximum size of about 540kg and appear to live for approximately 25 years. Sexual maturity seems to occur at ~4 years of age for the females and ~2 years for the males. Broadbill swordfish concentrate in areas where food is abundant and are common along frontal zones, where ocean currents or water masses intersect to create turbulence and sharp gradients in temperature and salinity. Broadbill swordfish populations are structured on a global scale. There are at least four genetically distinct populations of broadbill swordfish. Complete genetic isolation is not evident, however, indicating a limited level of gene flow on a global scale, with the highest estimated levels of gene flow occurring between the Atlantic and Pacific. Recent genetic analysis indicates that the Pacific is subdivided into two or three large populations with overlapping ranges in the eastern Pacific.

Key knowledge gaps and uncertainties

The broadbill swordfish fishery is rapidly developing off the east coast of Australia and is one for which data are inadequate and stock structure is uncertain to the point that meaningful quantitative stock assessment cannot be contemplated for several years.

Yellowfin tuna *Thunnus albacares*

Distribution

Yellowfin inhabit all tropical and subtropical seas, except the Mediterranean Sea, between about 40°N and 40°S. In Australia they are present from the Torres Strait to as far south as eastern Tasmania (~43°S) and from south-western Australia at about 128°E to Northern Territory waters at about 136°E. Most catches in the South-east Marine Region are off southern New South Wales between April and July and between 36°S and 38°S (Young et al. 2001).

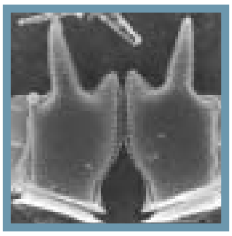
Fishery profile

The domestic fishery is confined to within 100 nautical miles of the coast, with 64% of domestic effort occurring within 50 nautical miles of the coast.

Effort (1000s of hooks) and catch (tonnes) increased dramatically for the area south of 34°S between 1986 (7 500 hooks with 2.6 t) and 1989 (402 400 hooks with 298 t). Japanese longliners have been fishing for yellowfin and bigeye in the AFZ between Cape York and southeastern Tasmania since the 1950s. The domestic fishery began in the mid-1980s following the demise of the New South Wales southern bluefin fishery. Annual catches of yellowfin the eastern AFZ have ranged between several hundred tonnes to almost 5000 t since 1979, with an average of 28% of the catch being taken by the Australian fleet since 1987, however most of the catch is taken north of the South-east Marine Region. In 1994 ~ 380 000 t of yellowfin was harvested in commercial fisheries across the western Pacific. High catches (> 240 t) were taken over the shelf break between 36°S and 37°S in May 1996 and 1997 as a result of favourable oceanographic conditions in the area (Young et al. 2001).

Biological & ecological profile

Distribution is limited by sea surface temperature less than 15°C, salinity extremes and low dissolved oxygen concentration. Yellowfin appear to concentrate at thermal discontinuities in regions of enhanced productivity and prey availability. Only during out-of-the-ordinary intrusions of warm water along the Tasmanian coast are yellowfin taken in any numbers off eastern Tasmania. Yellowfin are multiple spawners. Spawning in the Coral Sea commences in October and finishes in March, becoming less protracted with



increasing latitude. Average interval between spawning (spawning frequency) of yellowfin in the Coral Sea was 1.54 days. The estimated length at which 50% of yellowfin reached maturity is at ~108 cm in the handline fishery and 120 cm in the Japanese longline fishing area off northeastern Australia. Yellowfin inhabiting coastal waters may attain sexual maturity at a smaller size than those in offshore waters of the Pacific. Spawning of yellowfin in the handline area was triggered by a surface temperature of 26°C. Numbers of yellowfin larvae reach a peak in the southward-flowing EAC during November-December. Yellowfin larvae in the AFZ between July and September suggests some recruitment of yellowfin to the AFZ occurs from the north and east of the Coral Sea. Yellowfin spawning in the western Coral Sea may be a major source of recruits to the longline fishery in the eastern AFZ. There is strong evidence of spawning-site specific chemical signals in yellowfin otoliths (an earbone, which can be used to determine fish age). Otolith microchemical analysis has indicated there are at least two reproductively isolated stocks in the Pacific (western/central, and eastern). Genetic analyses suggest some degree of differentiation between juveniles in from western/central populations, but sample sizes are too low to confirm or refute this. Genetically, eastern Pacific yellowfin clearly differentiate from central/western Pacific yellowfin.

Key knowledge gaps and uncertainties and uncertainties

The stock structure needs to be further investigated. The reasons for variability in catches from year to year, the potential links to oceanographic processes and patterns of movements are not understood.

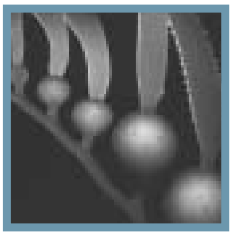
Albacore tuna *Thunnus alalunga*

Distribution

Albacore are pelagic fish, distributed from about 45°N to 50°S in all tropical, subtropical and temperate oceans and the Mediterranean. They have been found at least as deep as 500 m in the Pacific Ocean.

Fishery profile

Genetic evidence suggests that there is a separation between the Indian Ocean and Pacific Ocean populations of albacore (see below). Albacore are believed to comprise a discrete stock in the Pacific Ocean south of the equator, including albacore found off the east coast of Australia. It is possible that albacore from the east coast move around southern Tasmania and mix with the Indian Ocean stock, although the interchange is probably low. Prior to start of the drift gillnet fishery, surface catches were less than 2500 t. Between 1983–84 (start of commercial-scale drift netting) and 1985–86 (start of STCZ troll fishery), total surface catches were less than 5300 t. Rapid expansion of gill netting resulted in historically high catches of 29 000–58 000 t in 1988–89. Reductions in drift gill netting resulted in a decline of the surface catch to 9419 t in 1990–91. Since 1991 no drift gill netting has taken place and surface troll fishing catch is not likely to exceed 10 000 t. Longline catches increased with expanding effort from 1952 to 1967 to reach the historical peak of 40 572 t. However, since 1967 total longline catch has ranged between 21 000 and 39 000 t, but usually less than 35 000 t. Albacore catches have been incidental to more valuable target species such as southern bluefin tine, bigeye and yellowfin. From 1984 to 1988 an annual average of 1300 t of albacore was caught by Japanese longliners working in Australian waters. Albacore stocks are considered to be under-utilised in Australian waters. The withdrawal of the driftnet fleet from the Tasman Sea and broader south-west Pacific has considerably lessened earlier concern about the potential impact of that fleet on the south Pacific Ocean stock. The South Pacific albacore troll fishery has the capacity to reduce yields in the south Pacific longline fishery.



Biological & ecological profile

Distribution is related to oxygen concentration and water temperature – minimum [O_2] is probably similar to that for yellowfin tuna at ~2 ml/L . Minimum temperature and dissolved O_2 requirements of albacore larvae and juveniles may not be met in surface equatorial waters in any season, which suggests an effective physiological barrier to exchange of larvae and juveniles between North and South Pacific Oceans. Off southern Australia and New Zealand, albacore appear to prefer sea surface temperatures of 16–22˚C in association with temperature fronts, although they have been recorded in waters ranging between 9.5–~25˚C. Albacore are known to concentrate along thermal discontinuities. Albacore feed at the surface, but otherwise live at the thermocline, which in the Tasman Sea in summer tends to vary between 50–150 m depth. Juveniles move from the tropics into temperate waters and then eastwards along the subtropical convergence zone. At maturity they return to the tropics, but go back to temperate waters after spawning. In the South Pacific Ocean, larvae are distributed from northeast Australia – east through French Polynesia between 5–25˚S. Larvae are mostly caught during October to December, although present in most other months except January, March and April. Spawning appears to take place primarily in the November to February period north of 20˚S. Females mature at about 85 cm FL; males can be considerably smaller (50–70cm LCF). Relative growth rate based on tag returns, caudal vertebrae and length frequency analysis suggests rates on the order of 0.5 cm per month. Natural mortality may be about 0.3–0.4 per year, given the likely longevity of albacore.

Key knowledge gaps and uncertainties

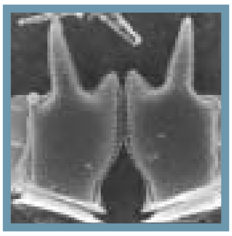
It is not understood whether the South Pacific albacore troll fishery has the capacity to reduce yields in the South Pacific longline fishery.

Southern bluefin tuna
Thunnus maccoyii

Distribution – Southern bluefin tuna are highly migratory throughout the Southern Hemisphere: temperate and cold seas, mainly between 30˚S and 50˚S, to nearly 60˚S.

Fishery profile

Tuna fisheries in Australia date back to 1938, but a significant effort in the southern bluefin tuna fishery did not begin until the early 1960s. The Japanese catches of southern bluefin tuna date back to early 1950s. Murphy and Majkowski (1981) reported in 1981 that the southern bluefin tuna fishery was fully exploited. Individual transferable catch quotas were introduced to the southern bluefin tuna fishery in 1984. Juvenile southern bluefin tuna form large schools in the surface waters off southern and south eastern Australia, while mature southern bluefin tuna are dispersed throughout the southern oceans. Efforts were made in the early 1980s to reduce total catches. In 1983-84 an interim management plan was adopted including a TAC of 21 000 t. October 1984 ITQ-based management introduced a TAC of 14 500t. Further reductions in TAC occurred in following years in response to continuing decline in the southern bluefin tuna parental stock. Since 1990 the global TAC has been limited to 11 750 t. Current management is under a trilateral arrangement – tripartite agreement was ratified in May 1994 as the Convention for the Conservation of Southern Bluefin Tuna (CCSBT). Since 1987–89 there has been an increase in catch of southern bluefin tuna by non-members of the CCSBT (400 t in 1987 and 1988; 2139 t in 1994; 4600 t in 1996). Since 1983 the Australian catch has not exceeded the set catch limit; between 1989 and 1994 the Japanese catch exceeded catch limits. New Zealand exceeded their allocated catch limit in both 1989–90 and 1990–91 seasons by 17 and 109 t, respectively. The value of the Australian southern bluefin tuna fishery has fluctuated over the period 1982 to 1996, however the trend has been one of increase, while the quantity has decreased. Lowest value was obtained in 1983–84 at $12.6 million (15.8 ktonnes) and the highest in 1994–95 season at 86.3 million dollars (5.2 ktonnes).



Biological & ecological profile

Spawning is entirely outside the South-east Marine Region. The only known spawning area is in the tropical east Indian Ocean. Spawning fish and larvae are encountered in waters with surface temperatures between 20°C and 30°C. southern bluefin tuna in spawning condition are found on the spawning ground during every month of the year except July. Juveniles leave the spawning grounds within a few months of hatching and move south along the continental shelf of Western Australia. Juveniles first appear in the GAB as one-year olds in summer and then disperse along the West Wind Drift in winter. Ovarian development in females less than 140cm indicates that they would not spawn in the coming season – the smallest mature female on the spawning ground has been recorded at 147 cm. Southern bluefin tuna have an asynchronous pattern of oocyte development: once a female begins to spawn, it spawns daily. Batch fecundity of southern bluefin tuna is estimated to be 57 oocytes per gram of body weight. As soon as individuals have finished spawning they quickly depart from the spawning ground. Bomb radiocarbon analysis to estimate age of southern bluefin tuna indicates that the species may reach ages in excess of 30 years – individuals that approach the asymptotic length are likely to be 20 years of age or older. The mean lengths two, three and four year old fish, and the increment from age one to three, have increased substantially over the history of the fishery. The increase in growth is probably a response to a decline in the population due to heavy fishing. Currently, otolith microchemistry does not provide good evidence for stock structuring in southern bluefin tuna. Overall, there is little conclusive evidence of either stock structuring or geographic variability in the composition of southern bluefin tuna otoliths. No significant spatial heterogeneity was detected in genetic analysis of southern bluefin tuna. Grewe et al (1997) found no genetic evidence to suggest other than a single panmictic stock of southern bluefin tuna and a single spawning area.

Key knowledge gaps and uncertainties

The Southern Bluefin Tuna is listed on the IUCN Red List as Critically Endangered. Currently, the very high prices paid for southern bluefin tuna mean that even low catches from a depleted stock are economically viable.

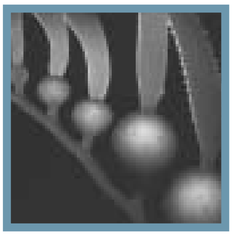
Skipjack tuna *Katsuwonus pelamis*

Distribution

Skipjack are widely distributed in Australian waters from Lady Elliot Island in Far North Queensland south to Storm Bay (Tasmania), excluding the Great Barrier Reef; from Kangaroo Island in the GAB west and north to beyond Broome, (Western Australia). Globally, skipjack are distributed throughout all tropical and subtropical waters except for the Mediterranean Sea and the Black Sea. In Australia, the main fishing area for skipjack is from Ulladulla (New South Wales) to just south of Gabo Island (Victoria).

Fishery profile

In Australia skipjack have been a part of the southern bluefin tuna fishery in the GAB since the 1950s. However catches are limited due to the low value of the fish. The skipjack tuna fishery is managed as part of the ECTF. Tuna fisheries are managed by the Commonwealth in all states except New South Wales, which has jurisdiction to 3 nautical miles from the territorial sea boundary. From the area of the south Pacific, annual skipjack catches rose from less than 5000 t in the early 1960s to about 220 000 t in the early 1980s. Total standing stock in the west and central Pacific is estimated to be three million tonnes in late 1970s-early 1980s. Stock structure is uncertain. Two popular hypotheses list at least five subpopulations within the Pacific, including two in the western Pacific. There are no distinct subpopulations, however the probability of skipjack schools interbreeding is proportional to the distance separating schools. Between 1985–86 and 1991–92 catches rose from an estimated 150 t to about 6000 t.



Biological & ecological profile

The preferred water temperature for skipjack is between 20°C and 30°C, however, they are sometimes found in waters as cold as 15°C. Minimum [O_2] requirement for skipjack to maintain a minimum swimming speed is 2.5 ml/L of seawater. Higher levels are required when activity levels increase. Maximum depth for skipjack is about 260 m, or above the thermocline where [O_2] levels are sufficient. Skipjack are a short-lived, fast-growing, highly fecund species. In Australian waters skipjack probably live to four years of age and a maximum length of about 80 cm FL. Maturity is reached at about 40–45 cm FL at an estimated age 1–2 years old. Skipjack probably spawn in the Coral Sea and in waters off northwestern Australia. In equatorial waters, spawning occurs year round. In subtropical waters the season is restricted to summer/early autumn. In tropical waters reproductively active females spawn almost daily. Estimates of the number of eggs released at each spawning range from 100 000 (small females) to two million eggs (large females). Off eastern Australia, larvae are distributed southwards into subtropical waters via the East Australian Current.

Key knowledge gaps and uncertainties

There are no estimates of sustainable yield or stock size for skipjack in Australian waters.

Ray's bream *Brama brama*

Distribution

Ray's bream are members of the family Bramidae. They are widely distributed in oceans of the Southern Hemisphere and a similar form (which appears to be another species) occurs in the Northern Hemisphere. Other bramid species are taken in the Region, eg the big-scale pomfret, *Taractichthys longispinnus* and the golden pomfret, *Xenobrama microlepis*, but they are easily distinguished based on body shape, fin shape and colour. In Australia, Ray's bream is distributed throughout southern waters from Narooma (New South Wales) to Israelite Bay (Western Australia), including Tasmania, in temperatures between 9–13° C. They commonly inhabit the upper 200 m of the water column.

Fishery profile

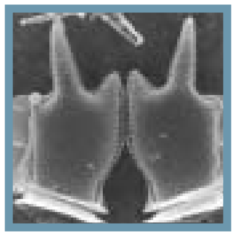
Ray's bream is caught primarily as a bycatch species in long-line fisheries for tuna, but has also been taken via pelagic trawling. Little fishery information is available for this species in Australian waters. The current and pre-exploitation age/size structure is unknown for Australian waters. Current yield is unknown, however Last & Baron (1994) estimated the catch of Ray's bream to have been in excess of 250 t between October and December 1993. Highest average catch rates, in excess of 40 fish per 1000 hooks, were obtained in November south of 40° S, with the majority coming from areas south of 44° S.

Biological & ecological profile

The biology and ecology of Ray's bream in Australia has been poorly studied.

Key knowledge gaps and uncertainties

As a consequence of the lack of research into the biology and ecology of this species in Australian waters, the population stock structure of Ray's bream in Australia is unknown.



Blue shark *Prionace glauca*

Distribution

Blue sharks are cosmopolitan occurring in both temperate and tropical oceanic waters. They are an oceanic pelagic species occurring from the surface to 350 m waters.

Fishery profile

The blue shark represents the main shark species in the bycatch of Japanese and domestic tuna and billfish longline fisheries. It is also taken in limited quantities in other fisheries. In Australia, it is targeted by small-sport fisheries, operating mainly off New South Wales. The most recent assessment was undertaken in (1998) based on logbook returns and observer catch monitoring. Japanese longliners have previously taken up to 1100 t/year from Australian waters. Domestic longliners reported a total catch of 45 t in 1997, but this is considered an under-estimate. There is no evidence of a decline in Australian waters. Other areas have shown small (20%) decline. Because the blue shark is a highly migratory species whose range encompasses international and multi-jurisdictional boundaries, it is difficult to manage. Illegal finning is a continuing threat due to high prices for fins.

Biological & ecological profile

Extensive (trans-oceanic) movements of the blue shark are associated with their reproduction and linked to ocean currents. Females move into coastal New South Wales to mate and give birth between September and December. Males are present in the area throughout the year. Gestation lasts nine to 12 months. Litters of up to 135 (average 35) are nourished by yolk-sac placenta. The full length of the female cycle is uncertain and therefore annual fecundity is not known. Males mature at around 4–6 years of age, while females mature when they are 5–7 years old. Longevity for the species is estimated to be around 20 years. Blue shark have high natural abundance and are more productive than many other sharks. It is likely that blue shark are therefore more resilient than other shark and ray species. Stock structure of blue shark is poorly known worldwide. Movement studies indicate that there is broad-scale mixing (Trans-Atlantic, Pacific-Atlantic).

Key knowledge gaps and uncertainties

Generally, the quality of the data is poor. The biology of this species is not well understood. More generally, the ecological effects of removing sharks as top predators are unclear.

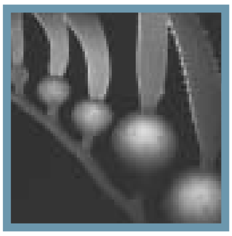
Patagonian toothfish *Dissostichus eleginoides*

Distribution

Distributed around the southern coast of Chile, the Patagonian shelf, and the subantarctic islands of Kerguelen, South Georgia, and Macquarie Island. Adult fish live in deep waters on the continental slope from 700–2500 m

Fishery profile

Since the mid-1980's the total world catch of toothfish has ranged between 2804 t to 75 500t in 1996–1997, including illegal catch. Patagonian toothfish are commonly marketed under the name Chilean Sea Bass. The fishery for toothfish began around Macquarie Island in 1994. They are caught using deep-sea trawl and deep-sea longline. Longlining for toothfish is not allowed within the Australian EEZ due to bycatch of albatross and other seabirds. The fishery for Patagonian toothfish operates south of the Polar frontal zone. Estimated annual consumption of toothfish by vertebrate predators was 28% of the highest estimate of biomass. The current fishery for toothfish will most likely impact on southern elephant seals, whose population has



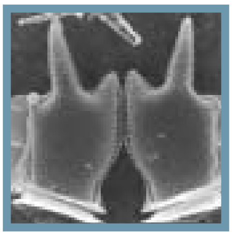
decreased by 50% between the 1950s and 1980s. Since 1992 there have been limited fisheries in Antarctica (around South Georgia) for toothfish. Fishing for toothfish was expanded to cover the whole of the Southern Ocean by 1997. Member states of CCAMLR have been compelled under domestic pressures to set catch limits above precautionary levels, despite limited information on biology and population size). It is estimated that more than 80% of the total toothfish catch (estimated annual value of US$500 million) is taken by illegal means. At the 2000 CCAMLR meeting it was estimated that illegal fishing took 50% more toothfish than in the previous year and the meeting noted that if illegal fishing continued at its present rate, toothfish would be commercially extinct in three years. Since the start of the 1998–99 fishing season catches and CPUE in all grounds around Macquarie Island have declined. Around 4564 fish have been tagged off Macquarie Island since the start of the 1995–96 season with a 11.5% recapture rate. Little movement/migration has therefore been noted. Established fishing grounds off Macquarie Island include the Aurora Trough, Colgate Canyon, Grand Canyon, and Beer Garden. Results of tagging and CPUE have seen a progressive reduction in TAC in the Aurora Trough from 750 t in 1996/97 to 200 t in 1997/98. Since 1999 Aurora Trough has been closed to fishing apart from a 40 t research quota. At the close of the 2000 season, tag-recapture models for the Aurora Trough showed a decline to approximately 30% of the pre-tagging available biomass. In the Northern Valleys region the decline may be much less than 30%. The magnitude of the decline ranges between 6:1 and 21:1 for the Aurora Trough and 3:1 to 28:1 for the Northern Valleys region.

Biological & ecological profile

These are slow growing and late maturing fish. In the Patagonian area, spawning of large pelagic eggs (4.3–4.7mm diameter) is thought to take place on the continental slope at about 500 m depth, with hatching occurring between August and November. Juveniles probably remain pelagic for a year until they reach 15–20 cm TL when they become demersal. Sexual maturity in the female is reached at a size of 90–100 cm TL (9–12 years), males at 64–94cm TL (7–11 years). Maximum recorded size is well above 2 m. The rate of natural mortality is low (less than 0.2) due to the longevity of the species, which is thought to be in the order of 35–50 years. At Heard Island the length at maturity is about 97.5 cm. No information on maturity is available for Macquarie Island because the catch consists of immature fish. At Heard Island spawning is thought to occur around June. Otolith analysis revealed an age maximum of 43 years. There is a major genetic break between populations of Patagonian toothfish in the Southern Ocean and those on the South American Plateau. In the Southern Ocean there are genetic differences among the isolated populations around subantarctic islands with little long-distance gene flow. Each small, localised population is a separate stock.

Key knowledge gaps and uncertainties

Long-lining activity has resulted in significant seabird bycatch in the toothfish fishery. Estimated bycatch of seabirds from illegal fishing for 1995–1999 was 105 900 to 257 000 birds. Reduced bycatch is aided by setting lines at night. In 1999 CCMALR adopted a Catch Document Scheme aimed at allowing member states to track the international trade in toothfish and to oblige member states not to import illegally caught fish. Sub-adult fish (<50 cm) are often caught in trawls as an incidental bycatch on the Patagonian shelf. The rough terrain around Macquarie Island has precluded a trawl survey that could provide a fishery-independent estimate of biomass.



Blue eye trevalla
Hyperoglyphe antarctica

Distribution

The blue eye trevalla is a widely distributed and highly valued species that belongs to the family Centrolophidae. It occurs throughout the Southern Hemisphere in waters of the continental shelf and upper slope and is associated with seamounts. A similar species, ocean blue eye (*Schedophilus labyrinthicus*), is sometimes caught in large quantities off New South Wales and may occur in other areas of southern Australia.

Fishery Profile

No quantitative stock assessment has been made for this species. Since 1998, it has been managed by global TAC (trawl and non-trawl). Catch rates have exceeded global TAC in 1999 and 2000. Currently the fishery is dominated by new recruits ranging in size between 45 and 55 cm FL, which is well below the size at first spawning. Declines in catch rates of older fish (>65 cm FL) were recorded in the early years of the fishery on seamounts off Tasmania. Gear selectivity and spatial patterns of effort influence catch rates and their size composition. In the short term, there do not appear to be major concerns about the sustainability of this fishery, although the species may be vulnerable to serial depletion in offshore regions if adult movement patterns are limited. Large adults are vulnerable to the dropline fishery during spawning aggregations. Recently, large catches have been reported from ridges off the New South Wales coast, although a component of this catch (unknown at this stage) appears to be ocean blue eye (*Schedophilus labyrinthicus*).

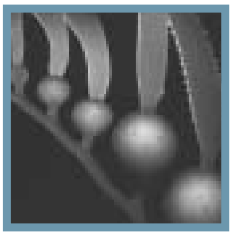
Biological & ecological profile

From genetic studies, there appears to be a single population of blue eye trevalla in Australian waters. The depth distribution is size dependent, with larger fish occurring in deeper water. Tagging studies of juveniles in New Zealand suggest that juveniles (two to three years) undertake significant movements along the continental slope.

The adults are believed to be more sedentary. Both sexes mature at a large size (females 71 cm, males 62 cm). Spawning occurs in summer-autumn but its timing varies across the region, occurring in March-April in Tasmania and April-June in New South Wales. Fecundity is high, and females spawn between two and 11 million eggs each year in three or four batches. Larvae have not been described and larval distribution is unknown. Juveniles appear to be pelagic up to 45 cm FL, and early stages are believed to be associated with kelp rafts. Growth rate is initially rapid, with fish reaching approx 30 cm in the first year and approximately 60 cm in the second. Recruitment to the fishery occurs between two and three years of age, while sexual maturity is reached at six to seven years of age.

Key knowledge gaps and uncertainties

Complex spatial and seasonal variability in size structure and availability suggest movement patterns and behaviour of fish are key uncertainties. The perceived sedentary nature of adults may lead to serial depletion of adult stock unless catch rates in discrete areas can be appropriately regulated. The relationship between fish in offshore (eg seamount, offshore rise) and continental slope regions remains unclear. Medium size fish (55–65 cm) are poorly represented in the commercial catch (all sectors) suggesting that they are either in habitats yet to be actively fished or are behaving in fundamentally different ways to other size classes. Blue eye are vulnerable to fishing pressure during spawning aggregations, but the effects on spawning success are unknown. Aggregated behaviour during spawning suggests that blue eye may be suitable for fishery-independent measures of stock size (eg acoustics or egg surveys), however such surveys would need to be regionally specific. Strong gear selectivity, changes in fishing efficiency, areas fished and depth specific size composition suggests that considerable caution needs to be applied to interpretation of catch composition in fishery and that there are considerable implications for shifting effort between sectors (eg dropline to trawl). Niche overlap and relative abundance of blue eye versus ocean blue eye needs identification, particularly in offshore New South Wales waters.



Jackass morwong
Nemadactylus macropterus

Distribution

Jackass morwong occur throughout southern Australia, from Moreton Bay (Queensland) to Perth (Western Australia) and around Tasmania. They are also found in New Zealand, South America, southern Africa, Amsterdam and St Paul Islands in the Indian Ocean. A related but larger species (King Tarakihi – *Nemadactylus* n. sp) occurs on offshore rises.

Fishery profile

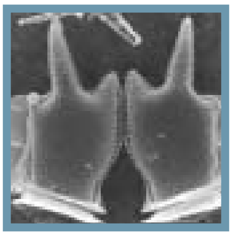
The majority of jackass morwong catch is taken by trawl and Danish seine, but the species is fished also by fish traps, line fishing and, occasionally, gill nets. The species is currently managed as a single stock. Catches peaked in 1981 (2200 t) and have averaged 1400 t between 1981 and 1993. Since 1992, TAC was set at 1500 t, and jackass morwong catches by the South East Fishery have ranged between 50–75% of this TAC. A catch rate performance criterion was triggered in 1995, 1996 and 1998. Catch rates exceeded this criterion in 1999, but reached a record low in 2000. Catch rates for jackass morwong may be inversely correlated with flathead. Market forces also have an effect on catch rates and there is competition on the domestic market with imports from New Zealand. In 2000 the catch in the SEF was 882 t, which amounted to 57% of the allocated TAC. Similarly, the agreed TAC in 2001 was 1185 t, with an actual TAC of 1413 t. Seasonal and depth variations in catch rate occur across the entire SEF area, with abundance being highest at depths between 100 and 149m and in summer. Some industry members have expressed concern regarding the status of the stock, although most believe that reduced catch rates are a result of environmental influences.

Biological and ecological profile

Adults and juveniles are demersal. Jackass morwong are serial spawners, with regional variations in the timing of spawning. In eastern Bass Strait spawning occurs in summer and autumn, with 80% of spawning activity occurring between April and June. Off eastern Tasmania, spawning peaks in summer. Females mature at three years of age. Females grow faster and live longer than males. Maximum age estimates for eastern Tasmanian fish are 41 and 30 years for females and males respectively. Jackass morwong have a protracted pelagic larval period (~8–12 months) with larvae occurring at the surface in offshore waters to at least 250 km from the shelf break. Dispersal of long-lived larval stages is linked to offshore oceanographic processes within the South-east Marine Region. Larvae have been described from southern Australia and have been recorded from southern New South Wales to southern Tasmania. There is some evidence for discrete nursery areas in south-eastern Australia – juveniles are restricted to coastal waters of Bass Strait and Tasmania, rarely caught in eastern Victoria, New South Wales or the GAB. Recruitment of pelagic post-larvae to shelf waters of Storm Bay and the east coast of Tasmania occur over an extended period during spring and early summer (September-January). There may be some movement of adult fish from eastern Tasmania into eastern Bass Strait during autumn. Genetic studies indicate that there is a single population of jackass morwong in Australia, with no convincing evidence of genetic structuring in the population. Australian and New Zealand populations are genetically distinct, the degree of differentiation corresponding to an estimate of ~80 migrations per generation.

Key knowledge gaps and uncertainties

Further research needs to be undertaken to assess whether jackass morwong in Australia represents a single stock. The extent to which catch rates are influenced by recruitment variability or environmental influences on stock availability remains uncertain. The possibility of environmental influences on recruitment variability warrants further investigation.



Flatheads *Neoplatycephalus* spp. *Platycephalus* spp.

Distribution

Distribution differs between species. Tiger flathead are found off northern New South Wales through to western Bass Strait and Tasmania.

Fishery profile

The sustainable yield of flathead is estimated at 2500–3000 t per year. The 2000 landed weight in the SEF was 3325 t with all but 103 t caught in Commonwealth waters. As a resource this species is being fully exploited. Catches were considered stable between 1986 and 1992 increasing between 1993 and 1999. Most other indicators of current stock status appear stable. There is some evidence of localised depletion off the New South Wales coast. Recruitment overfishing caused a collapse of the stock in the 1940s. Flatheads are targeted using both the Danish seine and trawl. Over 90% of the flathead catch taken is thought to be tiger flathead (*N. richardsoni*). Catches of tiger flathead, gold spot/toothy flathead (*N. aurimaculatus*), sand flathead (*Platycephalus bassensis*), *P. caeruleopunctatus* and *P.speculator* are regulated under a single combined 'flathead' quota within the SEF. Other flathead species are unregulated. Flatheads are also taken in the GAB trawl fishery.

Biological & ecological profile

Tiger flathead are found in waters of 10–400 m depth (more typically 30–160 m). They are mostly a demersal species on sandy or muddy bottoms, moving into the water column to feed at night. Mature adults move inshore to spawn. Catches are highest during summer months. Most recaptures of tagged fish have indicated movements of less than 50 km, however there remains a limited understanding of movements. There is an extended spawning season of October to May, which may begin earlier in the north. Up to 2.5 million eggs are produced per female. Eggs and larvae thought to be pelagic in nature while juveniles are assumed to occupy nursery areas inshore of fishing grounds. Flathead reach a maximum age of eight to twelve years and recruitment is at three to four years. No detailed studies of stock structure have been conducted although there is little evidence of more than one stock amd flathead are assumed to be a single stock for management purposes.

Key knowledge gaps and uncertainties

There is poor knowledge of effects of fishing on minor species. Increased catches of smaller flathead could represent an unregulated species with a high discarding rate of 13% (511 t) recorded in 2000, particularly of small fish. There are some concerns over the quality of logbook data and its suitability for assessment. Unstandardised catch rates between seine and trawl sectors are also a complication. Stock assessments are out of date and stock structure is unknown. Rates of movement, location and habitat requirements of juveniles also remain unknown.

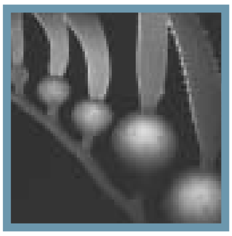
Pink ling *Genypterus blacodes*

Distribution

Pink ling are members of the family Ophidiidae. They are distributed from Newcastle (New South Wales) to Brusselton (Western Australia) including Tasmania, on the continental shelf and slope in waters between 40–900 m, but are mainly caught between 300–600 m depth. They are also recorded from New Zealand and South America. The related rock ling, *Genypterus tigerinus*, is also caught in the Region but is restricted to inshore waters in depths of less than 60 m.

Fishery profile

Ling were initially a bycatch species of the gemfish and blue grenadier fisheries in the SETF but they are now targeted in both the trawl and non-trawl sectors. In the latter, they are caught by longline, drop-line, traps and mesh nets. The trawl catch has been regulated by individual transferrable quota (ITQ) since 1992. ITQs were also introduced for the non-trawl sector in 1998. The current management objectives are to maintain the recruited biomass at the 1995 level and maintain CPUE



at or above its lowest annual average level from 1986 to 1994. Quantitative assessments for ling in the SEF were completed in 1999 and 2000 and stock assessment reports are available for 1994 and 1995. In 1987–88, the annual standing stock of pink ling in western Bass Strait was estimated at 1055 t. The mean annual biomass of pink ling in eastern Bass Strait was 3,200 t during 1992 and 1994. The 1999 assessment estimated the size of the overall stock to be between 6-48% of virgin (ie pre-fishing) biomass. The current stock status is estimated at 20–70% of the unfished biomass (taken as the 1977 biomass level). Commercial catches in the SEF increased from 790 t in 1984 to 1972 t in 1999 generally following the increase in TACs. However, catch rates have been stable since 1997. Fishery-independent catch rates off New South Wales were similar in 1976–77 and 1996–97.

Biological & ecological profile

Ling are believed to be relatively sedentary, although some movements associated with spawning have been reported (inshore to shallow water off western Tasmania and to sites off eastern Bass Strait and southern New South Wales). Spawning aggregations have been reported by commercial fishers off Strahan (Tas), Lakes Entrance (Victoria) and Gabo Island (New South Wales) during spring, although the occurrence of larvae suggests a more protracted spawning period. Larvae have been found in Tasmanian waters in all months except June, with peak abundances in September-October and January-February, however the specific identities of these larvae were not confirmed and may include the related rock ling (*G. tigerinus*). Dispersal is believed to occur in the early life history stage, as adults are believed to be sedentary. Ling have been aged using otoliths and the maximum reported age in Australia is 28 years. Juvenile and adult ling inhabit a variety of substrates from rocky ground to muds. Recent video footage has shown considerable numbers of ling on low relief rocky reefs in southeastern Australian shelf waters and these areas may currently provide refuge for the species. Ling are primarily epibenthic feeders and feed on fish. They are prey species of tiger flathead. Genetic studies of stock structure suggest that there is a single stock.

Key knowledge gaps and uncertainties

Catch rates appear to be affected by changes in fishery practices, environmental factors, or other extraneous factors such that CPUE is not a reliable indicator of abundance trends. Limited fishery independent data. Basic biology, reproduction and movements are poorly known.

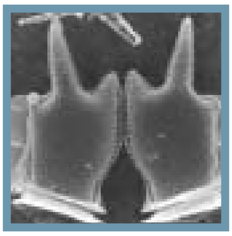
School whiting *Sillago flindersi*

Distribution

School whiting are distributed throughout southeastern Australia from eastern South Australia to southern Queensland. They prefer clean sandy substrate from the surf zone to depths of about 55 m. The major fishery is located in the eastern and central regions of Bass Strait. The species is distributed as a series of discrete stocks, and there is substantial genetic evidence to support the hypothesis that many of these stocks are separate populations.

Fishery profile

The agreed TAC for 2001 was 1500 t with the actual TAC exceeding this limit and reaching 1899 t. Annual landings of this species were close to zero in the early 1970s (from 1947 to 1970 annual catches ranged from 30–270 t), rising to 2000 t by 1986. Annual landings were generally under 250 t until a rapid increase in the mid–1970s. Landings peaked during the early 1990s at over 1500 t, however these figures have been declining in recent years. In 2000 the landed weight of school whiting was 759 t, which was 41% of the allocated TAC of 1870 t. The bulk of the catch is taken by Danish seine operating from Lakes Entrance and San Remo. The biomass of the eastern Bass Strait stock was estimated to be about 20 500 t in 1986. School whiting have a high annual mortality rate of 0.7–0.8. The current estimate of natural mortality ranges between 0.9 and 1.1, however there is considerable doubt about these figures. The age classes of this species stratify with



water depth. Ages of school whiting in catches ranged from one to eight years, but most were two to four year olds. There appeared to be a slightly greater proportion of older fish in catches in 1991 and 1992 while one year old fish were more numerous in the 1995 catch than in other years.

Biological and ecological profile

In eastern Bass Strait, spawning begins in October and continues until March of the following year. Mean potential fecundity ranges from 39 000 eggs for a two year old female to 115 000 eggs for a six year old female. Eastern Bass Strait school whiting grows to about 26 cm and eight years of age. Sexual maturity occurs at two years of age and eastern school whiting are multiple spawners. School whiting from central Bass Strait have a significantly different growth rate to those from eastern Bass Strait. Off northern New South Wales, peak spawning occurs during winter. Larvae can be distinguished from the similar *Sillago bassensis* on the basis of pigment and have been recorded from shelf waters throughout the Region, particularly in Bass Strait. Juveniles are generally found inshore of the adults. Recruitment is thought to be variable and full recruitment to the fishery occurs at 2–3 years of age, although one year olds are also taken. There is no direct evidence of migration by eastern school whiting. There are four stocks: north of Newcastle, Jervis Bay to Portland, west of Portland to southeast South Australia, and Tasmania. Three of the four stocks lie in the SEF. The boundaries between these stocks are not precise.

Key knowledge gaps and uncertainties

Eastern school whiting are targeted by recreational fishers. The size of the recreational catch is unknown, but possibly significant. The annual catch has largely been dictated by export demand. Because of the stock structure and apparent lack of large-scale migration, there is a risk of localised depletion if fishing pressure increases.

Jack mackerel *Trachurus declivis*

Distribution

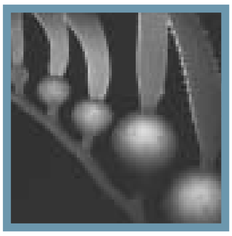
Jack mackerel are members of the family Carangidae. They occur throughout southern Australia from Wide Bay (Queensland) to Shark Bay (Western Australia), including Tasmania. A second species, the Peruvian jack mackerel (*Trachurus murphyi*) has been recorded in catches in recent years.

Fishery profile

Jack mackerel are taken predominantly by the SENTF although they are also taken in the SETF. The fishery is mostly concentrated in Tasmanian waters where it is based on large seasonal surface and subsurface schools that occur on the shelf in east coast waters from November to May.

Biological & ecological profile

Spawning is thought to occur throughout the species' range in southern Australia, although it is regionally variable in its timing. Spawning occurs in the GAB in summer between October and January off New South Wales, between November and February along the east coast of Tasmania where spawning fish move to the shelf break, becoming unavailable to the inshore fishery. The timing and spatial extent of spawning off eastern Tasmania appears to be consistent despite significant interannual changes in hydrography as a result of La Nina events. However, reproductive output may be influenced by the availability of food in the year prior to spawning Movements of adult fish may also be in response to the summer peak abundances of the lantern fish *Lampanyctodes hectoris*, a major prey species, in the shelf break region. Larvae have been described and recorded in shelf waters of eastern Tasmania from December to April and in southern New South Wales and Victorian waters (including Bass Strait) Tasmania and South Australia. Concentrations of larvae in excess of 500 per m^3 have been reported off eastern Tasmania in January. After spawning, adults return inshore where they re-enter the fishery in April-May. Both adults and juveniles usually inhabit continental shelf waters where they form dense schools. Jack mackerel are pelagic



crustacean feeders and omnivores, feeding on krill Nyctiphanes australis and pelagic fish (*Lampanyctodes hectoris*). There is some evidence that there are multiple stocks or sub-populations within eastern Australia.

Key knowledge gaps and uncertainties

Further data are required to elucidate stock structure. Regional patterns of movement poorly documented. The extent of catches of the related species Peruvian jack mackerel (*Trachurus murphyi*) is unknown.

Redbait *Emmelichtys nitidus*

Distribution

Redbait are members of the family Emmelichthyidae. They occur throughout all southern Australian waters south of 30°S and also occur in New Zealand, South Africa, Chile and oceanic islands in the same latitude.

Fishery profile

Redbait are largely a bycatch of the jack mackerel purse seine fishery however, they also form independent schools that may be targeted. Redbait are used largely for fishmeal, but have the potential for greater use as bait in the tuna industry. Annual landings currently may exceed 1000 t, with recorded peak landings in 1987–88 at 1280 t.

Biological & ecological profile

Very little is known of the biology and ecology of this species. Redbait are found throughout the continental shelf region, but are more common in water depths of 20–100 m. Spawning takes place in Tasmanian waters between October and January.

Key knowledge gaps and uncertainties

No studies on stock structure have been undertaken and our knowledge of its biology and ecology is generally poor.

Striped trumpeter *Latris lineata*

Distribution

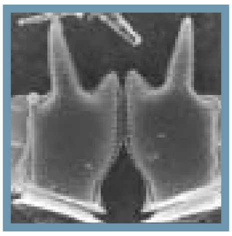
Striped trumpeter are members of the family Latridae. They are distributed throughout southern Australia from Sydney (New South Wales) to Kangaroo Island (South Australia) including Tasmania.

Fishery profile

Striped trumpeter are taken by a variety of methods including hook and gillnet (in Tasmanian State waters). They are targeted in the SENTF, are caught as bycatch in demersal trawling on the shelf (SETF) and as bycatch in the SSF. Striped trumpeter are also taken by recreational fishers – juveniles are taken in graball (gill nets) on coastal reefs and adults are taken by hook and line on offshore reefs. They are assumed to be a single stock in Australian waters. Current catches are approximately 100 t per annum. CPUE has generally increased in handline and dropline sectors of the fishery. There were significant increases in annual catch in the late 1990s due mainly to increasing effort in the handline and dropline sectors. There have been no formal stock assessments, although catch and effort trends are examined annually by the Tasmanian Aquaculture and Fisheries Institute.

Biological & ecological profile

Larger fish are found in deeper waters, indicating movement from inshore nursery areas to adult habitat on mid and outer shelf reefs. Fish originally tagged in Tasmania have been recaptured in southern New South Wales and the St Paul-Amsterdam Island group in the South Atlantic Ocean, indicating movements within the Region and broadscale oceanic movements. Striped trumpeter are multiple spawners. Fecundity increases with fish size. Spawning occurs on deep reef habitats from July to early October. Timing of spawning varies, with spawning occurring earlier in the northern part



of the species distribution. There is evidence of inter-annual recruitment variability. From laboratory studies, larvae appear to be long-lived and to have a similar pelagic juvenile phase to that of morwongs (cheilodactylids). However, the distribution of larvae in the wild is poorly known. Latrid larvae have been recorded from shelf waters of western Tasmania in September and October, although the species identification is uncertain. Juveniles occur on shallow reefs throughout southeastern Tasmania and remain attached to a site for several years. Larger juveniles gradually move to deeper offshore reefs. They occur mainly on the continental shelf over rocky reefs in depths to 300 m. Adult striped trumpeter are benthopelagic piscivores and prey on a variety of benthic and benthopelagic fish including ocean perch (*Helicolenus percoides*).

Key knowledge gaps and uncertainties

Little information is available of the size of the resource or the sustainability of current catches. Trends in CPUE are influenced by variations in the strength of year classes entering the fishery. The composition of the stock in terms of age and size has not been documented but is influenced by interannual variability in recruitment. Basic population parameters (growth, mortality and reproductive biology) are poorly known. There have been no genetic or otolith microchemistry studies of stock structure. Movements of juveniles and adults are poorly known and the extent to which larvae/pelagic juveniles disperse is also unknown. The recent recapture of a Tasmanian tagged fish from oceanic islands in the South Atlantic indicates movements can be extensive and that stock structure may be complex.

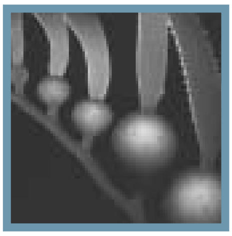
John dory *Zeus faber*

Distribution

John dory are members of the family Zeidae. They are widely distributed in coastal and continental shelf waters of Australia, the eastern Atlantic Ocean, Mediterranean Sea, Japan and New Zealand. In Australian waters they occur from Moreton Bay (Queensland) around the south coast to Cape Cuvier (Western Australia).

Fishery profile

John dory are caught largely as bycatch in the SEF when trawling for tiger flathead and jackass morwong, although some targeting occurs on inshore trawl grounds. They are also caught by several sectors outside the Region (particularly between Sydney and southern Queensland). John dory are managed by TAC (trawl sector only) with the objective of ensuring the spawning biomass does not fall significantly below its 1994 level and that CPUE is maintained above its lowest annual average level from 1986 to 1994. They are assumed to be a single stock throughout the Region. Catch rates in SETF have varied between 6 kg/h and 12 kg/hr. They were estimated at 7.4 kg/hr in 1999 with little seasonal variation. Catches are highest between depths of 150–200 m, although this largely reflects the distribution of trawling effort for flathead and morwong rather than distribution of John dory. Significant declines in catch rate were recorded from 1994–1998, with a slight increase in 1999. It is unknown if this reflects changes in abundance or changes in fishing practices, although generally it is considered that this reflects declining abundance. Discarding levels are believed to be low and probably restricted to small fish (reflecting the high market value of the species). Recruitment (or catchability) is interannually variable with fishers reporting good and bad years. John dory are also taken by recreational fishers, but the extent of catch and effects on the population are unknown.



Biological & ecological profile

John dory are a widely dispersed species on fishing grounds within the Region and aggregations of this species are rare. They are serial spawners, with spawning occuring from December to April in New Zealand. Recruitment appears to vary from year to year. Larvae have been described in various regions of the species distribution (eg New Zealand and the Mediterranean Sea) but have not been identified in Australian waters and their distribution in the Region is unknown. John dory are piscivores and feed primarily on benthopelagic fish. They are major predators of small redfish. John dory is assumed to form a single stock, although differences between size-at-age in New Zealand and Australia suggests that some separation occurs across the Tasman Sea.

Key knowledge gaps and uncertainties

Biological aspects of the species are poorly known (eg age validation, size-at-age, age-at-maturity, growth rate, mortality) and there are no fisheries-independent data to allow conclusive stock assessment. The variability in recruitment, driven by changes in environmental conditions, is considered a possible factor in the observed decline in abundance, but there are little data available to substantiate this.

Hapuka *Polyprion oxygeneios*

Distribution

Hapuka are members of the family Polyprionidae. They are distributed throughout southern Australia from Sydney (New South Wales) to Rottnest Island (Western Australia), including Tasmania. Elsewhere they occur off New Zealand and Chile.

Fishery profile

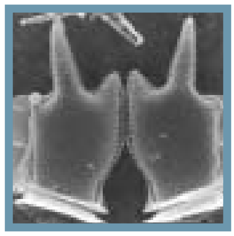
Hapuka make up a small portion of the bycatch of the blue eye trevalla fishery in southern Australia and are caught primarily by dropline, although they are also taken by trawl, gillnet and longline. In New Zealand they are targeted in the long-line fishery, but are not landed in large numbers in Australia. Catches of the closely related bass grouper, *Polyprion americanus*, were initially included in New South Wales catch statistics (until 1998) and hapuka were initially included in blue eye trevalla catch statistics in Tasmania. No stock assessments are available for hapuka. New South Wales dropline catches of bass grouper and hapuka combined ranged from 30 t–40 t in the mid–1980s, increasing to 50 t–70 t in the early 1990s and subsequently decreased to 30 t. When first separated from bass grouper in 1998 catch statistics, hapuka catch was recorded at 6 t. Trawl catches ranged from 3 to 9 t from 1986 to 1994 and then increased to 18 t–6 t from 1995 to 1998 with the increase coming from offshore seamount fishing.

Biological & ecological profile

Tagging studies of hapuka in New Zealand have demonstrated that this species is capable of long-distance migrations, up to ~1350 km. Larvae are undescribed. Juvenile hapuka are thought to live a pelagic existence in surface waters well offshore and are often associated with flotsam. Juvenile hapuka switch to a demersal habitat at about 50 cm TL and an estimated age of three to four years. Adults are often associated with deep reefs on the continental shelf as well as canyons of the continental slope to a depth of about 450 m.

Key knowledge gaps and uncertainties

Very little is known about hapuka in Australian waters.



Orange roughy
Hoplostethus atlanticus

Distribution

This species is demersal on the mid-slope (700–1200 m) and seamounts throughout the Region. Most targeted fishing is around Tasmania. It is a high value species taken by deep water trawl. Largest roughy catches are taken in the SEF with smaller catches in GAB Trawl. Catches are also taken in international waters including the STR (where the straddling stock is managed by Australia and New Zealand) and Lord Howe Rise. Orange roughy is the primary target species in the STR fishery

Fishery profile

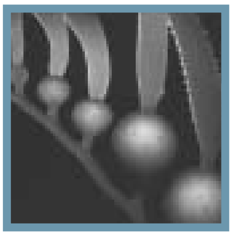
There was a shift in effort to distant grounds including the Cascade Plateau and South Tasman Rise in the late 1990s. SEF management is based on TAC for several zones. It is a management objective that stocks will be above 30% of virgin biomass by 2004. Stock size is estimated to be 10–26% of virgin biomass. In the SEF Southern Zone the TAC was 700 t and catch 311 t in the year 2000. There was a dramatic decline in catch rates in 1993 and aggregations are no longer forming in this area. In the same year, the SEF Western Zone TAC was 1600 t, catch 192 t. There is a 90% chance that management objectives are not being met, as the biomass is too low. Cascade Plateau: Current catches appear to be sustainable but there has not been a formal assessment. South Tasman Rise has consistently declining catches and has also not been subject to a formal assessment. There are no trends in data in the GAB trawl and catches are limited. Huge catches (>50 t per shot) have been taken and aggregations present essentially fixed targets when located. Sustainable yield is believed to be only a few percent of virgin biomass. The species has declined in other areas of the world where it is fished. Initial estimates of virgin biomass based on acoustic and egg surveys are approximately 100 000 t. Depletion is currently believed to be 20–30% or less of virgin biomass depending on stock structure analyses, the results of which are inconclusive. Serial depletion of the population has been recorded during the life of the fishery as operations target successively unfished seamounts and grounds. There are suggestions that vessel and trawl activity around spawning aggregations may disrupt spawning behaviour. Vulnerability of the stock is also increased by likely episodic recruitment patterns where recruitment to the adult population may be extremely low for periods of up to or greater than a decade. Highly episodic recruitment appears to drive the size structure of the fished population rather than fishing impacts per se. This recruitment variability may considerably influence risk of stock collapse and is generally not well handled in stock assessment models.

Biological & ecological profile

This species is an exceptionally long-lived deepwater species that is highly vulnerable to overfishing. Vulnerability stems from highly predictable aggregating behaviour (during spawning) and flee response to approaching trawl whereby individuals descend to the bottom when alarmed. Orange roughy are generally accepted to live around 100 years, but this has been disputed. They mature late, at 20–30 years and form spawning, pre-spawning and non-spawning aggregations. Spawning occurs in winter, with the exact timing varying between grounds. Spawning aggregations are targeted east of Tasmania. Spawning has been reported in eastern Tasmania, the Cascade Plateau and South Tasman Rise. Annual fecundity is low compared to other teleosts (11 000–180 000 eggs per female). The stock structure remains uncertain. Morphometric data suggests several stocks. Early allozyme (genetic) studies suggest no stock differences but other genetic studies suggest stock differences. Otolith shape analysis suggests eastern and southern zones are common migratory stock

Key knowledge gaps and uncertainties

Estimates of natural mortality are problematic. 1997, 2000 and 2001 stock assessments give conflicting results for eastern sector. It is not clear that management objectives for sustainability are being achieved and biomass estimates remain uncertain. There are no biomass estimates or formal assessments of the Cascade Plateau or South Tasman Rise.



Oreos *Allocyttus niger, A. verrucosus, Neocyttus rhomboidalis, Pseudocyttus maculatus*

Distribution

From New South Wales to Western Australia including Tasmania, mid-slope and seamounts. Adults live near the bottom, typically 750–1200 m.

Fishery profile

Oreos are taken as a bycatch in fisheries for orange roughy but are becoming increasingly targeted, especially around southern Tasmania. They are managed by the Commonwealth within the SEF but there are no set TACs or ITQ arrangements in place. Oreos are also taken in the GAB trawl fishery. *N. rhomboidalis* and *P. maculatus* were the main species landed in 1997. Annual SEF catches increased from around 60 t in 1985–1988; around 900 t in 1989–1990 and around 2000 t in 1997. GAB Trawl catches are highly variable: 30–200 t/year.

Biological & ecological profile

Adults form large shoals over seamount pinnacles and near canyons while smaller oreos are often distributed over smooth ground. They also occur on the Cascade Plateau and possibly the South Tasman Rise. *P. maculatus* and *A. niger* spawn in late spring/early summer. They have lower fecundity than most teleosts (*P. maculatus* 84 000 eggs maximum, *A. niger* 62 000). *A. verrucosus* spawn in autumn/winter while *N. rhomboidalis* spawn in spring. Several spawning sites have been located off Tasmania. Spawning is synchronous and eggs, larvae and juveniles are pelagic. Oreos mature at 24–31 cm (this varies between species). Radiometric ageing suggests oreos are long-lived, to a maximum of 130 years or more and mature at 24–28 years. Estimates based on otoliths suggest lower ages to a maximum age of around 20 years. Stock structure has been studied using genetic and morphological methods. There is some evidence of depth-related structure in spikey oreos. Warty oreos from Tasmania have been provisionally identified as separate from Western Australia/New South Wales stock. There is no evidence of stock structure in other species. A trophodynamic model is under development

Key knowledge gaps and uncertainties

There are no current stock assessments. The discarding rate is unclear and it is difficult to determine accurate catch rates. Declines in orange roughy catches could lead to increased targeting.

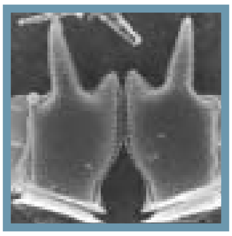
Blue grenadier *Macruronus novazelandiae*

Distribution

In Australia, blue grenadier occurs from central New South Wales around the south coast to the western GAB including Tasmania. The species also occurs in New Zealand, where it is referred to as hoki. Populations from Australia and New Zealand represent genetically distinct stocks. In New Zealand, the species has multiple stocks with different spawning areas, while in Australia genetic studies indicate the existence of a single breeding population. They are largely caught with a demersal trawl, although they can be caught by pelagic nets at night off western Tasmania.

Fishery profile

The blue grenadier fishery is managed with output controls implemented since 1992 as Individual Transferable Quotas. Allocated TAC was exceeded in 2000 and 2001. An assessment of blue grenadier in May 1997 indicated that fishing had not had a major impact on the stock as a whole, and that a 10 000 t annual catch should be sustainable. Further assessments in 1998 and 1999 also indicated a TAC of 10 000 t for



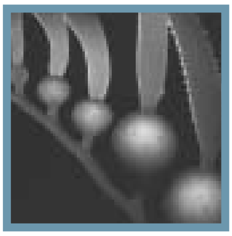
20 years has a low risk of reducing the spawner biomass to below 40% of the virgin biomass, but it was extremely sensitive to whether egg survey estimates were regarded as a measure of absolute or relative abundance. The fishery is divided into two sub-fisheries based on spawning and non-spawning fish. Commercial catches of the 'non-spawning' fishery declined between the late 1980s and 1997 while the spawning fishery showed no obvious temporal trends. Spawning biomass had declined by 1999 from a peak in 1989–91, although fishing mortality remained at <6% for each sub-fishery. Adult fish migrate to and from19 the principle spawning areas, however the rate of migration is unknown for either sex. Recruitment was low between 1990–1994 but above average in 1994–1995. There is a predicted increase in spawning biomass over the next five to ten years as a result of these strong 1994 and 1995 year classes, although the extent of this increase remains uncertain. The most recent assessment indicates the peak would occur during 2001 followed by a decline as those year classes move out of the fishery.

Biological and ecological profile

Adult blue grenadier fish occur on the continental slope in depths of 200–700 m but have been recorded as deep as 1000 m. Juveniles (20–30 cm) occur in estuaries in southeast Tasmania and over the outer shelf in western and eastern Tasmania, eastern Victoria and, in some years, off southern New South Wales. Adults migrate to the spawning area (west coast Tasmania) from throughout southeastern Australian waters during Autumn. Blue grenadier can be found in the spawning area year round, albeit with declining mean length through the season. Estimates of potential annual fecundity vary between years. Spawning occurs primarily off the west coast of Tasmania during winter and early spring. The onset of spawning varies between years and may be linked to water temperature during autumn and early winter. Limited spawning may occur off northeast Tasmania/Victoria in some years based on the occurrence and distribution of small larvae in those areas. Larvae have been described and recorded from northwest Tasmania, around the southern Tasmanian coast up to eastern Tasmania and between Bermagui (New South Wales) and Point Hicks (northeastern Victoria). Larvae move from west Tasmanian spawning grounds to eastern Tasmania nursery areas primarily transported by the Zeehan Current. A persistent northern flowing current on the shelf between eastern Bass Strait and Bermagui appears to be the main means of transport for larvae in southern New South Wales. Adults are moderately long-lived, with an estimated maximum age of approximately 25 years. They reach maturity at four to five years of age. Genetic studies have provided some evidence of a differential spawning migration by fish with particular genotypes from eastern Tasmania to the west coast. The implications for stock structure of a second possible spawning area off northeast Tasmania and eastern Victoria are unclear.

Key knowledge gaps and uncertainties

Interactions with seals have led to trials of seal exclusion devices in demersal and pelagic trawls over the west Tasmanian grounds, with mixed success. The development and trial of exclusion devices is continuing. The predicted growth in seal populations is likely to result in increased seal interactions with this and other fisheries. Evidence for, and location of, a possible eastern spawning area as well as its implications for stock assessments on stock require further investigation. Absolute biomass is poorly determined by the assessment model and relies on egg survey data – if this is positively biased the risk of depletion using a 10 000 t TAC could be severely under-estimated.



Redfish *Centroberyx affinis*

Distribution

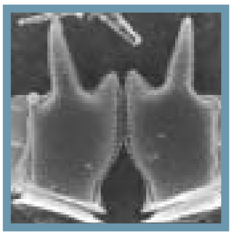
Redfish are restricted to southeast Australia from Morton Bay (Queensland) to western Bass Strait, including northeastern Tasmanian waters and offshore ridges (eg Norfolk and Lord Howe ridges). Redfish also occur in New Zealand, most commonly within the northern waters. In Australia, most of the catch is taken off the New South Wales south coast between Sydney and Eden, where, in recent years approximately 65% of catch has been taken from trawl grounds during winter and spring.

Fishery profile

Redfish within the South East Fishery are considered a single stock for the purpose of stock assessment, although no studies have been undertaken to confirm this assumption and the genetic relationship of these fish with those elsewhere is unknown. Growth rates vary between areas, suggesting different northern and southern stocks with a boundary between Ulladulla and Eden (New South Wales). Redfish have been fished since 1915, however there was little or no market demand at that time and discarding was probably common. Catches peaked in 1949 and again in 1980, after which there was a steady decline in catch up to 1989 followed by a slight increase between 1989 and 1993. Annual TAC regulates catches. A substantial amount of catch is recorded to come from waters under state jurisdiction and therefore not subject to Commonwealth TAC, however, less than 10% of the catch comes from waters less than 100 m depth. Discarding and high grading have been significant features of the fishery, although discard rates dropped from an estimated 50% by weight to less than 10% between 1993 and 1995. The recent closure of a Sydney fish processing plant may lead to an increase in the discard of small redfish. Recent modelling has estimated that stock biomass has declined since 1969 down to less than 20%. However, redfish biomass appears to have stabilised during the 1990s. Recruitment to the commercial fishery (ie minimum sizes recorded in the catch, appears to be largely determined by the selectivity of the cod-end mesh size and occurs over the range 17–21cm FL at an estimated age of three to four years. Small size classes dominate the current catch and may be useful as a surrogate recruitment index. Significant numbers of redfish are taken by recreational fishers.

Biological & ecological profile

Juvenile redfish often aggregate and inhabit estuaries and shallow coastal waters. Adult fish also aggregate, forming large demersal schools in shelf and slope waters to a depth of about 500 m. Distribution suggests an offshore movement associated with increasing length, although little research has been done on the life history of redfish. They are known to spawn in late summer and autumn, and are thought to spawn over shelf waters throughout their geographical range. Larvae from southern Australia have been described and recorded in New South Wales coastal waters from November to May, which suggests that spawning may occur somewhat earlier than indicated by studies on adults. Earlier spawning is also suggested by recent adult sampling. There are no known spawning migrations. The annual fecundity of redfish is unknown. Recent tagging studies and analysis of sectioned otoliths indicates that growth is slow – with maximum recorded age of 44 years for ffemales and 37 years females or males. A recently collected redfish from the Norfolk Ridge was estimated at 50 years. Females are thought to mature between five to seven years of age. No studies have been undertaken on biological factors affecting recruitment strength. Interestingly, an inverse relationship between Southern Oscillation Index and CPUE has recently been noted. In general, the relationship between spawning stock size and recruitment is unknown.



Key knowledge gaps and uncertainties

Stock structure and the dynamics leading to regionally variable growth remain key uncertainties for redfish. Selectivity studies are required on existing trawl gear and ways to increase the size at first capture need to be identified in order to protect smaller fish currently taken by the fishery. Inter-annual differences in catch rates may be due to movements and/or responses to fishing strategies (targeting rougher ground or new areas) and this, as well as the processes leading to recruitment variability, need to be examined. No fishery- independent estimate of biomass is available, although acoustics may offer some promise. Also, validation of age and growth estimates requires further work. Whether the current stock size, recruitment levels and catch rates are sustainable is the subject of considerable debate within the fishery. In particular, there are considerable concerns regarding the effects of growth overfishing.

Blue warehou *Seriolella brama*

Distribution

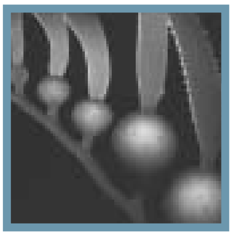
Blue warehou occur over the continental shelf and upper slope waters of southeastern Australia and New Zealand. Occurs throughout southeastern Australia from New South Wales to South Australia including Tasmania and Victoria to, at least, a depth of 500 m, from which adults have been caught. Blue warehou are caught primarily by trawl and gill-net, primarily in depths of 50–300 m. Blue warehou are sometimes caught as mixed catch with closely related spotted (or silver) warehou (*Seriolella punctata*)

Fishery profile

Formal stock assessments for this species have been carried out since 1998. Stock structure is not well understood. In particular it is not clear whether there is a single southeastern Australian population or two populations east and west of Bass Strait. Distribution of larvae, geographically separate spawning areas, inferred recruitment patterns and differences in size/age compositions suggest that there may be separate populations east and west of Bass Strait or at least that populations in these areas respond differently. Assessments are undertaken separately for eastern and western regions. The trawl catch is dominated by two to four years age classes, while gill-net catch is dominated by larger four to six year age classes. This is probably due to mesh selectivity, as small fish are known to occur in areas targeted by the gill net fishery. Catches of females exceed those of males in the commercial catch and this cannot be explained on the basis of gear selectivity. Catches of large/old fish in western Tasmania declined markedly between 1986 (when the fishery was considered to be in a near virgin state) and 1999, but assessments in the west are considered to be less robust than those for eastern regions. Overall, catch rates have been declining since peak in abundance in 1989–90. The most recent assessments indicate that the biomass in recent years was less than 30% of 1986/87 levels, both east and west of Bass Strait. The fishery (and stock assessments) appears to be subject to the effects of strong year classes recruiting to the populations, with the 1996 year class being the strongest to date.

Biological & ecological profile

Blue warehou is perceived to be a highly mobile species and believed to undertake extensive movements in relation to spawning and in response to environmental conditions, including water temperature and hydrology. Spawning occurs in winter, and there are some regional differences in the timing (May–August east of Bass Strait; June–October west of Bass Strait). There are two main spawning areas known, the primary being off western Tasmania and Victoria, and a smaller one off southern New South Wales and eastern Victoria. Each season, three batches of eggs are spawned with each female releasing between 430 000–1350 000. Females are mature at a size included between 38 and 55 cm. Larvae from southern Australia have been recorded from shelf waters off southern New South Wales, Victoria, Bass Strait, Tasmania and South Australia. Late stage larvae and small juveniles are often associated with



jellyfish and flotsam in coastal and estuarine waters. Older juveniles are known to inhabit coastal bays and to occur occasionally in large numbers in estuaries. The populations east and west of Bass Strait appear to have different patterns of recruitment for reasons at present unclear. Growth is rapid, and individual fish reach a mean length of 20 cm in the first year and maturity at 40 cm, approximately at three to four years of age. Blue warehou appear to live up to approximately ten years of age.

Key knowledge gaps and uncertainties

Stock structure remains a key uncertainty for blue warehou and, in particular, the relationship between populations east and west of Bass Strait. Recruitment variability and the influence on it of environmental conditions are key uncertainties in assessing trends in stock and setting sustainable TACs (the current ability to estimate poorly recruited year classes is low). Environmental effects on distribution, movements, availability and recruitment are poorly understood. Influence of changes in fleet dynamics on catch rates is at present unknown. Blue warehou may be suitable for egg and or acoustic surveys as fishery-independent estimate of biomass (fisheries independent data are currently lacking). The magnitude, age and size composition of discarded catch requires confirming and monitoring, and data on recreational catch is currently lacking. Trophic relationships may offer some insight into the links between recruitment dynamics, movement patterns, availability and environmental forcing.

Spotted warehou *Seriolella punctata*

Distribution

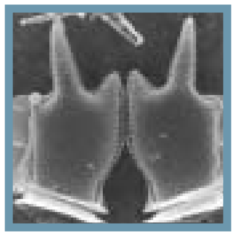
Spotted trevalla are members of the family Centrolophidae. They are recorded from New South Wales, Victoria and Tasmania and also occur in New Zealand and may occur in South America. Adults occur over the outer shelf and slope to depths of 650 m.

Fishery profile

Spotted trevalla are caught primarily by trawling, although a small tonnage (36 t in 1999 and 5 t in 2000) is taken as bycatch in the SENTF. Management of the trawl sector is by TAC, with the objective to ensure that the spawning stock biomass does not significantly decline below the 1994 level. Quantitative stock assessment commenced in 2000 with the model currently under further development. Stock assessment reports for the SEF are available for 1994 and 2000. There are no estimates of virgin biomass. The CPUE is variable across the area as well as from year to year. Catches reach a seasonal peak during the spawning period in winter-spring, although there is marked interannual variability in catches. The availability and/or abundance of spotted warehou have increased over recent years – especially associated with the winter blue grenadier fishery off western Tasmania, where catches of spotted trevalla have doubled since 1998. Catch in 1998 was 2412 t; 1999 catch was 3253 t and the 2000 catch was 3726 t (which was 77% of actual TAC). Mixed catches with blue warehou occur and early catch statistics combined both species under the name of 'Tassie trevally'. Industry members report no concerns with the stock status of spotted warehou. Fishing mortality is estimated to be less than 10%. The 2001 assessment concluded that the fishery has had little impact on the stock with current biomass levels similar to those in the late 1980s.

Biological & ecological profile

Spotted warehou spawn in late winter-early spring. There is some evidence of regional variability in timing of spawning, with spawning occurring slightly later in Tasmanian waters compared to New South Wales and eastern Victoria. The distribution of small larvae



(< 5 mm TL) is contiguous between western Tasmania around the southern Tasmanian coast to southern New South Wales. This suggests the occurrence of widespread spawning and a continuous link between regions in southeast Australia. Peak abundances of larvae are present off western Tasmania and southern New South Wales suggesting main spawning activity in each of those areas. Recruitment is variable, with a strong year class (spawned in 1993) currently passing through the fishery. Diets of larvae and juveniles are unknown. The occurrence of juveniles in inshore waters (coastal bays and estuaries) suggests that their diet differs from adults. There seem to be links between patterns of movement and distribution and fish size, with advanced larvae and small juveniles being often associated with jellyfish and flotsam in coastal and estuarine waters, subadults occurring in large coastal embayments and older and larger specimens occurring in deeper water (down to 650 m). Adult spotted warehou are predators of pelagic invertebrates and feed primarily on pyrosomes (ie salps).

Key knowledge gaps and uncertainties

A large amount of uncertainty characterises our understanding of this species and its interactions with the fishery. Environmental effects (eg water temperature) have been suggested to influence catchability and recruitment, although the causal factors are unknown and data are sparse. Spatial dynamics of the population are highly complex and poorly understood on both a seasonal and interannual scale. Assessments are highly sensitive to the value of natural mortality for reasons that are unclear. Assessments and the use of CPUE as an indicator of abundance are complicated by the interannual variability in recruitment and catchability/availability, the aggregating nature of the species and confounding between size-depth relationship and gear selectivity. The stock-recruitment relationship for this species is unknown. Gaps in our knowledge also encompass reproductive biology, including fecundity, and diets of larvae and juveniles.

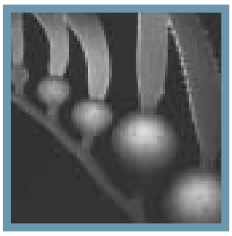
Royal red prawn
Haliporoides sibogae

Distribution

Royal red prawn are members of the family Solenoceridae. They are widely distributed on the edges of continental shelves and the continental slopes around the Indo-west Pacific between 100–1460 m. In Australia, they occur from northern Queensland to northwest Western Australia. In New South Wales they occur along the entire coast from 270–820 m but appear to be more abundant in depths of 350–550 m.

Fishery profile

The royal red prawn is a quota species within the SETF and is caught primarily in New South Wales between Sydney and Ulladulla. The commercial exploitation of royal red prawn was initially developed in South Australia's waters in the mid 1970s. Catches were initially small (< 100 t in the mid 1970s) but increased to 322 t by 1979. Thereafter, catches were relatively steady at 300–350 t with the exception of a peak of 700 t in 1984, which appeared to be a result of increased effort as the southern New South Wales grounds were targeted. Catches along the northern New South Wales/southern Queens; and region (north of the South-east Marine Region) were initially 90–166 t per year until 1984 and then declined substantially. Most of the fishing effort is targeted between 34°S and 35°S and in the depth range of 400–500 m. Standardised CPUE did not vary markedly between seasons within the fishing area for the years 1985–1988. However, there are several limitations to using CPUE as an indicator of abundance and it is difficult to determine the impact of the fishery on the abundance of the royal red prawn stock. Most of the catch is of prawns aged between two and three years and below the size at maturity, however most spawning appears to occur north of the fishing area, hence adults are under-represented in the catch. They are fished over well-established muddy grounds but may also occur over untrawlable bottom.



Biological and ecological profile

Latitudinal size distribution of prawns suggests movements from a southern recruitment ground to a northern spawning ground along the New South Wales coast. Most of the spawning appears to occur north of the prime fishing areas and outside the Region. Females breed several times during their life as apposed to males which probably only breed once. Two restricted spawning seasons occur (February-April and July-August).

Key knowledge gaps and uncertainties

The stock structure, the occurrence and distribution in areas not currently fished and the potential impacts of fishing on the stock are not known.

Eastern gemfish *Rexea solandri*

Distribution

Gemfish are distributed from northern New South Wales to Western Australia, including around Tasmania and in the Great Australian Bight. Eastern gemfish are caught from eastern Tasmania to northern New South Wales. Eastern gemfish are mainly caught using demersal board trawlers that target the winter spawning migration in depths of about 400 m. Eastern gemfish are caught along the edge of the continental shelf by demersal trawling and drop lining. In summer the fish are scattered around the eastern Tasmanian shelf break and aggregated around canyons.

Fishery profile

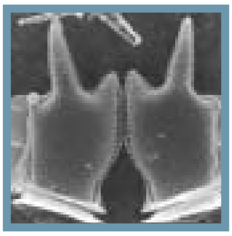
The agreed eastern gemfish TAC for 2001of 150 t was met and the limit was not extended due to evidence of poor recruitment levels. Catches of eastern gemfish peaked in 1980 at 5000 t and declined to a TAC of 3000 t in 1988. From 1988 to 1992 TAC was progressively reduced from 3000 t to 200 t, culminating in a TAC of zero set from 1993 to 1996. Trip limits that account for bycatch have been set since 1993. In 1997 there was a 1000 t TAC allocation for the trawl component of the SEF (trawl catches amounted to 358 t). The available evidence indicates that there has been a dramatic decline in recruitment to the eastern spawning stock since 1989. Due to further evidence of poor recruitment the TAC for bycatch has been declining since 1998 (300 t) to the present 150 t (actual and agreed) for 2001.

Biological and ecological profile

Eastern gemfish mature at three to five years for males and four to six years for females. They live to a maximum age of 17 years. Examination of whole otoliths indicate a maximum age of 13 years for gemfish collected from the east coast and estimated maximum length at 112.3 cm. Mature eastern gemfish migrate north along the New South Wales shelf break during winter and aggregate prior to spawning. Spawning of the eastern gemfish is known to occur only in a single location, near Crowdy Head in New South Wales. There is some argument over whether or not the winter spawning aggregations of eastern gemfish have evolved in response to sub-surface plumes of nutrient-rich deep subantarctic mode water or if the pre-spawning aggregations are determined by a combination of the time of season and latitude. Fecundity is closely related to fish weight, the majority of females producing approximately 1–1.5 million eggs. A genetically distinct stock of (western) gemfish occurs to the west of Tasmania. The split between the stocks of eastern and western gemfish occurs at the western end of Bass Strait, with limited mixing off western Tasmania. Studies of parasites provide some evidence of different stocks of common gemfish in Australia: an eastern stock, a south Australian stock (including eastern and western Bass Strait) and a distinct stock in the Great Australian Bight.

Key knowledge gaps and uncertainties

Efforts should be made to determine if gemfish are spawning anywhere on the south coast of Australia.



Western gemfish *Rexea solandri*

Distribution

The western gemfish occurs in the outer shelf and slope waters of western Tasmania and western Bass Strait, across the GAB to the west coast of Western Australia and extending as far north as 23° 25' S latitude. Many of the comments on the biology of the eastern gemfish can be extrapolated to the western stock. Important differences are highlighted below. Note that the western gemfish in the SEF are at the eastern end of their distribution and, as such, activity in the GABTF will affect the western gemfish in the SEF.

Fishery profile

The SEFAG Plenary Meeting in 2001 noted that landings of the western gemfish by the GAB trawl fishery have risen significantly over recent years and if the fishery continued to develop, priority should be given to the establishment of complementary management measures between the GAB and the SEF. Catch rates indicate a decline in western gemfish abundance and/or catchability from the mid–1980s to the mid–1990s. The fishery showed an improvement in 1996, with catches containing predominantly 40–60 cm fish (two to four year olds) compared with the 1995 catch of proportionately more larger, older fish.

Biological and ecological profile

Genetic studies have concluded that eastern and western gemfish are separate populations, although some mixing occurs off western Tasmania. Within the western gemfish, there is some evidence of the existence of two stocks. Spawning of the western gemfish appears to occur in summer in the western section of the GAB. Growth, age at maturity and longevity are similar to that of the eastern gemfish. Recruitment appears to vary from year to year, but the causes of this variation are not understood. They feed primarily on benthopelagic fish.

Key knowledge gaps and uncertainties

Spawning dynamics, spawning-related movements and locations are not known for the western gemfish. Variability in recruitment is not understood and stock structure requires further work to confirm the existence of two stocks.

Mirror dory *Zenopsis nebulosus*

Distribution

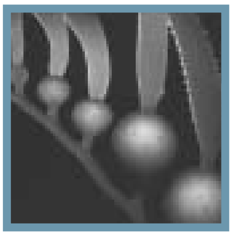
Mirror dory are distributed throughout the continental shelf and upper slope waters of southern Australia from Broken Bay (New South Wales) to the North West Shelf (Western Australia) including Tasmania. They are widespread throughout the Pacific Ocean, occurring in waters off New Zealand, Japan, Korea, Hawaii, California and Chile. They have been recorded as deep as 800 m, but are more usually caught in depths between 50–600 m.

Fishery profile

Mirror dory are caught using either a trawl or a Danish seine, although they are primarily caught by trawl as a bycatch of gemfish. For management purposes a single stock of mirror dory is assumed for the SEF. The agreed TAC for 2001 was 800 t which was exceeded by an actual catch 996t (trawl fishery only). The recorded catch of mirror dory in 1999 was 352 t, which was 37% of the allocated TAC of 960 t (1999 landings were 17% lower than the 1998 landings at 426 t). The agreed TAC for 2000 was 800 t, with actual TAC being 977 t. The 400–450 m depth strata is now the most important depth strata in terms of recorded mirror dory catch. Since 1996, catches of mirror dory have been boosted by increased catches to the west of Bass Strait. Overall, catches have declined since 1997. No yield estimates can be made for mirror dory due to the lack of biological information, in particular age and growth data.

Biological & ecological profile

Mirror dory spawn during winter in New South Wales (May to September) and reach a maximum size of 70 cm total length and at least 3 kg. They are considered mature at about 35 cm in length. Spawning



occurs over a wide geographical area, with no apparent migration associated with spawning activity. Fecundity is probably low with the possibility of serial spawning. Based on a total of six fish and examination of whole otoliths, the maximum age of mirror dory is estimated to be at least 13 years. Recent age estimates ranged from two to fourteen years for fish between 30 and 63 cm in length. Although no specific studies have been undertaken, age and size structure as well as length-at-age appear to be significantly different between eastern and western regions of SEF.

Key knowledge gaps and uncertainties

Factors governing recruitment and the nature of the stock structure are unknown and discarding remains a major issue for the species. The rate of discarding of mirror dory in the eastern zones has been high – between 50 and 80% by weight being discarded in previous years. Since 1997, discarding has decreased in the eastern zones to about 8%. High levels of discarding have also occurred off eastern Tasmania with a rate of 44% in 1999. In 1999, about 20% of the mirror dory catch was discarded (by weight) across the fishery. Off New South Wales and northeastern Victoria, mirror dory abundance peaks during winter, in exactly the same depth strata as the winter gemfish spawning run leading to a targeting and gemfish bycatch problem.

Silver trevally *Pseudocaranx dentex*

Distribution

Silver trevally occur throughout southern Australia from North West Cape (Western Australia) to northeastern Queensland, including Tasmania and the Lord Howe and Norfolk Islands. They are also found in New Zealand and the subtropical to temperate waters of the Atlantic, Indian and Pacific Oceans.

Fishery profile

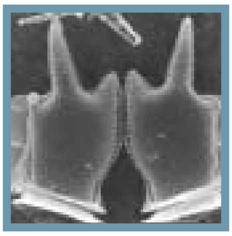
They are caught primarily in the SETF but are also taken by trap, recreational line fishing and estuarine fishing sectors. Silver trevally are managed by TAC with the objective of maintaining CPUE above its lowest annual average level from 1986 to 1994. Recorded catches increased from < 200 t in the 1960s to around 1500 t in the late 1980s. Significant declines in catches occurred in the late 1990s. The 1999 commercial catch was 340 t. Recreational catches of approximately 120 t per annum have been reported for New South Wales ocean waters and similar amounts are believed to have been taken by recreational fishers from New South Wales estuarine waters in the early 1990s. There are indications that the fishery has had a significant effect on the size structure of the stock. The average size of fish in commercial catches during 1997–99 was 28.4 cm and 500 g.

Biological and ecological profile

Silver trevally are a partial spawner, releasing several batches of eggs over a period of several weeks. Fecundity is estimated at 220 000 eggs for a 37 cm female and in larger females may be up to 1 000 000 eggs. Silver trevally in spawning condition were reported off the north coast of New South Wales from October to December, however the distribution and occurrence of larvae suggest that spawning is widespread, protracted and regionally variable in its timing within the Region. Recent work by Rowling concluded that silver trevally in New South Wales spawn from spring to autumn. Silver trevally feed on benthopelagic fish and to a smaller extent, megabenthos and benthic crustaceans. Silver trevally are a shallow water species, reaching a maximum depth of approximately 120 m. Juveniles usually inhabit estuaries, bays and shallow continental shelf waters, while adults form schools near the seabed on the continental shelf. Larger adults have been found over deeper shelf waters.

Key knowledge gaps and uncertainties

The exact nature of stock structure is unknown. Gear selectivity is also unknown.



Ocean perch
Helicolenus percoides, H.barathri

Distribution

Ocean perch are members of the family Scorpaenidae and occur in both Australia and New Zealand. Two species occur in Australia (the inshore *H. percoides* and offshore *H. barathri*) which are similar in form and overlap in their depth distribution. They occur from 29°S in New South Wales to 26°S in Western Australia at depths of 50–750 m (Smith & Wayte, 2001).

Fishery Profile

They are primarily caught by the SETF as bycatch. The majority of the catch is *H. barathri* although the species are not separately logged. Both species of ocean perch are managed by a common TAC with the objective of ensuring that the spawning biomass does not significantly decline below the 1995 level and that CPUE is maintained above its lowest annual average level from 1986 to 1994. There are no quantitative assessments of ocean perch. Stock assessment reports are available for 1994 and 1996. The status of stocks is uncertain. High levels of discarding occur, particularly inshore. Discarding of fish less than 23-25 cm in length occurs in both species, which are fish less than or equal to four years and ten years for *H. percoides* and *H. barathri*, respectively. It has been noted that a significant decline in catch rates between 1976-77 and 1979-81 and further declines between 1979-81 and 1996-97. The reasons particularly for the latter decline are uncertain. Estimated catches have ranged from 187 to 464 t since 1977. The 2000 TAC was 500 t.

Biological and ecological profile

Ocean perch occur in shelf and upper slope waters in depths of 50–750 m. They are viviparous, have a low brood size and, based on studies of adults, spawning occurs in late winter/early spring. However, larvae have been recorded from coastal waters around Tasmania from mid-winter to late summer suggesting a more protracted period of spawning. Fecundity is poorly documented in Australian specimens. A New Zealand study by Mines (1975) reported that 30 cm female ocean perch produce between 150 000 and 200 000 eggs during a breeding season, of which 40 000 to 50 000 were fertilised and developing embryos. Ocean perch are benthopelagic omnivores and feed on megabenthos and benthic crustaceans.

Key knowledge gaps and uncertainties

Stock status, composition and gear selectivity are uncertain. The impacts of high levels of discarding of small fish are not clearly defined.

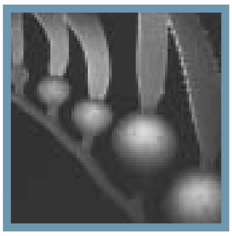
Skates *Family Rajidae*

Distribution

Skates are widely distributed world-wide except for parts of the insular western Pacific. Many Australian species are thought to be endemic with localised distributions. They are a bycatch species of trawl fisheries, including SEF and Subantarctic. They are found primarily on the continental shelf and slope in 50–2300 m in Australian waters

Fishery profile

Independent surveys off southern New South Wales show catch rates have declined by 83% for skates and by 66% for stingarees. Overseas studies show declines in the larger species and that smaller species may be increasing. There are no catch limits in Australia. The Fishery is partly regulated by total quotas in New Zealand. Skates are extraordinarily vulnerable, one of the most threatened groups of all marine species worldwide. There have been local and near extinctions overseas. Currently there are concerns for other batoids including stingarees (*Urolophidae*) and stingrays (*Dasyatididae*).



Biological and ecological profile

There are 38 skate species in Australia. These species are benthic and demersal. Almost nothing is known of Australian skate biology or stock size and catches are unregulated. Their growth is slo and they have a high age of maturity (6–11years) with a longevity up to at least 18 years. Their fecundity is low (estimated 40 eggs/year) compared to teleosts. Larger skates grow to >20 cm before hatching and are immediately vulnerable to commercial trawl mesh. Recruitment is dependent on adult stock size.

Key knowledge gaps and uncertainties

Nothing is known of stock structures in Australia. The limited existing fishery data does not separate species, and trends for individual species may be masked by aggregation of data. There is a lack of independent data. Stock structure is unknown and there are taxonomic problems. Some skate species may be endemic. Their biology is poorly known. There are similar concerns for stingarees and stingrays. If larger, late-maturing skate species are being replaced by smaller earlier-maturing ones, there will be ecological effects. There may be under-reporting of discarded catches. There also may be a potential for directed fisheries to develop if marketing improves.

Dogfishes *Family Squalidae*

Distribution

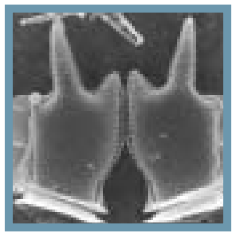
Members of this diverse group occur in three distinct habitats: the continental shelf (*Squalus acanthias*, *Squalus megalops*), upper slope *Centrophorus* spp., *Squalus* spp.) and mid-slope (*Centroscymnus* spp., *Deania* spp. and *Etmopterus* spp.).

Fishery profile

At least 16 species are taken as target and bycatch species. The meat is marketed as flake and the liver oil is refined and exported. Australian dogfish fisheries have recently been reviewed. Currently the largest targeted catches are mid-slope species taken in the SET. Previously the largest targeted catches were upper-slope species taken in the SET and Southern Shark Fisheries. The current estimated total catch is between 790–1430 t (whole weight). Catches are not limited by TAC or ITQ. Populations of shelf species are probably stable. Fishery, scientific and market data suggests major declines in upper-slope species. Some upper-slope species have been nominated for vulnerable and endangered listings (Environment Protection and Biodiversity Conservation ACT). Fishery and independent data suggest mid-slope species are at lower risk. Current targeted catches of mid-slope species are unregulated. Declines in upper-slope species are too severe to address within fishery management.

Biological and ecological profile

These ecological groups differ in their reproductive biology and vulnerability to fishing. Geographic distribution varies between species. Most commercial catches are taken off southern Australia. At least one species (*Centrophorus harrissoni*) is thought to be endemic. Market data suggests seasonal movements of upper slope species. Some species have adaptations for particular bathymetric features (eg seamounts). Shelf and upper slope species are targeted throughout their vertical distribution making them most vulnerable to capture. Mid slope species extend deeper than fishing operations and deep water may therefore offer some



refuge from commercial fishing operations. Dogfishes have low fecundity compared to teleosts and a stronger link between adult stock size and recruitment (litter sizes 1–32, some species probably breed less than once per year). Validated studies indicate shelf species live up to 70 years. Unvalidated radiometric ageing studies suggest upper-slope species mature at 9–15 years, and live for up to 46 years. Unvalidated age estimates from spine ring counts suggest that mid-slope species live to at least 18 years.

Key knowledge gaps and uncertainties

There have been no stock structure studies in Australia. Stock structure studies are unlikely to be undertaken until taxonomic problems are resolved. There is insufficient knowledge of movements, home range and critical habitat for appropriate remedial actions. Previously there has been under-reporting of discarded catches. Fishery data is poor and there has been limited independent data. Knowledge of reproduction, age and growth is limited and there are taxonomic problems – there is possibly more than one endemic species.

Gummy shark *Mustelus antarcticus*

Distribution

Gummy shark are found throughout Australia from New South Wales (northern border) to Western Australia (Shark Bay) including Tasmania. They are demersal, from continental shelf and upper slope, inshore to 400 m. 84 percent of the commercial catch is taken in 25–75 m.

Fishery profile

There is a long history of targeted fishing using bottom set long-lines and gill nets in the Commonwealth-managed Southern Shark Fishery, which is regulated by ITQ and TAC. It is a small recreational fishery. Annual catch has increased overall from 860–1520 t between 1970 and 1998. Catches peaked in 1989 and additional fishery regulations limited subsequent catches. 1991 and 1992 assessments concluded that gummy sharks were over exploited and further restrictions were introduced in 1992. Current catches of gummy shark appear to be sustainable. Fishing is restricted in designated nursery areas in shallow bays and estuaries in Tasmania.

Biological and ecological profile

Gummy shark have low productivity, slow growth and a low capacity to recover from overfishing. Their breeding is seasonal, with ovulation from October to December in southeastern Australia. Its gestation period is 12 months and the full female cycle may take up to three years. Females produce up to 38 embryos per female (average 14). Newborns and juveniles aggregate in scattered pupping areas. The maximum age 16 years. Movements associated with reproduction are not fully understood. Early tagging, genetic and morphometric studies suggested a single stock in Australia while more recent genetic studies suggest potentially three stocks.

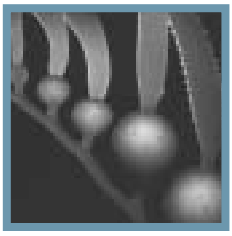
Key knowledge gaps and uncertainties

Stock structure is unclear. Movement associated with reproduction needs further examination. Gummy shark fishing may have unsustainable impact on school sharks as bycatch. There is a lack of independent data. Changes in fishery management are likely to influence catch data more than abundance.

School shark *Galeorhinus galeus*

Distribution

School shark are found throughout southern Australia from Queensland (Brisbane) to Western Australia (Houtman Abrolhos) including Tasmania and Lord Howe Island. Thgey are demersal on the continental shelf and upper slope and are mostly fished on the continental shelf (<200 m).



Fishery profile

School shark are fished commercially off Victoria, Tasmania and South Australia and are taken by gillnet and bottom set longlines in the Commonwealth-managed SSSF. Catches have been regulated by global TAC and ITQ since 2001. Catch has declined from 2600 t in 1970 to 600 t in 1998. They have been severely overfished, particularly in Bass Strait and are currently assessed as over-exploited. They are now a bycatch of the gummy shark fishery. The 1998 assessment estimated biomass at 13–45% of virgin biomass and suggested that reduced catches were needed. An assessment in 2000 estimated pup production at 12–18% of virgin biomass. Inter-annual variability of environmental effects may affect numbers and assessments. A single stock is assumed for setting TAC. Biological and catch data suggests possibly more than one stock. The latest assessment allows for the possibility of multiple stocks.

Biological and ecological profile

There are large seasonal movements across southern Australia including widespread movements between the GAB and eastern Australia. Data suggest some aggregating behaviour of males in the south and females in the north. Productivity and growth is slow. There is a close relationship between parent stock and recruitment. School shark have a low capacity to recover from overfishing. Their gestation is twelve months, and a full female cycle may take up to three years, with 15–43 embryos per female (average 20). Pregnant sharks move to South Australia and later eastward to give birth. There are nursery areas in shallow bays and estuaries of eastern Bass Strait, eastern Victoria and eastern and southern Tasmania. The young move from nurseries to deeper water over winter. Sexes and sizes segregate into separate schools. The maximum age probably exceeds 60 years. Large seasonal movements across southern Australia have lead to the inference that there is a single stock. Genetic evidence suggests that Australian school sharks form a common stock, which is distinct from the New Zealand stock. School sharks tagged in New Zealand have been recaptured in Australia, indicating some mixing.

Key knowledge gaps and uncertainties

The quantity caught as bycatch of the gummy shark fishery is unclear – they may be a discarded bycatch. The age/size structure of the catch is also unclear and pupping/recruitment/fecundity is not understood. More knowledge of movements, particularly associated with reproduction, is needed. There is a potential for bycatch quantities to deplete the fishery. The lack of fishery-independent data will make future stock assessments difficult. Recent changes in management are likely to affect fishery data more than abundance. Stock assessments are sensitive to movements of sharks between Australia and New Zealand, the effects of which are poorly known. There is interannual variability in environmental factors. Stock structure is still not clear and global TAC will not be appropriate for multiple stocks.

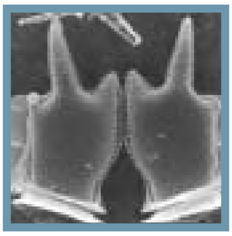
Sawsharks *Pristiophorus* spp.

Distribution

There are two sawsharks commonly found throughout the southern waters of Australia: *Pristiophorus cirratus* (common sawshark) and *P. nudipinnis* (southern sawshark). A third species, *Pristiophorus* sp. (eastern sawshark) occurs off New South Wales.

Fishery profile

Sawsharks are generally a bycatch of the SSF and the SEF. They were the third most important shark catch in the SSF in 2001, representing 8.3% of the annual harvest. Catches in Commonwealth waters are limited by ITQ. Aggregated SSF catch data shows that total catch was 359 t (carcass weight) in 1995 and around 200 t in 2001. There have been no formal catch assessments or CPUE analysis to date.



Biological and ecological profile

Pristiophorids (sawsharks) are a marine, bottom dwelling shark species. Very few biological parameters are available for these species. The biology of sawsharks is currently under examination by the Marine and Freshwater Resources Institute as part of a Fisheries Research and Development Corporation Project and published findings are expected in early 2002. Sawsharks are a live-bearing species with a fairly low fecundity. Common and southern sawsharks have around 20 pups per litter and probably breed only every second year. The diet of this species includes small teleosts and cephalopods. The southern sawshark occurs most commonly on sandy bottoms inshore. The common sawshark is caught to 300 m mainly by trawlers on flat ground.

Key knowledge gaps and uncertainties

There is limited knowledge of the biology of all species in this family and limited fishery data reflects this uncertainty. No stock assessments have been conducted and knowledge of stock structure is poor. Trends and characteristics of individual species may be masked by the aggregation of data of the entire family.

Elephant fish *Callorinchus milii*

Distribution

Elephant fish are distributed throughout the continental shelves of cool and temperate regions of Australia and New Zealand in depths to at least 200 m. In Australia, they are distributed from Sydney (New South Wales) to Esperance (Western Australia) including Tasmania, with abundance increasing south of Bass Strait.

Fishery profile

Elephant fish are largely a bycatch of the SSF and the SEF. In 1991 the catch from the SSF was about 50 t, however the bycatch from trawl and Danish seine was unknown. Declining catch rates from gill nets suggests that this species may be fully-, if not over-exploited.

Biological and ecological profile

Callorhinchus milii, elephant fish, are demersal and grow to about 120 cm in length and 9 kg. The biology and population dynamics of elephant fish are poorly known. Adult elephant fish migrate into the shallower waters (generally less than 40 m depth) of estuaries and bays in spring to breed. They are oviparous, laying two egg cases on sandy or muddy bottoms. In New Zealand, females are thought to deposit several egg pairs over the breeding season, possibly as frequently as every two weeks. Embryos take as long as eight months to develop and they hatch at about 15 cm in length.

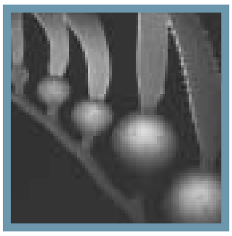
Key knowledge gaps and uncertainties

There is a lack of biological and population dynamic information for this species and a large part of the bycatch from the trawl and Danish seine fisheries is either discarded or not recorded to species, adding to the uncertainty. Recruitment variability is unknown.

Snapper Pagrus *auratus*

Distribution

Snapper occur throughout southern Australia from Hinchinbrook Island (Queensland) to Barrow Island (Western Australia), including northern Tasmanian waters. A similar species, *Pagrus major*, occurs in the northern hemisphere in waters of Japan, China, Taiwan, Indonesia and the Philippines and was classified as a reproductively isolated population of *P. auratus* by Paulin (1990).



Fishery profile

They are an important commercial and recreational species across their range and are also important in aquaculture. Commercial catches in Tasmania are negligible compared to the other States. They are primarily caught by handline, longline, dropline and mesh nets but are also taken as bycatch in inshore trawling, prawn trawling and in the SSF. The largest fish are taken by longline and variability in catches reflects variations in recruitment and the passage of strong and weak year classes through the different sectors of the fishery. Growth rates are highly variable between stocks and regions. During the 1990s, catches in South Australia ranged between 223 and 456 t, ranking South Australia behind New South Wales (450–650 t) andWestern Australia (725–944 t), but ahead of Queensland (80–110 t), and Victoria (50–185 t). Poor recruitment led to a decline in catch rates in the handline fishery from 1990/91 to 1994/95, with a recent increase for 2000 (projected to 2004) as the strong year classes from 1990 and 1991 recruit to the fishery. Similar declines in catch rates also occurred in the longline fishery as the 1979–year class was fished down, improvements are expected in 2004–2006 as the 1990– and 1991-year classes recruit to the fishery, although this will depend on the impact on stocks of the handline fishery. The Victorian commercial snapper catch has been consistently declining since 1978–79 and the 1996–97 catch of 49 t was the lowest since records began in 1914. Catches improved slightly to 60 t in 1997–98.

Biological and ecological profile

Snapper are capable of changing sex and are a serial spawning species in which spawning occurs on a daily basis in the majority of individuals with batch fecundity of about 100 000 eggs per kg weight. The timing of spawning varies between regions. In southern Australia, spawning occurs between late October and early March, while in more northern waters, spawning occurs during winter between late May and August. Snapper are benthic omnivores and juveniles feed on polychaetes, molluscs and crustaceans while adults feed on crustaceans, molluscs and sea urchins. Juvenile and small adult snapper inhabit bays, estuaries and inlets, often over mud and seagrass. At about one year of age, snapper move from these sheltered habitats to coastal rocky reefs at depths up to 300 m, but more commonly to depths of about 35 m.

Key knowledge gaps and uncertainties

The determinants of recruitment variability are unknown for Australian waters. Movement dynamics and the relationship of fish availability to fishing gear are largely unknown and appear to be important in various areas. Uncertainty about the relative contributions of fishing pressure and natural fluctuations in reproductive success (combined with uncertainties regarding movements) make it difficult to interpret trends in fisheries data.

Southern calamari
Sepioteuthis australis

Distribution

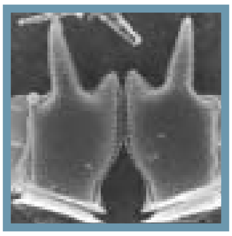
This species of squid is found around the southern half of Australia from Brisbane (Queensland) to Dampier (Western Australia), including Tasmania.

Fishery profile

A small fishery developed in Tasmania in the 1980s with peak catches of approximately 90 t in 1999.

Biological and ecological profile

The main spawning periods in spring-summer (Tasmania) although some spawning and hatching may occur year-round. Each female can lay a number of egg batches. Females may deposit eggs collectively in clustered egg mops that contain 50 to several hundred strands of egg capsules each with four to seven eggs. Egg mops are most commonly attached to *Amphibolis* seagrass. The hatching of the four to seven mm long juveniles occurs



three to five weeks after spawning, depending on water temperature. The rate of growth is extremely rapid with the animal gaining an extra 8% of body weight per day. However, this is a short-lived species with maximum life span of approximately one year.

Key knowledge gaps and uncertainties

As with many squids, relatively little is known about this species. The relatively small size of the fishery has limited the amount of research conducted on the southern Calamari.

Southern rock lobster *Jasus edwardsii*

Distribution

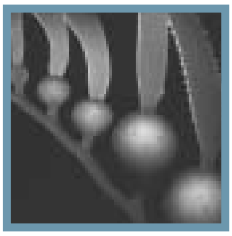
Southern rock lobster are distributed across the southern Australian coast, from Coffs Harbour, in northern New South Wales, to Dongara in Western Australia. Southern rock lobster also occurs in New Zealand waters, where they are commercially fished and known as red rock lobster.

Fishery profile

The main region of the commercial fishery ranges from the western GAB through to South Australian, Victorian and Tasmanian waters, with smaller fisheries in Western Australia (primarily around Esperance) and southern New South Wales. There are also significant recreational fisheries, particularly in South Australia and Tasmania. The fishery is divided into seven management zones, with the assumption that populations within each zone contribute only to local recruitment. The fishery in South Australia is divided into two management zones, Northern and Southern. The Tasmanian fishery is divided into eight regions for stock assessment purposes due to regional differences in growth, mortality, size at maturity and catch rates. Despite some recent improvements in catches, the Tasmanian fishery is considered over-exploited, with catch rates declining since the 1980s (1.6–0.9 kg per pot lift between 1980 and 1995). Total allowable catches of 1500 t are required to prevent further declines. The Victorian fishery is divided into western and eastern management zones, with 80% of the catch taken in the western zone. Catch rates have declined from 2.5 kg per pot lift in the 1950s to 0.3 and 0.5 per pot lift in the eastern and western zones respectively by the mid 1990s. Egg production in both Victorian zones is currently estimated to be at 6–20% of the unfished stock.

Biological and ecological profile

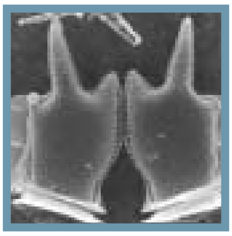
Considerable differences in growth, age at maturity, sex ratio, mortality, catch rates and spawning biomass occur between rock lobster populations in different areas. Size at maturity and growth rates vary across the range of the species. Growth rate differs markedly between regions and depth, probably as a result of water temperature and food availability. Mating occurs during autumn and early winter. Eggs hatch from September to January and the timing varyies slightly with latitude and are widely-dispersed in offshore watersm being found right across the Tasman Sea to New Zealand, however it is generally believed that larvae retained within 500 km of the coast return to settle within the Australian fishery. Larvae develop through a series of eleven stages before metamorphosing into a non-feeding stage which settles on coastal reefs. Early stage larvae occur in shelf waters; mid and late stage larvae are found almost exclusively offshore where they occur primarily in waters of the Subtropical Front. Circulation processes within the Subtropical Front are thought to play a primary role in larval transport and supply. Frequency of wind and storm events and presence of particular water masses offshore appear to influence the settlement of larvae. The magnitude of settlement varies among years but shows some correlation between regions. The timing of settlement is generally consistent within regions. Main settlement



peaks are usually in summer or winter or both. The magnitude of the summer or winter peaks varies regionally and low-level settlement may occur year-round in some areas. The similarities in settlement trends across southern Australia suggest that broad-scale physical processes have a controlling influence on settlement patterns. In Tasmania, spawning stock biomass varies markedly across the range of the fishery. Some links have been suggested with the offshore seasonal movement of the subtropical front. A large peak in settlement in 1995 was subsequently reflected in increased catch rates of recruits to the fishery in 1999 (East Coast waters). Recruitment to fishery is complicated by variable growth rates between regions and comprises multiple year classes in areas of slow growth areas (eg southernTasmania) or single year classes in areas of more rapid growth (eg northeastern Tasmania). In South Australia, settlement is variable between years and commonly displays summer and winter peaks in the Southern Zone and a winter peak in the Northern Zone. Settlement may be related to upwelling events, southeasterly storms and northwest coastal currents in the south east regions of the state. Estimates of recruitment for the Northern Zone point to a link between the strength of the westerly winds and the July-September settlement, with a 5–7 year time lag. Westerly wind strength (and recruitment) shows a 10–12 year cycle. Southern rock lobsters are known to live for at least 20 years (based on tag recaptures) and grow to at least 230 mm (length of the carapace). Size at maturity varies regionally, from 65 mm (carapace length) in southern Tasmania to 115 mm at King Island (northern Tasmania). Fecundity increases with female size, from 69 000 to over 600 000 eggs for females with a 74 mm and 155 mm carapace length, respectively. In Victoria, fecundity estimates from samples taken in 1994–1996 indicate that fecundity increases with size. Size at onset of maturity for females varies between eastern and western zones (western zone = 90 mm carapace length; Eastern zone = 112 mm carapace length). Growth rate of males is higher than females and growth rates are highest in the eastern Zone. Studies suggest a single genetic stock spanning Australia and New Zealand although this may not reflect effective management sub-units.

Key knowledge gaps and uncertainties

Interactions between rock lobster, sea urchins and macroalgae are not well understood. There may be ecological effects of depleted abundance and reduced size and frequency in fished areas. CPUE data as a measure of stock size/abundance may be problematic due to variations in catchability, selectivity of pots and because it does not take into account the searching time and behaviour of fishers. Fleet dynamics models may be necessary to appropriately set TACs between regions. Genetic stock structure probably does not reflect effective management units as long-lived and widely dispersing larvae link otherwise separate populations. Stock structure may be better defined by adult movements, dispersal of larvae or analyses of catch statistics. Linkages between management zones via larval dispersal and the extent to which spawning within a zone contributes to recruitment in other zones is unclear. Several population and biological parameters vary markedly over the geographic area of the fishery and finer scale resolution of these parameters may be necessary in order to refine models for stock assessment purposes.



Scallop *Pecten* spp.

Distribution

The scallop species *Pecten fumatus* occurs from central New South Wales to roughly the border between South Australia and Western Australia (western limit unclear), including Tasmania. *Chlamys asperrimus* is distributed from New South Wales to Geographe Bay (Western Australia), including Tasmania. *C. bifrons* is distributed from New South Wales to South Australia, including Tasmania.

Fishery profile

The scallop fishery in southern Australian waters is based on a number of species: *Pecten fumatus*, *P. alba*, *P. meridionalis* (which are considered to be clinal variations of the one species) *P. modestus*, *Chlamys (Mimachlamys) asperrimus*, and *C. (Equichlamys) bifrons*. Scallops are taken primarily by dredge but also by SCUBA divers. The scallop fishery is based on animals in a roed (reproductive) state (roe-on fishery) and fishing is concentrated in a period when the gonad is most fully developed and condition and meat yield are highest – in Port Phillip Bay this is between July and October. Scallop fisheries have a history of overfishing and collapse. In Australian waters, the fishery has remained closed in several years. *Pecten* species have historically been the most important species in the scallop fisheries of southern Australia. In the past commercial quantities of *Pecten* species were taken throughout southern Australia, including New South Wales. By 1985 the main scallop beds were depleted, with the last major bed being fished out in 1986. The fishery is now based primarily in Tasmanian and Victorian waters, with smaller fisheries operating in Jervis Bay (New South Wales) and Coffin Bay and Spencer Gulf (South Australia). The *Pecten* fishery reached a peak in 1983, with a record catch of 4136 t of meat. The commercial fishery for *Chlamys* species is limited to the D'Entrecasteaux Channel in southern Tasmania.

Biological and ecological profile

Fluctuations in recruitment are characteristic of scallop populations, and the relationship between recruits and parent stock is poorly understood. However, evidence suggests that a certain minimum adult-population density is required to ensure successful spawning and high levels of recruitment. Scallops inhabit enclosed embayments as well as exposed oceanic environments. *P. fumatus* tend to congregate in discrete beds from depths of 1–120 m. *Chlamys* spp. live on a variety of substrates (attached by a byssus) in depths from 7–69 m. They are most commonly found on coarse bottom substrates in water depths from 2–40 m.

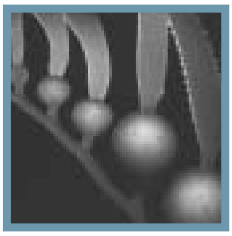
Key knowledge gaps and uncertainties

Scallop fisheries experience high natural variability in abundance, growth, mortality and meat yield, making traditional stock assessment difficult. There are major information deficiencies in scallop biology that affect yield estimates in stock assessment models including growth, mortality, age and condition. Further information on the contribution of the area, size and density of beds to recruitment is needed. The potential effects of introduced species to the scallop fishery are unknown (starfish are attracted to scallops damaged by dredging and lead to increased incidental mortality due to dredging effects).

Australian salmon *Arripis trutta, A. truttaceus*

Distribution

The eastern Australian salmon (*Arripis trutta*) occurs in waters off Brisbane (Queensland) to Port Phillip Bay (Victoria), including Tasmania and Lord Howe and Norfolk islands. *A. trutta* also occurs in New Zealand. The western Australian salmon (*Arripis truttaceus*) is confined to the southern and western coasts of Australia from central Victoria, including Tasmania, to Geraldton (Western Australia).



Fishery profile

The eastern Australian salmon is the predominant species caught in the Tasmanian and New South Wales commercial fisheries. The western Australian salmon makes up the bulk of the Western Australian and South Australian fishery while a roughly equal mix of eastern and western Australian salmon is caught in the Victorian commercial fishery. The total catch of Australian salmon has remained steady at about 4000 t per annum since 1997–98.

Biological and ecological profile

There are two species of Australian salmon, which are both members of the family Arripidae. Between November and February, adult eastern *A. trutta* migrate to waters between the Gippsland Lakes (Victoria) region and Bermagui (New South Wales) for spawning. Some also disperse northwards along the New South Wales coastline. *A. truttaceus* migrates westwards to southwest Western Australia to spawn. Recruitment strength in South Australia is correlated with strength of the Leeuwin Current/El Nino signature. Eastern Australian salmon are serial batch spawners. Eggs, larvae and juveniles of eastern Australian salmon disperse, initially by drifting aided by the East Australian Current, from the New South Wales spawning grounds to Tasmania and Victoria. Each species is considered to be represented by a single genetic stock in Australian waters. Genetic studies have also shown that the New Zealand population of eastern Australian salmon forms a further discrete breeding population, however, they are not sufficiently divergent to be considered a separate species. Adult eastern Australian salmon occur in shelf waters, commonly inhabiting bays and estuaries to a depth of about 30 m. They are also sometimes found in large schools over seagrass beds and in mangrove-lined creeks.

Key knowledge gaps and uncertainties

Unvalidated data may have caused some inaccurate age-based demographics. The fecundity of the species is also unclear.

Pilchard *Sardinops neopilchardus, S. sagax*

Distribution

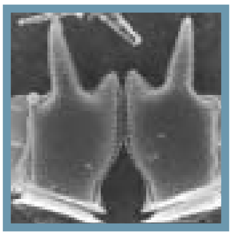
Pichard are distributed from Hervey Bay (Queensland) throughout the southern region of Australia to Red Bluff (Western Australia), including Tasmania. The species is also widespread throughout the temperate waters of most continents.

Fishery profile

The fishery for pilchards began in the 1800s but remained underdeveloped until the 1970s when fishing intensified. The main commercial fishing areas are in South Australia and Western Australia with a smaller fishery in Victoria. Pilchards are also caught in New South Wales and Queensland, although the amount taken is negligible compared to the other States. There is no recreational fishery for pilchards in Australia, although small quantities may occasionally be collected for bait.

Biological and ecological profile

Pilchards are members of the family Clupeidae. The average size of pilchard caught varies between locations, however, in general, fish are 14–16 cm and 2–5 years old. Pilchards are synchronous multiple-batch spawners (ie they spawn more than once per year). Batch fecundity estimates for the pilchard range from about 10 000 eggs in females of about 13 cm, to roughly 47 000 eggs in females of about 18 cm in length. The timing of spawning varies throughout the



range of the pilchard. In Western Australia spawning occurs during autumn and winter; in South Australia, between summer and autumn; in Victoria and Tasmania between spring and summer; and along the New South Wales-Queensland coast from autumn to spring. Spawning in the GAB is thought to extend over the summer and autumn period. Spawning in general appears to occur inshore on the continental shelf. In South Australia preliminary evidence suggests that spawning of pilchards in exposed areas is associated with upwelling regions. Both adult and juvenile pilchards occur on the continental shelf to a depth of about 200 m.

Key knowledge gaps and uncertainties

The genetic relationship between pilchards from different areas is unknown, leading to uncertainty in the number and size of stocks in Australia. The longterm effects of a massive 1995 pilchard kill throughout the range of the pilchard are unknown.

Blue sprat *Spratelloides robustus*

Distribution

Blue sprat are distributed throughout southern Australia from southern Queensland to the Dampier Archipelago (Western Australia), including Tasmania.

Fishery profile

Blue sprat are a minor bycatch of other clupeiod fisheries. Potential for a fishery based on this species as a substantial resource possibly exists.

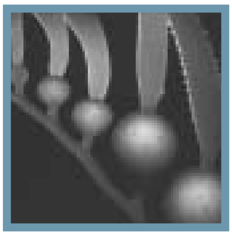
Biological and ecological profile

Blue sprat are members of the family Clupeidae. Little is known of the biology of this species. Larvae have been found entering Wilson Inlet (Western Australia) in December and January, entering Lake Macquarie (New South Wales) from September to April (peaking in February-March) and in coastal waters off Sydney (New South Wales) from November to April.

In South Australia there is some evidence to suggest that juveniles may remain in bays, inlets and estuaries until they reach about eight to twelve months of age before moving further offshore to join schools of adult fish.

Key knowledge gaps and uncertainties

Population structure is unknown. Biology is poorly known. Stock structure is unknown. Resource size is unknown. Spawning and egg development is unknown.



Appendix D: Species of Conservation Significance – Status and Ecological Profile

This Appendix outlines the conservation status and main ecological and biological characteristics of species that live in the South-east Marine Region (SEMR) and are listed in Commonwealth and/or State legislation or Action Plans. Information to compile the list below was drawn principally from:

- Environment Protection and Biodiversity Conservation (EPBC) Act Threatened Flora list
- EPBC Act Threatened Fauna List F
- Action plan for Australian Birds (2000)
- Action plan for Australian Cetaceans (1999)
- Action plan for Australian Seals (1999)
- EPBC Act Section 248 – Draft informative list of marine species
- EPBC Act (Division 3) – Draft informative list of Cetaceans
- State legislation Lists and schedules for South Australia, Victoria, Tasmania and New South Wales
- Tasmania's Threatened Fauna Handbook (1999)

Comprehensive references on the species are included in this Appendix. Please also note that lists and schedules are continuously updated, which results in either change in conservation status or the inclusion/exclusion of species. For comprehensive and up to date listings relevant links and contact information can be found at the following websites:

Commonwealth:
http://www.ea.gov.au/epbc/index.html

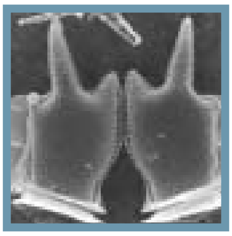
New South Wales:
http://www.npws.New SouthWales.gov.au/wildlife/threaten.htm
and
http://www.fisheries.New SouthWales.gov.au/conservation/species/home_threatened.htm

South Australia:
http://www.environment.sa.gov.au/biodiversity/threatened.html

Tasmania:
http://www.dpiwe.tas.gov.au/inter.nsf/ThemeNodes/RLIG-53KUPV?open

Victoria:
http://www.nre.vic.gov.au
(under the conservation and environment category)

Under Section 248 of the EPBC Act, all species belonging to listed families are protected, which means that it is an offence to kill, injure, take, trade, keep, or move any member of those marine species on Commonwealth land or in Commonwealth waters without a permit. Current list includes the Families Hydrophiidae and Laticaudidae (sea snakes); the Family Otariidae (eared seals); the Family Phocidae (true seals); the Family Cheloniidae (marine turtles); the Families Syngnathidae and Solenostomidae (seahorses, sea-dragons, pipefish and ghost pipefish); all species in the Class Aves (birds) that occur naturally in Commonwealth marine areas. Only those species belonging to the listed Families that are also listed under other legislation, or are part of an Action Plan, and occur within the Region, have been included in this Appendix.



In assessing what protected species are of relevance to the Region planning process, we have considered those species with direct ecological links with the marine environment, thus excluding some species that associate exclusively with the coastal and intertidal environment (eg shore birds), and including those species that, having a predominantly land-based ecology, are nevertheless threatened by ocean-based activities (eg the Orange-bellied Parrot).

Finally, note that State fisheries legislation provides for the protection of a number of plants and animals for the purpose of maintaining and enhancing productivity, in some instances imposing partial regulations to protect reproductive, or otherwise vulnerable, stages of their life cycles (eg only females of blue and giant crabs, rock lobster and yabbies that carry external eggs are protected by the South Australia's Fisheries (General) Regulations, 1984). This Appendix, however, does not include marine organisms protected under fisheries legislation, with the exception of those that are also listed under conservation legislation.

The following abbreviations are used. Note that not all of these categories are used by all jurisdictions, and that the meanings vary slightly between jurisdictions.

CE	Critically Endangered
E	Endangered
T	Threatened
NT	Near Threatened
V	Vulnerable
R	Rare
L	Listed (Victoria's Flora and Fauna Guarantee Act)
N	Nominated
EP	Endangered Population – this category is part of the New South Wales Threatened Species Conservation Act (1995) and, in this Appendix, applies only to the Manly (New South Wales) population of Little Penguin. Although the listed population is outside the Region, the species has been included here as common in other parts of the Region.
TP	Totally Protected – this category is used to indicate fish and marine plants that are protected under the New South Wales Fisheries Management Act 1994.
P	Protected – this category is used here to indicate species protected under the Living Marine Resources Act (1995) Tas. Note that in Tasmania all Syngnathidae fish (pipefish, seahorses, seadragons) and Brachionichthyidae (handfish) are protected under this Act.
Ins.	Insufficient Information
S	listed in the Draft informative list of Marine Species (not including non-pelagic migrating birds) of Section 248 of the EPBC Act or Draft Informative list of Cetaceans Division 3 of the EPBC Act.
REC	recommended for listing.

Table 4: *Species of conservation significance*

Phylum	Class	Scientific Name	Common Name	Cth	Tas	Vic	NSW	SA
Algae	Pheophyta	*Cystoseira trinodis*	Brown Alga		R			
Vascular plant	Angiospermae	*Zostera mucronata*	Garweed					R
Invertebrates	Molluscs	*Platydoris galbana*	Opisthobranch			L		
Invertebrates	Molluscs	*Rhodope genus*	Opisthobranch			L		
Invertebrates	Echinoderms	*Marginaster littoralis*	Seastar		E			
Invertebrates	Echinoderms	*Patiriella vivipara*	Live-Bearing Seastar		E			
Invertebrates	Echinoderms	*Smilasterias tasmaniae*	Seastar		R			
Vertebrate	Fish	*Carcharias taurus*	Grey Nurse Shark	CE		L	E TP	
Vertebrate	Fish	*Carcharodon carcharias*	Great White Shark	V	V	E^{REC}	V TP	L
Vertebrate	Fish	*Epinephelus daemelii*	Black Rock Cod				V TP	
Vertebrate	Fish	*Brachionichthys hirsutus*	Spotted Handfish	E	E			
Vertebrate	Fish	*Sympterichthys* sp. (CSIRO #T1996.01)	Waterfall Bay Handfish	V	P			
Vertebrate	Fish	*Sympterichthys* sp. (CSIRO #T6.01)	Ziebell's Handfish	V	P			
Vertebrate	Fish	*Phyllopteryx taeniolatus*	Weedy Sea Dragon	S			TP	
Vertebrate	Fish	*Phycodurus eques*	Leafy Seadragon		P			L
Vertebrate	Fish	*Thunnus maccoyii*	Southern Bluefin Tuna			L		
Vertebrate	Fish	*Prototroctes maraena*	Australian Grayling	V	V	L		
Vertebrate	Fish	*Lovettia sealii*	Tasmanian Whitebait			V		
Vertebrate	Reptile	*Dermochelys coriacea*	Leathery Turtle	V S	V	E^{REC}		V
Vertebrate	Reptile	*Caretta caretta*	Loggerhead Turtle	E S	E			V
Vertebrate	Reptile	*Chelonia mydas*	Green Turtle	V S	V			V
Vertebrate	Reptile	*Eretmochelys imbricata*	Hawksbill Turtle	V S	V			
Vertebrate	Bird	*Aptenodytes patagonicus*	King Penguin	NT^{*} S				
Vertebrate	Bird	*Pygoscelis papua papua*	Gentoo Penguin	V^{*} S				
Vertebrate	Bird	*Eudyptes chrysocome*	Rockhopper Penguin (Eastern)	V^{*} S				
Vertebrate	Bird	*Eudyptes schlegeli*	Royal Penguin	V^{*}				
Vertebrate	Bird	*Eudyptula minor*	Little Penguin	S			EP	
Vertebrate	Bird	*Pelecanoides georgicus*	South Georgian Diving-Petrel	V				
Vertebrate	Bird	*Macronectes giganteus*	Southern Giant Petrel	E E^{*} S	V		E	
Vertebrate	Bird	*Macronectes halli*	Northern Giant Petrel	V E^{*B} V^{*NB} S	R	E^{REC}		
Vertebrate	Bird	*Daption capense capense*	Cape Petrel (Southern)	LC^{*} S		E^{REC}		
Vertebrate	Bird	*Pterodroma lessonii*	White-Headed Petrel	V^{*B} LC^{*NB} S	V			

Table 4: *Species of conservation significance – continued…*

Phylum	Class	Scientific Name	Common Name	Cth	Tas	Vic	NSW	SA
Vertebrate	Bird	*Pterodroma solandri*	Providence Petrel	V* S			V	
Vertebrate	Bird	*Pterodroma mollis deceptornis*	Soft-Plumaged Petrel	CE* S	E			V
Vertebrate	Bird	*Halobena caerulea*	Blue Petrel	V CE* S	V			V
Vertebrate	Bird	*Pachyptila desolata*	Antarctic Prion	V* S				
Vertebrate	Bird	*Pachyptila turtur subantarctica*	Fairy Prion	E* S	E			
Vertebrate	Bird	*Procellaria aequinoctalis*	White-chinned Petrel	V*NB S				
Vertebrate	Bird	*Procellaria cinerea*	Grey Petrel	E* S	E[REC]			
Vertebrate	Bird	*Puffinus assimilis assimilis*	Little Shearwater (Tasman Sea)	V* S			V	
Vertebrate	Bird	*Diomedea exulans*	Wandering Albatross	CE* S	E	CE[REC]	E	V
Vertebrate	Bird	*Diomedea dabbenena*	Tristan Albatross	E E* S				
Vertebrate	Bird	*Diomedea antipodensis*	Antipodean Albatross	V V* S			V	
Vertebrate	Bird	*Diomedea gibsoni*	Gibson's Albatross	V V* S			V	
Vertebrate	Bird	*Diomedea sanfordi*	Northern Royal Albatross	E E*NB S				E
Vertebrate	Bird	*Diomedea epomophora*	Southern Royal Albatross	V V*NB S		N[REC]		V
Vertebrate	Bird	*Diomedea amsterdamensis*	Amsterdam Albatross	E CE*NB S				
Vertebrate	Bird	*Thalassarche melanophris*	Black-Browed Albatross	E* S	E		V	
Vertebrate	Bird	*Thallassarche impavida*	Campbell Albatross	V V*NB S				V
Vertebrate	Bird	*Thalassarche cauta*	Shy Albatross	V V* S	V	N[REC]	V	V
Vertebrate	Bird	*Thallassarche steadi*	White-Capped Albatross	V V*NB S				
Vertebrate	Bird	*Thallassarche eremita*	Chatham Albatross	E CE*NB S				
Vertebrate	Bird	*Thallassarche salvini*	Salvin's Albatross	V V*NB S				V
Vertebrate	Bird	*Thallassarche chrysostoma*	Grey-Headed Albatross	V E* S	E	N[REC]		V
Vertebrate	Bird	*Thallassarche chloporhyncos*	Atlantic Yellow-Nosed Albatross	V*NB S				
Vertebrate	Bird	*Thallassarche carteri*	Indian Yellow-Nosed Albatross	V V*NB S		N[REC]		
Vertebrate	Bird	*Thallassarche bulleri*	Buller's Albatross	V V*NB S		N[REC]		V
Vertebrate	Bird	*Thallassarche nov.sp "platei"*	Pacific Albatross	V V*NB S				
Vertebrate	Bird	*Phoebetria fusca*	Sooty Albatross	V V*NB S	R	L	V	V
Vertebrate	Bird	*Phoebetria palpebrata*	Light-Mantled Sooty Albatross	V*B V*NB	V	NREC		
Vertebrate	Bird	*Oceanites oceanicus oceanicus*	Wilson's Storm Petrel	V* S	R			
Vertebrate	Bird	*Oceanites nereis*	Grey-Backed Storm Petrel	E*				

Table 4: *Species of conservation significance – continued…*

Phylum	Class	Scientific Name	Common Name	Cth	Tas	Vic	NSW	SA
Vertebrate	Bird	*Morus capensis*	Cape Gannet	V* S				
Vertebrate	Bird	*Morus serrator*	Australasian Gannet	LC*B LC*NB S				
Vertebrate	Bird	*Leucocarbo atriceps purpurascens*	Imperial Shag/ Macquarie Island Shag (Macquarie Island)	V* S	V			
Vertebrate	Bird	*Catharacta lonnbergi lonnbergi*	Subantarctic Skua (Southern)	V*				
Vertebrate	Bird	*Larus pacificus pacificus*	Pacific Gull (Eastern)	LC* S				
Vertebrate	Bird	*Sterna striata*	White-Fronted Tern	V*B LC*NB S	V			
Vertebrate	Bird	*Sterna vittata bethunei*	Antarctic Tern	E E*S	E			E
Vertebrate	Bird	*Neophema chrysogaster*	Orange-bellied Parrot			CE[REC]	E	
Vertebrate	Bird	*Puffinus carneipes*	Flesh-Footed Shearwater	S			V	R
Vertebrate	Bird	*Sterna albifrons sinensis*	Little Tern	S	E	L V[REC]	E	V
Vertebrate	Bird	*Sterna hirundo*	Common Tern					R
Vertebrate	Bird	*Sterna nereis nereis*	Fairy Tern		R	L V[REC]		V
Vertebrate	Bird	*Haliaeetus leucogaster*	White-bellied Sea Eagle			T		V
Vertebrate	Bird	*Pandion haliateus*	Osprey					R
Vertebrate	Mammal	*Arctocephalus tropical*	Subantarctic Fur Seal	E S	E			
Vertebrate	Mammal	*Arctocephalus gazella*	Antarctic Fur-seal	Lower Risk S				
Vertebrate	Mammal	*Arctocephalus pusillus doriferus*	Australian Fur Seal	Lower Risk S			V	R
Vertebrate	Mammal	*Arctocephalus forsteri*	New Zealand Fur Seal	Lower Risk S	R		V	
Vertebrate	Mammal	*Neophoca cinerea*	Australian Sea Lion	NT S				R
Vertebrate	Mammal	*Mirounga leonina*	Southern Elephant Seal	V S	E			R
Vertebrate	Mammal	*Hydrurga leptonyx*	Leopard Seal	Lower Risk S				R
Vertebrate	Mammal	*Lobodon carcinophagus*	Crab-eater Seal	Lower Risk S				
Vertebrate	Mammal	*Leptonychotes weddellii*	Weddell Seal	Lower Risk S				
Vertebrate	Mammal	*Ommatophoca rossii*	Ross Seal	Lower Risk S				
Vertebrate	Mammal	*Australophocoena dioptrica*	Spectacled porpoise	Ins. S				
Vertebrate	Mammal	*Mesoplodon hectori*	Hector's Beaked Whale	Ins. S				R
Vertebrate	Mammal	*Kogia simus*	Dwarf Sperm Whale	Ins. S				R
Vertebrate	Mammal	*Lissodelphis peronii*	Southern Right Whale dolphin	Ins. S				
Vertebrate	Mammal	*Caperea marginata*	Pygmy Right Whale	Ins. S				R
Vertebrate	Mammal	*Balaenoptera acutorostrata*	Minke Whale	Ins. S				R
Vertebrate	Mammal	*Balaenoptera borealis*	Sei Whale	V S			V	

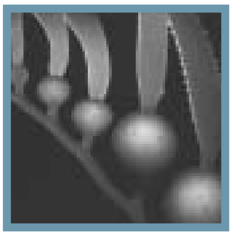
Table 4: *Species of conservation significance – continued…*

Phylum	Class	Scientific Name	Common Name	Cth	Tas	Vic	NSW	SA
Vertebrate	Mammal	*Balaenoptera edeni*	Bryde's whale	Ins. S				
Vertebrate	Mammal	*Balaenoptera musculus musculus*	Blue Whale	E S	E	CE[REC]	E	E
Vertebrate	Mammal	*Balaenoptera physalus*	Fin Whale	V S	V			V
Vertebrate	Mammal	*Megaptera novaeangliae*	Humpback Whale	V S	E	E[REC]	V	V
Vertebrate	Mammal	*Mesoplodon grayi*	Gray's Beaked Whale	Ins. S				R
Vertebrate	Mammal	*Mesoplodon bowdoini*	Andrew's Beaked Whale	Ins. S				R
Vertebrate	Mammal	*Mesoplodon mirus*	True's beaked whale	Ins. S				
Vertebrate	Mammal	*Ziphius cavirostris*	Cuvier's Beaked Whale	Ins. S				R
Vertebrate	Mammal	*Hyperoodon planifrons*	Southern Bottlenose Whale	Ins. S				R
Vertebrate	Mammal	*Physeter catodon (macrocephalus?)*	Sperm Whale	Ins. S			V	R
Vertebrate	Mammal	*Kogia breviceps*	Pygmy Sperm Whale	Ins. S				R
Vertebrate	Mammal	*Lagenorhynchus obscurus*	Dusky Dolphin	Ins. S				R
Vertebrate	Mammal	*Lagenorhynchus cruciger*	Hourglass dolphin	Ins. S				
Vertebrate	Mammal	*Grampus griseus*	Risso's Dolphin	Ins. S				R
Vertebrate	Mammal	*Tursiops truncatus*	Bottlenose dolphin	Ins. S				
Vertebrate	Mammal	*Delphinus delphis*	Common dolphin	Ins. S				
Vertebrate	Mammal	*Lagenodelphis hosei*	Fraser's dolphin	Ins. S				
Vertebrate	Mammal	*Eubalena australis*	Southern Right Whale	V S	E	L CE[REC]	V	V
Vertebrate	Mammal	*Pseudorca crassidens*	False Killer Whale	Ins. S				R
Vertebrate	Mammal	*Orcinus orca*	Killer whale	Ins. S				
Vertebrate	Mammal	*Globicephala melas*	Long-finned pilot whale	Ins. S				
Vertebrate	Mammal	*Globicephala macrorhynchus*	Short-Finned Pilot Whale	Ins. S				R
Vertebrate	Mammal	*Tasmacetus shepherdi*	Shepherd's Beaked Whale	Ins. S				R
Vertebrate	Mammal	*Berardius arnuxii*	Arnoux's Beaked Whale	Ins. S				R
Vertebrate	Mammal	*Mesoplodon densirostris*	Blainville's beaked whale	Ins. S				
Vertebrate	Mammal	*Mesoplodon layardii*	Strap-toothed beaked whale	Ins. S				
Vertebrate	Mammal	*Dugong dugon*	Dugong	S			E	

[*] from The Action plan for Australia Birds (reviewed in 2000), where assessment of species conservation status is done against IUCN criteria.

[B] symbol for breeding population, used when breeding and non-breeding population have different status – when not specified, status refers to breeding population

[NB] population non-breeding in Australia but visiting Australia's territory.



Listed species – conservation status and ecological notes

Plants

Only two plant species – an alga and a seagrass – are currently listed in conservation legislation within the Region. Marine plants, however, are broadly protected in Australia by State fisheries and marine resource legislation, in recognition of their importance for the productivity of the marine environment.

Information on the two species listed below can be obtained from the relevant state departments. Contact details can be found on the websites listed in the introduction to this Appendix.

Brown Alga *Cystoseira trinodis*

Status

This brown alga is listed as Rare under the Tasmanian Threatened Order 2001.

Distribution

This species is widespread along tropical Australia, and its southern form reaches down to Victoriator Harbour (South Australia) in the west and Dunalley (Tasmania) in the east.

Ecology

Inhabits shallow waters on sheltered reefs; the thallus reaches up to 1.5 m in length and the southern Australian form lacks leaf-like branches.

Main threats

Threats to brown alga and other macroalgae might include pollution and effluent runoff, physical disturbance of habitat by boats, increases in siltation and changes in water temperature.

Garweed *Zostera mucronata*

Status

This seagrass species is listed as Rare under Schedule 9 of the South Australia's National Parks and Wildlife Act 1972 and is protected under South Australia's Native Vegetation Act 1992.

Distribution

Zostera mucronata is a common temperate seagrass on the eastern, southern and western coasts of Australia.

Ecology

Seagrasses are flowering plants in an underwater environment. They provide food and shelter to a wide variety of other species. Their presence can improve the health of an ecosystem.

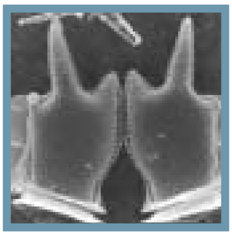
Main threats

In some areas large tracts of seagrass have been killed by sewage effluent runoff from urban areas. Other causes of seagrass decline include increased siltation, disturbance of habitat by vessels and infrastructure and other industrial pollutants.

Invertebrates

The status and conservation of marine invertebrates has only recently become a matter of concern for the protection of Australia's biodiversity resources. The general widespread distribution and high potential for dispersal of many marine invertebrate species may suggest that the risk of extinction for these species is somehow low. However, as we improve our understanding of the biology and ecology of these species, we are learning that many have life history traits that make them highly vulnerable to the impacts of human activities. Invertebrate species described below include organisms that have restricted ranges during all or some critical stages of their life cycles, low potential for dispersal (as in the case of the Tasmanian live-bearing seastar, *Patiriella vivipara*), are highly dependent on habitats at risk and/or are subjected to overexploitation.

Several species of invertebrates have been recently recommended for listing under Victoria's Flora and Fauna Guarantee Act 1988. These are not considered below because they are still under consideration. They include four crustaceans, seven echinoderms and one mollusc recognised as threatened and requiring



legislative protection. Several more species have also been identified as of conservation concern because of their dependency on vulnerable habitats. A number of invertebrates of commercial importance are also protected in Australia through States' fisheries legislation.

Some information sources for the species listed below, which include further references, are:

Bryant S and Jackson J (1999). *Tasmania's Threatened Fauna Handbook: what, where and how to protect Tasmania's threatened animals*. Threatened Species Unit, Parks and Wildlife Service, Hobart.

O'Hara T. and Barmby V. (2000) *Victorian Marine Species of Conservation Concern: Molluscs, Echinoderms and Decapod Crustaceans*. Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne, Australia.

Opisthobranch *Platydoris galbana*

Status

Listed in 1988 on the Victoria's Fauna and Flora Guarantee Act, because of its limited distribution.

Distribution

Known only from the reef flat at San Remo, whose marine community is also protected, but may occur elsewhere and remain undiscovered.

Ecology

Little is known about Opisthobranch species. Many remain undescribed and are relatively uncommon. They have been known to have specialised relationships with sponges, hydroids and bryozoans. The San Remo site is an intertidal/shallow water habitat within an embayment.

Main threats

Coastal development is a potential threat to this species and its habitat.

Opisthobranch *Rhodope* genus

Status

Listed under the Victoria's Fauna and Flora Guarantee Act, because of its limited distribution.

Distribution

Known only from the reef flat at San Remo, whose marine community is protected also, but may occur elsewhere and remain undiscovered.

Ecology

Little is known about Opisthobranch species. Many remain undescribed and are relatively uncommon. They have been known to have specialised relationships with sponges, hydroids and bryozoans. The San Remo site is an intertidal/shallow water habitat within an embayment.

Main threats

Coastal development is a potential threat to this species and its habitat.

Seastar *Marginaster littoralis*

Status

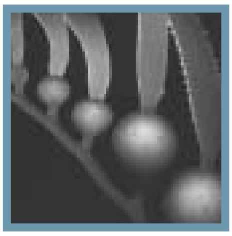
Listed under the Tasmanian Threatened Species Protection Act 1995 as Endangered.

Distribution

This species is endemic to southeastern Tasmania. First described from specimens collected in and around the Derwent River.

Ecology

Grows up to 17 mm in diameter and has five arms. The sea star is green-brown in colour on its dorsal (top) side with an off-white outer edge. The actinal (arm) surface is off-white with blue-green colouring around the spinelets of the abactinal (bottom) area. This species lives in shallow water environments and recent surveys indicate that it's total range may be less than one hectare.



Main threats

Key threats include the removal of habitat, the decrease of water quality and an increase in nutrients and silt from urban runoff, increasing coastal development, collection of specimens for aquaria and competition from introduced pests.

Live-bearing seastar *Patiriella vivipara*

Status

Listed under the Tasmanian Threatened Species Protection Act 1995 as Endangered.

Distribution

This species is endemic to Tasmanian waters, and was first discovered near Sorell.

Ecology

This species is one of four known live-bearing seastar species. It is found singularly or as part of a colony of up to several hundred individuals. Individuals vary in size up to 15mm and can possibly reach an age of eight to ten years. The species is slow moving and live young do not spread as far as species with a larval stage in their development.

Main threats

Key threats include the removal of habitat, the decrease of water quality and an increase in nutrients and silt from urban runoff, increasing coastal development, collection of specimens for aquaria and competition from introduced pests.

Seastar *Smilasterias tasmaniae*

Status

Listed on the Tasmanian Threatened Species Protection Act 1995 as Endangered.

Distribution

This species is endemic to south-eastern Tasmanian waters. First described from specimens collected south of Hobart.

Ecology

This species reaches a maximum radius of about 20 mm. Its spines appear flattened and truncated, sometimes with a swollen end. The species is found in relatively few sites each with less than thirty individuals.

Main threats

Key threats include the removal of habitat, the decrease of water quality and an increase in nutrients and silt from urban runoff, increasing coastal development, collection of specimens for aquaria and competition from introduced pests.

Fish

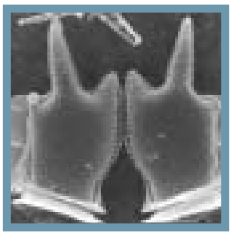
As is the case for marine invertebrates, marine fishes have also been long overlooked in terms of their conservation status, based on the preconception that most have broad dispersal and distribution. However, following decades of overexploitation for fisheries or aquarium trade, or due to inherently vulnerable life history traits, several fish species are currently considered of concern for their conservation.

Please note also that, at the time of printing this report, an Action Plan for marine fishes is being prepared (see also the report Conservation Overview And Action Plan For Australian Threatened And Potentially Threatened Marine And Estuarine Fishes, Report to Environment Australia).

Many fish species of commercial significance are protected under fisheries legislation with the aim of maintaining and or enhancing fisheries productivity. Species of commercial importance have been considered here only when they are also of conservation significance, such as, for example, the Southern Bluefin Tuna, which is listed as Critically Endangered in the authoritative Red List of the International Union for the Conservation of Nature. For details of marine species of commercial significance in the South-east Marine Region, please see Appendix C of this Report.

Some sources that can be consulted for further information and comprehensive reference lists include:

- Bruce BD and Green MA (1998). *The Spotted Handfish 1999-2001 Recovery plan*. Commonwealth Endangered Species Program (ESU Project 572) and Commonwealth FISHCARE program, Department of Primary Industry and Energy, Canberra.
- Bryant S and Jackson J (1999). Tasmania's Threatened Fauna Handbook: what, where and how to protect Tasmania's threatened animals. Threatened Species Unit, Parks and Wildlife Service, Hobart.
- Environment Australia (2000) Draft Recovery plan for Great White Sharks Carcharodon carcharias in Australia. Environment Australia, Canberra.
- http://www.amonline.net.au/fishes/fishfacts/fish/edaemelii.htm
- http://www.amonline.net.au/fishes/students/focus/seadrag.htm
- http://www.ifc.tas.gov.au/fact_sheets/tasmanian_whitebait.htm
- http://www.ifc.tas.gov.au/fact_sheets/grayling.htm
- Information on conservation issues for the Southern Bluefin Tuna see:
- http://www.redlist.org/search/details.php?species=21858
- http://www.fishbase.org/Summary/SpeciesSummary.cfm?ID=145&genusname=Thunnus&speciesname=maccoyii



Grey nurse shark *Carcharias taurus*

Status

Grey nurse sharks are listed as vulnerable on Schedule 1 of the Endangered Species Protection Act 1992 (ESP Act). The Commonwealth lists the species as Critically Endangered on the east coast of Australia and Vulnerable on the west coast, and the species is listed as endangered in New South Wales. Grey nurse sharks are protected under Fisheries Legislation in New South Wales, Tasmania and Queensland.

Distribution

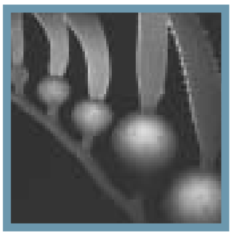
The Grey nurse shark is found world wide mainly in warm-temperate inshore waters. Within Australia it is found primarily on the east and west coastlines, and around the southern half of the continent. Relatively little is known about the migratory habits of the shark.

Ecology

Grey nurse sharks are often observed just above the sea bed in or near deep sandy-bottomed gutters or rock caves in the vicinity of inshore rocky reefs and islands. They can occur either alone or in small to medium sized groups, usually under 20 sharks. The grey nurse shark feeds on fish, other sharks, squids, crabs and lobsters. The species has a relatively low growth rate and takes 4–6 years to mature, with both males and females maturing at 220 cm in length. At birth the grey nurse shark is independent and measures approximately 1 m in length. The average life span of the species in the wild is unknown, though animals kept in captivity have lived for 13–16 years.

Main threats

The primary threat to this population appears to be commercial and recreational fishing bycatch, shark control activities and shark finning. However, there remains much research to be done on this species and more threats may become apparent.



Great white shark *Carcharodon carcharias*

Status

The Great White is listed as vulnerable on Schedule 1 of the Endangered Species Protected Act 1992. It is protected in all Australian State and Commonwealth waters, and is listed as Vulnerable under New South Wales, Tasmanian and Commonwealth legislation.

Distribution

This species is found throughout the world in temperate and subtropical oceans. Within Australia it is usually found off the coast, from southern Queensland around the southern coast to North West Cape in Western Australia. The Great White has been observed at depths of up to 1280 m. Long term movements of white sharks are poorly known.

Ecology

Great white sharks are primarily observed in inshore coastal areas close to the surf line and in inshore waters in the vicinity or rocky reefs and islands, and often near seal colonies. Great Whites are non-social animals with a very large range. They have few natural predators. Their diet consists mainly of finfish, marine mammals, other sharks and rays. The species can reach lengths of as much as 7 m with unconfirmed reports of larger specimens. Individuals are typically 1.4–6 m. Precise population numbers are still unknown Female white sharks mature at between 4.5–5 m. Minimum age at maturity for females and males are estimated to be 11 and nine years respectively. Longevity of the species is unknown, but it is considered to be in excess of 30 years.

Main threats

There are a number of threats to this species including beach meshing, recreational game fishing (before protected by legislation) and commercial bycatch. The degradation of coastal waters may have an impact on breeding and nursery grounds, but more research is required to confirm this.

Black rock cod *Epinephelus daemelii*

Status

Totally protected in New South Wales under the Fisheries Management Act (1994)

Distribution

Found in coastal and offshore reefs and off islands from southern Queensland to eastern Victoria.

Ecology

This species is territorial, living for years in the same deep cave or ledge. It is found along the entire coast of New South Wales, growing to 1.6 m and weighing over 50 kg.

Main threats

Vulnerable to illegal fishing, incidental catch, habitat disturbance and alteration of predator and prey relationships.

Spotted handfish *Brachionichthys hirsutus*

Status

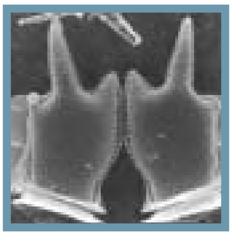
Listed as Endangered by the Commonwealth and Tasmanian governments.

Distribution

This species is endemic to Tasmanian waters. Found in a very limited range in the Derwent River estuary and adjoining bays and channels.

Ecology

The name of the spotted handfish derives from the fact that the pectoral (side) fins of the handfish have specialised into five 'finger-like' digits, which the fish uses to pull itself along the seafloor. The preferred habitat of the handfish is soft substrate in shallow depressions or near rocks at depths between two and 30 meters. The handfish spawns in September and October laying a relatively few 80 to 250 eggs. In the Derwent River, handfish most commonly lay their eggs around the base of a stalked ascidian (sea squirt). The female remains with the egg mass for the 7–8 weeks before hatching. Handfish hatch as fully formed juveniles (6–7 mm in length) and grow to a maximum length of about 13 cm.



Main threats

Habitat modification or destruction as a result of siltation and water pollution caused by urban runoff. The habitat is often disturbed by dredges, fishing nets and boat anchors. The eggs of the handfish are also subject to predation by invasive pests such as the Pacific Seastar. Specimens are sometimes illegally collected for private aquaria.

Waterfall Bay Handfish *Sympterichthys* sp. CSIRO #T1996.01

Status

Listed as Endangered by the Commonwealth and Tasmanian governments.

Distribution

This species is endemic to Tasmania, and found only within limited areas on the rocky reefs off the south-east side of the island.

Ecology

Relatively little information is available on this species compared to that of the spotted handfish, although the species are very similar in form.

Main threats

Habitat modification or destruction as a result of siltation and water pollution. Physically disturbing the habitat of this species can be damaging given the extremely limited range of the population. Invasive pests such as the Pacific seastar prey on the species' eggs. Illegal collection for aquaria can reduce numbers.

Ziebell's handfish *Sympterichthys* sp. CSIRO #T6.01

Status

Listed as Endangered by the Commonwealth and Tasmanian governments.

Distribution

This species is endemic to Tasmania, and found only within limited areas on the rocky reefs off the southeastern side of the island.

Ecology

Relatively little information is available on this species compared to that of the spotted handfish, although the species are very similar in form.

Main threats: Habitat modification or destruction as a result of siltation and water pollution. Physically disturbing the habitat of this species can be damaging given the extremely limited range of the population. Invasive pests such as the Pacific Seastar prey on the species' eggs. Illegal collection for aquaria can reduce numbers.

Weedy seadragon *Phyllopteryx taeniolatus*

Status

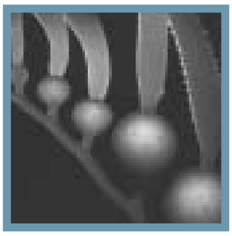
Totally protected in New South Wales under the Fisheries Management Act 1994

Distribution

Found in shallow areas, on protected reefs and algal beds off the south of New South Wales and most of southern Australia.

Ecology

Weedy seadragons can grow to 45 cm. They use camouflage as their primary defence, and are found along the reefs and sandy underwater areas of southern Australia. Though they are similar in appearance to sea horses, weedy seadragons do not have prehensile (gripping) tails, but rather appear to use them for steering.



Main Threats

Current impacts on this species are minimal. Its basic requirements make it difficult to keep in an aquarium. It is not yet commonly used in traditional medicine. Fishery impacts are minimal. The animal's rocky habitat protects it from trawling.

LEAFY SEADRAGON *Phycodurus eques*

Status

As a member of the Sygnathid family, this species is a protected in Commonwealth waters as a Listed Marine Species under the EPBC Act. It is also protected in Tasmanian waters, and it is illegal to collect specimens in Western Australia and South Australia.

Distribution

The leafy seadragon is endemic to the southern coastline of mainland Australia including Victoria, South Australia and Western Australia.

Ecology

Some specimens have been recorded at more than 40 cm in length, although hatchlings are only about 3.5 cm long. The specialised camouflage of the seadragon makes it ideally suited for a typical habitat of sandy-bottomed sheltered waters in or adjacent to kelp reefs. They have been recorded at depths down to 30 m.

Main threats

The main threat to the seadragon is loss of habitat for various reasons including excessive fertiliser runoff.

SOUTHERN BLUEFIN TUNA *Thunnus maccoyii*

Status

The southern bluefin tuna is managed under the Convention for the Conservation of Southern Bluefin Tuna. The aim of the Convention is to ensure through appropriate management, the conservation and optimum utilisation of southern bluefin tuna. It is also listed as Critically Endangered by the IUCN.

Distribution

This species is found in temperate and cold Southern Hemisphere seas mainly between 30° and 60° latitude. They are a highly migratory species, being found in Australian waters, from north-western Australia around the south of the continent to northern New South Wales.

Ecology

This large species reaches lengths of about 2.45 m and weights of about 260 kg. Spawns in waters of 20°C to 30°C, in September to March. Maturity is reached at approximately eight years of age, and they live to about 20 years in age. Young fish are generally found closely associated with coastal and continental shelf waters, mature fish live in oceanic pelagic environments. They feed on cephalopods, crustaceans, fish and salps (Thaliacea).

Main threats

A highly sought after species by commercial and game fishers. The primary threat to southern bluefin tuna is over-exploitation of the species by fishing.

AUSTRALIAN GRAYLING *Prototroctes maraena*

Status

Listed as Vulnerable under the Environment Protection Biodiversity Conservation Act 1999. Also listed as Vulnerable in Victorian and Tasmanian legislation.

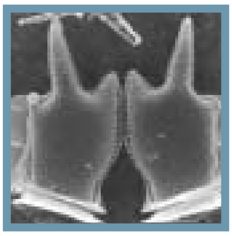
Distribution

Found throughout Tasmania and the southeastern Australian mainland, this species migrates between fresh and salt water.

Ecology

Usually this species is about 170 to 180 mm long, but individuals may reach up to 300 mm. Spawning occurs in fresh water. The larval fish are washed downstream to the ocean where they remain for about six months before returning to freshwater streams. They have a life expectancy of about three years.

Main threats: The loss of riparian and instream habitat and the creation of stream barriers such as dams that prevent migration can impact on population numbers.



Tasmanian whitebait *Lovettia sealii*

Status

Listed as Rare under Victorian legislation.

Distribution

Found in coastal waters of Tasmania and Victoria.

Ecology

This species migrates upstream to spawn before dying. Young fish are swept downstream to the sea where they remain for most of their life. They are usually about 60 mm in length and prefer coastal estuarine habitats.

Main threats

Destruction of riparian habitat and the creation of barriers such as dams and weirs that can prevent migration upstream impact on population numbers. Contaminants and the destruction of estuarine habitat impact on the adult population.

Reptiles

Of the six species of marine turtles that live in Australia, four have distributions that extend to temperate waters and have been recorded from the South-east Marine Region. These are the loggerhead, hawksbill, green, and leathery turtles, all of conservation significance due to the declines in their populations. Studies of population dynamics suggest that marine turtles are strongly affected by even small increases in mortality rates above natural levels. This means that accidental deaths from human activities may have detrimental repercussions on the survival of these species. In recognition of their vulnerability, the 'Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South' has been listed as a Key Threatening Process under the Environment Protection and Biodiversity Conservation Act.

Although all four species occur in the Region they reproduce and spend most of their life in tropical and subtropical waters. Of the four, the leathery – or leatherback – turtle is most commonly sighted in the Region and is believed to migrate to Victorian, South Australian and Tasmanian waters from either western or eastern subtropical Australia.

The summary information below has been drawn from a number of sources, including:

- Bone C (1998). *Preliminary investigation into leatherback turtle Dermochelys coriacea (L.). Distribution, abundance and interactions with fisheries in Tasmanian waters*. Report to Tasmania Parks and Wildlife Service, Hobart.
- Bryant S and Jackson J (1999). *Tasmania's Threatened Fauna Handbook: what, where and how to protect Tasmania's threatened animals*. Threatened Species Unit, Parks and Wildlife Service, Hobart.
- Marsh H, Corkeron PJ, Limpus CJ, Shaughnessy PD and Ward TM (1995). The reptiles and mammals in Australian seas: their status and management. In: Zann LP and Kailola P (Eds) 1995 *The State of the Marine Environment Report for Australia. Technical Annex: 1 The Marine Environment. Ocean Rescue 2000*, Department of Environment, Sport and Territories, Canberra.

Leathery turtle *Dermochelys coriacea*

Status

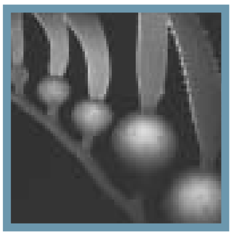
Leathery turtles are listed as vulnerable under Commonwealth, South Australian and Tasmanian legislation. Additionally, this species is listed on the EPBC Act as a true migratory species under the Bonn Convention.

Distribution

This species is found globally as far north as the North Sea and as far south as New Zealand. They are the most widespread species of marine turtle. Nesting is usually confined to tropical and sub-tropical beaches.

Ecology

Leathery turtles are the largest of the marine turtle species reaching 1.6 m in length and weighing up to 500 to 1000 kg. They are adapted to survive more



extreme conditions than other species and forage in cold waters. They are pelagic feeders at all life stages and can feed throughout the water column to 200 m depth. Little is known about the diet of juveniles, but adults feed mainly on jellyfish and squid.

Main threats

In the past, harvesting of this species had a major impact on the population. Until the recent development of turtle exclusion devices on trawlers, bycatch was a major cause of animal mortality. Boat strikes have also impacted on the stressed population.

Loggerhead turtle *Caretta caretta*

Status

Loggerhead turtles are listed as endangered under Commonwealth and Tasmanian legislation and vulnerable under South Australian legislation. Additionally, this species is listed on the EPBC Act as a true migratory species under the Bonn Convention.

Distribution

This species appears globally in tropical, sub-tropical and temperate waters. Although it breeds and nests in tropical regions, it has been sighted in waters of all Australian states.

Ecology

Adult turtles reach about 1 m in length compared to hatchlings which are about 5 cm in length. Hatchling and sub-adult loggerheads forage for food in the open ocean while larger adults will come in closer to shore to feed. They can be found foraging around reefs, embayments, mudflats, estuaries and seagrass meadows.

Main threats

In the past, harvesting of this species had a major impact on the population. Until the recent development of Turtle Exclusion Devices on trawlers, bycatch was another major cause of animal mortality. Boat strikes have also impacted on the stressed population.

Green turtle *Chelonia mydas*

Status

Green turtles are listed as vulnerable under Commonwealth, South Australian and Tasmanian legislation. Additionally, this species is listed on the EPBC Act as a true migratory species under the Bonn Convention.

Distribution

This species appears globally in tropical, sub-tropical and temperate waters usually above the 20° isotherm. Although it breeds and nests in tropical regions, it has been sighted in waters of all Australian states.

Ecology

Green turtles reach about 1m in length with hatchlings about 4.4 cm long. They are mainly herbivorous, feeding on seagrass and algae. Hatchlings and sub-adults are pelagic, feeding at sea and coming inshore when they reach adulthood, to feed on seagrass beds and algal mats.

Main threats

In the past harvesting of this species had a major impact on the population. Until the recent development of Turtle Exclusion Devices on trawlers, bycatch was a major cause of animal mortality. Boat strikes have also impacted on the stressed population.

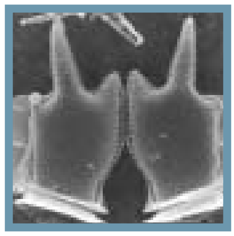
Hawksbill turtle *Eretmochelys imbricata*

Status

Hawksbill turtles are listed as vulnerable under Commonwealth and Tasmanian legislation. Additionally, this species is listed under the EPBC Act as a true migratory species under the Bonn Convention.

Distribution

This species appears globally in tropical, sub-tropical and temperate waters. Although it breeds and nests in tropical regions, it has been sighted in waters of all Australian states.



Ecology

Hawksbill turtles reach an average length of about 80 cm with hatchlings about 4 cm long. Hatchlings and sub-adults spend several years feeding in a pelagic environment often associated with drifting Sargassum rafts. Adults move inshore, typically to coral or rocky reefs, to forage for food and live for several decades.

Main threats

In the past harvesting of this species had a major impact on the population. Until the recent development of turtle exclusion devices on trawlers, bycatch was another major cause of animal mortality. Boat strikes have also impacted on the stressed population.

Birds

All species of birds that naturally occur in Commonwealth marine areas are included in the Draft informative list of marine species, Section 248 of the Environment Protection and Biodiversity Conservation Act and therefore are protected. This means that a permit is required to kill, injure, take, trade, keep, or move any member of those marine species on Commonwealth land or in Commonwealth waters. Birds of conservation significance in the Region include large oceanic birds (such as albatrosses and giant petrels), penguins, and a number of smaller seabirds that breed on or visit Macquarie Island and the Region's coasts and feed in waters of the continental shelf or, further offshore. The orange-bellied parrot has no links with the marine environment but is included below because it is critically endangered and migrates across the Bass Strait, where disturbances from marine based activities may have detrimental effects on its population.

The incidental catch of seabirds during oceanic longline fishing operations is now listed in the EPBC Act as a key threatening process. Due to dramatic population declines observed over recent decades, albatrosses and giant petrels are of particular concern. The Recovery Plan for Albatrosses and Giant-Petrels (2001) lists five species of albatross and two species of giant petrels as breeding in Australia, and 16 species of albatrosses as foraging in Australian waters (of which, fifteen are believed to forage in waters of the South-east marine Region). Of the penguin species included below, four species breed on Macquarie Island but may visit regularly Tasmania and the coasts of mainland Australia. Threats to these species may be at sea or on land, particularly during breeding.

Information sources consulted for the section below include:

- Environment Australia (2001) *Recovery Plan for Albatrosses and Giant-Petrels*. Wildlife Scientific Advice, Natural Heritage Division, Environment Australia
- Garnett ST and Crowley GM (2000). *The Action Plan For Australian Birds*. Environment Australia, Canberra.
- Goldsworthy SD, He X, Tuck GN, Lewis M and Williams R (2001) *Trophic interactions between the patagonian toothfish, its fishery, and seals and seabirds around Macquarie Island*. Marine Ecology progress Series 218: 283-302.

King penguin
Aptenodytes patagonicus **fam.: Spheniscidae**

Status

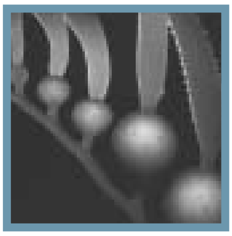
Australian population is Near Threatened (only two breeding locations). Globally it is of Least Concern.

Distribution

Moving widely around Southern Ocean when not breeding. Two breeding colonies in Australian's EEZ (Heard Is. and Macquarie Is.). Vagrants reach Tasmania.

Ecology

King penguins nest on beaches. They forages in deep waters for small cephalopods and fish and their breeding cycle takes 15 months with two chicks per pair every three years.



Main threats

King penguins were historically harvested for oil. Currently, on land, cats and ticks are a threat while at sea, marine debris, particularly plastic can result in deaths. It is unclear whether fishing is a threat but this should be monitored, particularly the potential for development of myctophid fisheries (eg *Electrona carlsbergi*) should be closely monitored as evidence shows that there may be direct competition for this species (Goldsworthy et al. 2001). Climate change, with rising seawater temperature is likely to represent a major threat.

Gentoo penguin
Pygoscelis papua papua **fam.: Spheniscidae**

Status

Australian population is listed as Vulnerable (only two breeding locations). Globally it is Near Threatened.

Distribution

There are 53 breeding colonies of Gentoo penguins on Macquarie Island and 16 on Heard Island. Non-breeding birds are likely to disperse widely across the Southern Ocean.

Ecology

Gentoo penguins nest on various ice-free surfaces and choice of breeding sites may depend on access to shallow feeding grounds. They feed on fish and euphasiids.

Main threats

Vulnerable during breeding to cats on land. Likely to have little resistance to introduced diseases and plastic at sea are also a threat. Commercial fishing may be a disturbance and the effect of climate change on food supply is a potential threat.

Rockhopper penguin (eastern)
Eudyptes chrysocome **fam.: Spheniscidae**

Status

Listed globally and in Australia as Vulnerable (population decline of 20–50% is expected from monitoring of global population).

Distribution

Rockhopper penguins move widely across the Southern Ocean in winter and spring, when they are not breeding, and are regularly encountered off Tasmania. There are 23 breeding colonies on Macquarie Island and 12 colonies on Heard Island, and there are also small colonies on adjacent islands.

Ecology

Rockhopper penguins nest among rocks and tussock grass and forage in surrounding waters, feeding primarily on euphasiids (krill). They are likely to feed closer and less efficiently than the co-occurring royal penguin.

Main threats

Diseases introduced by visitors are a potential threat. Observed declines have been associated with shifts of prey from the shore due to increased sea temperatures. Fishing may impact prey abundance and should be monitored, particularly the potential for development of myctophid fisheries (eg *Electrona carlsbergi*) should be closely monitored as evidence shows that there may be direct competition for this species (Goldsworthy et al. 2001); plastic debris.

Royal penguin
Eudyptes schlegeli **fam.: Spheniscidae**

Status

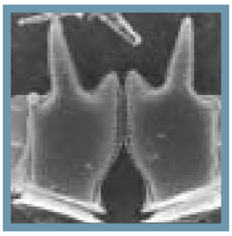
Vulnerable (only two breeding locations)

Distribution

The royal penguin is confined to Macquarie Island and other small subantarctic islands.

Ecology

The royal penguin nests in large colonies on bare, level, pebbly, rocky or sandy ground. When breeding they feed on euphasiids, fish and squid and travel to the polar frontal zone.



Main threats

Fishing may impact prey abundance and should be monitored, particularly the potential for development of myctophid fisheries (eg *Electrona carlsbergi*) should be closely monitored as evidence shows that there may be direct competition for this species (Goldsworthy et al. 2001).

Little penguin
Eudyptula minor FAM.: SPHENISCIDAE

Status

Listed in the draft informative list of marine species not including non-pelagic migrating birds, EPBC Act Section 248. Outside the region it is also listed as endangered as part of the New South Wales Threatened Species Conservation Act 1995 and, in this Appendix, applies only to the Manly (New South Wales) population of little penguin. The species has been included here, as it is common in other parts of the Region.

Distribution

Little penguins can be found around the southern coastline of Australia from Fremantle, Western Australia to northern New South Wales. They are mainly found on offshore islands. The largest known colony is on Phillip Island near Melbourne with a population of 20 000 birds.

Ecology

Little penguins are the smallest of the penguins – only 40 cm tall and 1.1kg.They are also known as fairy penguin, little blue penguin, northern or southern blue penguin. They eat small, highly mobile, midwater shoaling fish (anchovy and pilchard), squid that are less than 12 cm long and crustaceans. They catch their prey by pursuit – diving to shallow depths usually less than 15 m for about 23 seconds. They depend on both land and sea for their survival. Breeding typically occurs between September and February each year. The female lays two eggs, but both parents share equally in incubation (36 days) and chick rearing (two months). After the chicks have fledged, the adults forage intensively at sea for about two weeks, during which time they double their mass in preparation for a moult that requires a three-week fast ashore.
Young birds or fledglings disperse widely; the longest known movement was from Phillip Island to Spencer Gulf – 1100 km.

Main threats

Disturbance to their ocean and beach habitats effects both the survival and breeding of little penguins. Ocean threats include overfishing (especially of pilchards, whitebait and squid), the use of gill nets, disturbance from boating, oil spills and related pollution. On land, predation and disturbance by cats, dogs, and foxes, as well as careless recreational use of beaches by humans, seriously effects little penguin survival.

South Georgian diving-petrel
Pelecanoides georgicus FAM.: PROCELLARIIDAE

Status

Australian breeding population is Vulnerable (breeding at only two locations). Globally is of Least Concern.

Distribution

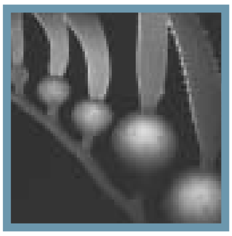
South georgian diving-petrels are found mainly on Heard Island but reported from other subantarctic islands (including Macquarie Island) across the Southern Ocean.

Ecology

They are colonial nesters, nesting in burrows dug in sandy areas, plains and hillsides. They feed on small crustaceans.

Main threats

There are no immediate threats but climate change may impact food supply. The introduction of cats or rats to breeding islands could also be devastating.



Southern giant petrel
Macronectes giganteus **fam.: Procellariidae**

Status

Australian breeding population is Endangered (50% population decrease since mid 1900) while the global population, including those birds visiting Australian territory, is vulnerable.

Distribution

Southern giant petrels breed in the Australia Antarctic Territory, Heard Island, Macquarie Island and smaller subantarctic islands, generally south of the 53°S. In winter, they migrate north and may be found in subtropics or further north.

Ecology

Southern giant petrels nest in small colonies in open vegetation and, if successful, raise a single chick. They feed on cephalopods and euphasiids, scavenging on land and on fishing boats for discards. They also prey on other birds on land and at sea and may abandon nests if disturbed by humans.

Main threats

Drowning when hooked on longlines. Predation by cats and rats may impact nesting success, as does the increase in the population of Subantarctic Skuas. Marine debris is also a threat along with chemical contaminants and human disturbance.

Northern giant petrel
Macronectes halli **fam.: Procellariidae**

Status

Australia breeding population is Vulnerable (breeds at a single location), while global population including those birds visiting Australian territory, is Near Threatened.

Distribution

The northern giant petrel breeds on Macquarie Island, foraging mainly in waters of southern Australia. In winter they are found throughout the oceans south of 28°S.

Ecology

Northern giant petrels nest as dispersed pairs in dense vegetation. They raise a single chick and feed on fish, cephalopods, crustaceans and carrion (increases in breeding populations have been associated with local increases in seal populations). They also attend fishing vessels.

Main threats

Drowning through being hooked on longlines. Predation by cats and rats may impact on nesting success, as does the increase in the population of Subantarctic Skuas. Marine debris is also a threat along with chemical contaminants and human disturbance.

Cape petrel (southern)
Daption capense capense **fam.: Procellariidae**

Status

Australian breeding population is Vulnerable (breeding at a single location), the population visiting Australian territories is Least Concern.

Distribution

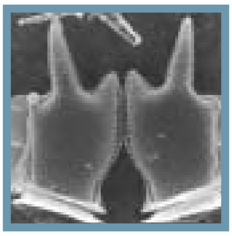
Cape petrels breed on Heard Island, while non-breeding birds are common along southern coasts, particularly in winter.

Ecology

Cape petrels nest among rocks and on cliffs in summer. They forage for euphasiids, cephalopods and fish and, when available, offal.

Main threats

At sea they may get caught on longlines, but are usually displaced by larger scavengers and therefore less vulnerable. Threatened by cats and rats.



White-headed petrel
Pterodroma lessonii **fam.: Procellariidae**

Status

Australian breeding population is Vulnerable (restricted area of occupancy and past decline – now apparently halted), while visiting population is of Least Concern.

Distribution

White-headed petrels have a circumpolar pelagic distribution. Breeding populations are most abundant on Macquarie Island.

Ecology

White-headed petrels breed alone or in colonies, nesting in burrows dug among tussocks and herbfields. They feed pelagically on cephalopods and crustaceans.

Main threats

Past observed decrease probably due to cats, wekas, rats and increased skua population numbers.

Providence petrel
Pterodroma solandri **fam.: Procellariidae**

Status

Vulnerable (only two breeding locations).

Distribution

There are at least 20 pairs of providence petrel which breed on Phillip Island, but the majority of the population breeds on Lord Howe Island.

Ecology

Providence petrels breed in earth burrows, often in rainforest, while at sea they forage in warmer waters for cephalopods, crustaceans and offal. They also feed close to fishing boats.

Main threats

The breeding population is now confined to two mountain tops and a tiny islet.

Soft-plumaged petrel
Pterodroma mollis deceptornis **fam.: Procellariidae**

Status

Critically endangered (less than 50 mature adults in Australia); globally, Critically Endangered also.

Distribution

The soft-plumaged petrel possibly breeds on Maatsuyker Island, where they occur throughout the year.

Ecology

Their ecology is little known but they probably nest in rocks and tussocks, and feed on squids in nearby waters.

Main threats

Accidental introduction of predators to Maatsuyker Island would be catastrophic.

Blue petrel
Halobalena caerulea **fam.: Procellariidae**

Status

Critically endangered (restricted area of occupancy and continuous decline in numbers of mature adults); globally is of Least Concern (but little genetic exchange is assumed to occur between populations).

Distribution

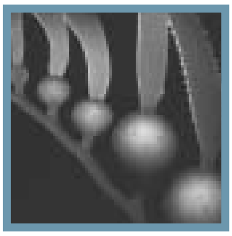
Breeding populations of blue petrels on stacks offshore from Macquarie Island. They probably forage in the vicinity of breeding colonies but are spread throughout the Southern Ocean.

Ecology

Blue petrels nest in colonies, laying one egg among tussocks or rocks. They feed on pelagic crustaceans, fish, cephalopods and insects.

Main threats

Blue petrels are under threat from predation by cats and rats, and destruction of nests due to trampling by Imperial Shags and/or storms. Increased population numbers of Subantarctic Skuas, which feed on adults is also a threat.



Antarctic prion

Pachyptila desolata **fam.: Procellariidae**

Status

Vulnerable (only two breeding locations).

Distribution

Antarctic prions breed at Macquarie Island and Heard Island.

Ecology

Antarctic prions nest in burrows dug among rocks or low vegetation.

Main threats

Increases in subantarctic skuas may represent a threat along with predation by cats and rats. The developing krill fishery also has the potential to affect this species.

Fairy prion

Pachyptila turtur subantactica **fam.: Procellariidae**

Status

Australian breeding population is Endangered, while globally is of Least Concern (assumed little genetic exchange between populations) .

Distribution

Fairy prions breed on Macquarie Island and adjacent islets and some individuals migrate to southern Australia in winter.

Ecology

Fairy prions nest in burrows, usually under the cushion plant Colobanthus muscoides or in peaty soils. They feed on euphasiids (krill).

Main threats

Predation by feral cats is a threat, exacerbated by the species being one of the few remaining on Macquarie Island during winter. Habitat degradation by rabbits is also a threat along with increases in population numbers of Subantarctic Skuas.

White-chinned petrel

Procellaria aequinoctalis **fam.: Procellariidae**

Status

Population visiting Australia Territory is Vulnerable (observed decline in size of population visiting Australia).

Distribution

The white-chinned petrel does not appear to breed in Australia but they do breed on many subantarctic islands and visit southern Australia.

Ecology

White-chinned petrels nest in burrows on subantarctic islands and feed on fish and offal, regularly attending fishing vessels. They are generally scavengers and while breeding, also feed on cephalopods.

Main threats

Longline fishing has determined the decline in population size throughout their range.

Grey petrel

Procellaria cinerea **fam.: Procellariidae**

Status

Australian breeding population is Endangered (less than 50 individuals but recolonisation in process); globally is Near Threatened.

Distribution

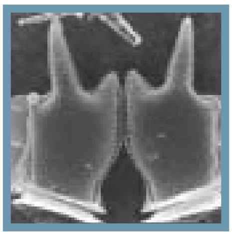
Grey petrels breed on Macquarie Island and other subantarctic islands throughout the Pacific, Indian and Atlantic Oceans. Non breeding birds are found throughout the Southern Ocean, to at least 30°S. They are scarce near the Australian continent.

Ecology

Grey petrels nest in burrows in colonies and forage on pelagic cephalopods, fish and crustaceans.

Main threats

On land, predation by cats and Wekas is a threat to grey petrels. At sea, in New Zealand waters they have been recorded as ensnared by longline fishing gear at rates similar to Albatrosses.



Little shearwater (Tasman Sea) *Puffinus assimilis assimilis* fam.: Procellariidae

Status

Australian population is Vulnerable (breeding at less than five locations).

Distribution

Little shearwaters breed on Ball's Pyramid, on the western margin of the Lord Howe Rise. After breeding, they disperse across the Tasman and Coral Seas.

Ecology

Little shearwaters nest in burrows dug in soft soil, among loose rocks or succulents and forage at sea.

Main threats

Little shearwaters have been eliminated from Lord Howe Island, and possibly from Norfolk Island, by black rats. The accidental introduction of predators to refuge islands may be catastrophic.

Wandering albatross *Diomedea exulans* fam.: Diomedeidae

Status

Australian breeding population is Critically Endangered (less than 50 mature individuals); globally, is Vulnerable (population declining) (little genetic exchange between Australian breeding and visiting populations).

Distribution

Wandering albatross have a circumpolar distribution, with decreasing range. They breed on Macquarie Island (10 pairs) and Heard Island (1 pair recorded). They feed throughout the Southern Ocean, including around southern Australia with non-breeding birds usually found between 30˚S and 50˚S. They are known to travel large (>15 000 km) distances to forage.

Ecology

Wandering albatross breed biennially in small colonies with large mud nests among tussocks. They feed in pelagic offshore and inshore waters, on squid, fish, crustaceans and carrion. They often attending fishing vessels, where they dominate several other albatross species.

Main threats

Longline fishing gear, exacerbated by high mobility (high chance of encounter of fishing vessels) is a major threat. They are also illegally shot for bait or to prevent fishing competition from dropline fisheries. On land, breeding success and/or nest site selection is adversely affected by increased populations of Subantarctic Skuas, and also by human disturbance. Marine debris, especially plastics (and regurgitation to chicks) and contaminants are also a threat.

Tristan albatross *Diomedea dabbenena* fam.: Diomedeidae

Status

Population visiting Australia territory is Endangered (small area of occupancy).

Distribution

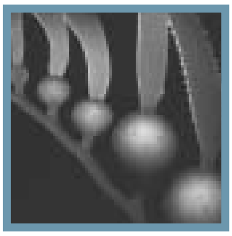
Breeding of tristan albatross is restricted to the South Atlantic Ocean while they forage almost to the equator. There is only one record of tristan albatross from Australian waters.

Ecology

Tristan albatross breed biennially in colonies, nesting among tussocks and feeding on squid, fish and crustaceans.

Main threats

Longline fishing gear is a threat to tristan albatross along with illegal shooting to prevent fishing competition and accidental collisions with above-surface gear.



Antipodean albatross
Diomedea antipodensis **fam.: Diomedeidae**

Status

Australian population is Vulnerable (estimated population decline >20% in next three generations, as a result of fishing bycatch); Globally, is Vulnerable (breeding at less than five locations).

Distribution

Antipodean albatross breed on Antipodes and Campbell Island (New Zealand) and feed in the south-west Pacific and Tasman Sea.

Ecology

Antipodean albatross breed biennially in colonies in tussock grass on remote subantarctic islands and they feed pelagically on squid, fish and crustaceans.

Main threats

Drowning on longline fishing gear is a threat, as are collisions with above-water elements of fishing gear. Antipodean albatross are also occasionally shot to prevent fishing competition.

Gibson's albatross
Diomedea gibsoni **fam.: Diomedeidae**

Status

Australian population is Vulnerable (expected population decline >20% over next three generations); globally, is Vulnerable (breeds at less than five locations).

Distribution

Gibson's albatross breeds on Auckland Island (New Zealand). Females feed in the Tasman Sea while males feed further south or in the mid-Pacific Ocean. In Australia they have been recorded foraging between Coffs Harbour (New South Wales) and Wilsons Promontory (Victoria)

Ecology

Gibson's albatross breed biennially in colonies among grass tussocks on remote subantarctic islands. They feed pelagically on squid, fish and crustaceans. They travel great distances – during and between breeding seasons – using winds and exploiting weather conditions to maximise foraging.

Main threats

The main threats are drowning on longline fishing gear and collision with above-water elements of fishing gear.

Northern royal albatross
Diomedea sanfordi **fam.: Diomedeidae**

Status

Population visiting Australia Territory is Endangered (visiting from an Endangered population); globally is also Endangered (small area of occupancy and inferred population decline).

Distribution

Northern royal albatross breed on Chatham Island and Taiaroa Head (New Zealand). Their non-breeding range extends to the south-west Atlantic and they regularly visit Tasmanias and South Australian waters to feed and occasionally visit New South Wales.

Ecology

Northern royal albatross reed biennially in colonies among grass tussocks on remote subantarctic islands. They feed pelagically on squid, fish and crustaceans.

Main threats

The main threats are drowning on longline fishing gear and collision with above-water elements of fishing gear.

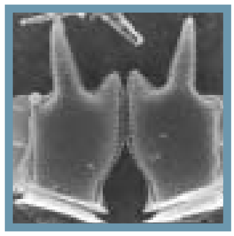
Southern royal albatross
Diomedea epomophora **fam.: Diomedeidae**

Status

Population visiting Australia Territory is Vulnerable (likely to decrease by >20% over next three generations); globally is Vulnerable (the species breeds at less than five locations).

Distribution

Southern royal albatross are found along the southern coast of mainland Australia and around Tasmania. They breed on Campbell (majority of breeding pairs), Enderby, Auckland and Adams Islands.



Ecology

Southern royal albatross breed biennially (when successful) in colonies among grass tussocks and feed pelagically, primarily on squid and fish.

Main threats

Drowning in longline fishing gear is the primary threat, they may also suffer from collision with cables above-water fishing gear.

AMSTERDAM ALBATROSS
***Diomedea amsterdamensis* FAM.: DIOMEDEIDAE**

Status

Population visiting Australia (although not confirmed record, visitation is likely) and globally is Critically Endangered (one population with 40 mature birds).

Distribution

Amsterdam albatross breed on Amsterdam island, foraging in the surrounding Indian Ocean and are likely to reach Tasmania and New Zealand.

Ecology

Amsterdam albatross breed biennially in colonies among grass tussocks and feed on squid, fish and crustaceans.

Main threats

Amsterdam albatross are considered the world's rarest seabird and therefore any death is likely to have amajor impact. Longline fishing gear is the most likely threat in Australian waters.

BLACK-BROWED ALBATROSS
***Thalassarche melanophrys* FAM.: DIOMEDEIDAE**

Status

Australian breeding population is Endangered (likely to decrease >20% over next two generations); globally, is Near Threatened (declined density over half its range).

Distribution

Globally, the majority of breeding pairs of black-browed albatross are found in the Falkland Islands. In Australia the majority of breeding pairs are found on Heard Island (600–700 pairs) and other subantarctic islands, including 40 pairs on Macquarie Island.

Ecology

Black-browed albatross breed annually with low recruitment rates. They nest in colonies in tussock grass and feed on continental shelves, oceanic upwellings and boundaries of currents on crustaceans, fish and to a lesser extent cephalopods, salps and jellyfish. Black-browed albatross also scavenge on penguin flesh and attend fishing vessels.

Main threats

Illegal culling to prevent fishing competition, particularly over longline hooks is a threat to this species. Breeding success and/or nesting site selection is also likely to be affected by cats and increased numbers of Subantarctic Skuas.

CAMPBELL ALBATROSS
***Thalassarche impavida* FAM.: DIOMEDEIDAE**

Status

Population visiting Australia is Vulnerable (population decline of 20% over last three generations); globally is Vulnerable (breeding at less than five locations).

Distribution

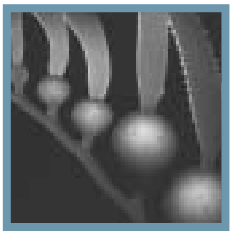
Campbell albatross breed only on Campbell Island (New Zealand) with breeding birds foraging on the New Zealand continental shelf. Non-breeding birds forage in shelf waters of New Zealand, Australia and the central and western Pacific Ocean.

Ecology

Campbell albatross breed annually in colonies among grass tussocks and forage pelagically over near shore waters on squid, fish and crustaceans. The also attend fishing vessels to feed on offal.

Main threats

Campbell albatross are threatended by drowning in longline fishing gear (sub-adults are over-represented in bycatch) and also by collisions with above-water fishing gear.



Shy albatross
Thalassarche cauta fam.: Diomedeidae

Status

Population is Vulnerable (expected to decrease by at least 20% over next three generations).

Distribution

Shy albatross are endemic to Australia, breeding on Albatross Island, Bass Strait, Mewstone and Pedra Branca (southern Tasmania). Non-breeding and breeding adults are not likely to move large distances (~700 and 200 km respectively) while immature birds from southern Tasmania migrate as far as South Africa and those from Albatross Island as far north as southern Queensland.

Ecology

Shy albatross breed annually in colonies on rocky islands and feed in waters over the continental shelf, including harbours and bays, on fish, cephalopods, crustaceans and tunicate. Flocks also attend fishing vessels.

Main threats

Shy albatross were historically killed for feathers and are also among the most frequently killed species on longlines in Australian waters. Trawling fishing gear is also a threat, as birds can get trapped in nets and/or collide with above-water equipment. They are illegally culled off Tasmania and South Africa and vulnerable to avian pox virus. Overexploitation of squid or fish in Bass Strait poses a threat by direct competition.

White-capped albatross
Thalassarche steadi fam.: Diomedeidae

Status

Population visiting Australia is Vulnerable (likely to decrease by more than 20% over next three generations; globally is Vulnerable (breeding at less than five locations).

Distribution

White-capped albatross breed on small islands south of New Zealand and breeding birds forage in nearby waters. They are likely to be common off southeastern Australia, where they are recorded in bycatch off Tasmania, but are hard to identify.

Ecology

Little is known about the ecology of the white-capped albatross. They probably breed annually and nest in tussocks and diet probably consists of inshore cephalopods and fish.

Main threats

Drowning in longline fishing gear and collision with fishing equipment (trawlers) are the main threats and on Auckland Island they are also threatened by pigs predating on nests.

Chatham albatross
Thalassarche eremita fam.: Diomedeidae

Status

Globally and population visiting Australia are Critically Endangered (small area of occupancy and inferred population decline).

Distribution

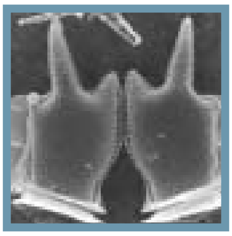
Chatham albatross breed only on Pyramid Rock (Chatham island, New Zealand) and forage in coastal waters off New Zealand and Tasmania (they also forage in the south Pacific and off South America).

Ecology

Chatham albatross nest in dense colonies on grassy slopes and probably feed on fish and cephalopods. They also attend fishing boats.

Main threats

Drowning in longline fishing gear is a threat to Chatham albatross and they are also threatened at the breeding site by introduced predators, habitat degradation and hunting.



Salvin's albatross
Thalassarche salvini **fam.: Diomedeidae**

Status

Population visiting Australia is Vulnerable (likely to decrease more than 20% over next three generations); globally is Vulnerable (breeding at less than five locations).

Distribution

Salvin's albatross nests on islands south of New Zealand and forages across the southern Pacific Ocean. They occasionally occur in the Indian and South Atlantic Oceans.

Ecology

Salvin's albatross nest in dense colonies on bare rocky islands and feed in shelf waters, probably on inshore cephalopods and fish. They als attend fishing vessels.

Main threats

Drowning in longline fishing gear is a threat to salvin's albatross along with collisions with trawling fishing equipment.

Grey-headed albatross
Thalassarche chrysostoma **fam.: Diomedeidae**

Status

Australian breeding population is Endangered (50–250 individuals); globally is vulnerable (20–50% decline in population over last three generations); little genetic exchange with extra-limital populations.

Distribution

In Australia grey-headed albatross breed on Petrel Peak (Macquarie Island). They also breed on islands in the Pacific, Indian and Atlantic Oceans. Breeding and non-breeding birds disperse widely across the Southern Ocean and in winter their range shifts north and birds visit waters off southern Australia and New Zealand. In Australia, most records are from Tasmania.

Ecology

Grey-headed albatross breed biennially in dispersed colonies, nesting in grass tussocks. They forage away from the continental shelf and their diet varies geographically and includes squid, fish, crustaceans, penguin carrion and lampreys. They are regularly seen foraging at fishing boats.

Main threats

Earlier declines of grey-headed albatross occurred due to egg-collecting and hunting. The current main threat is drowning on longline fishing gear with high mortality rates around breeding colonies (population on Macquarie Island is particularly vulnerable). High numbers are also killed by collisions with trawling equipment and are shot for bait and to prevent competition with fishing vessels. The expanding squid fishery may result in direct competition. On land they are threatened by cats and by increases in population numbers of Subantarctic Skuas.

Atlantic yellow-nosed albatross
Thalassarche chloporhyncos **fam.: Diomedeidae**

Status

Population visiting Australia is Vulnerable (likely to decrease more than 20% over next three generations); globally listed as Data Deficient.

Distribution

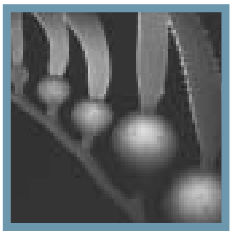
Atlantic yellow-nosed albatross breed on islands of the southern Atlantic Ocean. They usually feed in surrounding waters but occasionally reach Australian waters south of 20°S.

Ecology

Atlantic yellow-nosed albatross are colonial nesters and probably feed on squid and fish. They also attend fishing vessels to scavenge.

Main threats

Drowning on longline fishing gear and collisions with trawling fishing equipment.



Indian yellow-nosed albatross
Thalassarche carteri **fam.: Diomedeidae**

Status

Population visiting Australia is Vulnerable (likely to decrease by more than 20% over next three generations); globally is Vulnerable (breeding at <5 locations).

Distribution

Indian yellow-nosed albatross breed on islands of the Indian Ocean and forage mostly in the southern Indian Ocean. They are particularly abundant off Western Australia (but can occur throughout southern Australia).

Ecology

Indian yellow-nosed albatross nest in colonies and feed on cephalopods and fish. They also attend fishing vessels.

Main threats

Drowning on longline fishing gear and collisions with trawling fishing equipment.

Buller's albatross
Thalassarche bulleri **fam.: Diomedeidae**

Status

Population visiting Australia is Vulnerable (likely to decrease by more than 20% over next three generations); globally is Vulnerable (breeding at <5 locations).

Distribution

Buller's albatross breed on Snares and Solander Islands (New Zealand), foraging nearby. They may cross theTasman Sea and have been recorded in southern New South Wales and South Australia.

Ecology

Buller's albatross are colonial nesters. Their diet is unknown although they attend fishing vessels.

Main threats

Drowning on longline fishing gear and collisions with trawling fishing equipment.

Pacific Albatross
Thalassarche sp.nov. "platei" **fam.: Diomedeidae**

Status

Population visiting Australia is Vulnerable ((likely to decrease by more than 20% over next three generations); globally is Vulnerable (breeding at <5 locations).

Distribution

Pacific albatross breed on Chatham and Three Kings Islands (New Zealand) and forage in the Pacific ocean and Tasman Sea, reaching Australian mainland coasts.

Ecology

Pacific albatross are colonial nesters. Their diet is unknown although they attend fishing vessels.

Main threats

Drowning on longline fishing gear and collisions with trawling fishing equipment.

Sooty albatross
Phoebetria fusca **fam.: Diomedeidae**

Status

Population visiting Australia and globally are Vulnerable (estimated decline of 20–50% over last three generations; likely to decrease by more than 20% over the next three generations)

Distribution

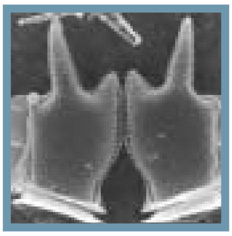
Sooty albatross breed on islands in the southern Indian and Atlantic oceans, foraging south of 30°S, between southern New South Wales and Argentina.

Ecology

Sooty albatross breed biennially, nesting either singly or in colonies in grass tussocks or other vegetation. They feed on cephalopods, crustaceans, fish, siphonophores and penguin carrion in high seas. They attend whales and fishing boats.

Main threats

Drowning on longline fishing gear and collisions with trawling fishing equipment.



Light-mantled albatross
***Phoebetria palpebrata* fam.: Diomedeidae**

Status

Australian breeding population is Vulnerable (breeds at only two locations; likely to decline more than 20–50% over next three generations); global population and population visiting Australia is Vulnerable (likely to decline more than 20–50% over next three generations).

Distribution

In Australia, light-mantled albatross breed on Heard and Macquarie islands. Elsewhere, they breed on islands of the southern Pacific, Indian and Atlantic Oceans. They forage circumpolarly, usually south of 35°S, but can reach the subtropics. Breeding and non-breeding birds are common visitors to the open ocean south and west of Tasmania.

Ecology

Light-mantled albatross are among the longest-lived of all birds. They breed every 2-3 years in dispersed pairs or small colonies, nesting in steep tussock grasslands and/or cliffs. They feed on squid, crustaceans and fish and attend fishing vessels.

Main threats

Light-mantled albatross are killed on longline fishing gear, particularly when moving north during non-breeding season. They are also likely to have been impacted by feral cats and increased numbers of Subantarctic Skuas.

Wilson's storm petrel
***Oceanites oceanicus oceanicus* fam.: Hydrobatidae**

Status

Australian breeding population is Vulnerable (although abundant, breeds at only two locations); globally is of Least Concern (assumed little genetic interchange).

Distribution

In Australia, wilson's storm-petrels breeds on Heard and Macquarie islands. Elsewhere they breed in the southern Indian and Atlantic Oceans, migrating north after breeding and reaching to the equator.

Ecology

Wilson's storm petrels nest in burrows or crevices among rocks and feed from the ocean surface on small crustaceans, particularly euphasiids, fish and cephalopods.

Main threats

On land, cats are a likely threat, while at sea, development of krill fishheries may affect this species.

Grey-backed storm petrel
***Oceanites nereis* fam.: Hydrobatidae**

Status

Australian breeding population is Endangered (breeds at only two locations); globally is of Least Concern (assumed little genetic interchange).

Distribution

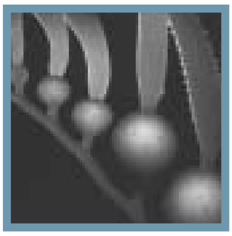
Grey-backed storm petrels probably breed on Macquarie island and on islands off Tasmania. Outside of Australian waters they breed on islands throughout the Southern Ocean. During winter they travel northward and become more frequent around Australian coasts.

Ecology

Grey-backed storm-petrels nest on the ground under vegetation and feed on immature barnacles and a few small fishes.

Main threats

On land, cats and rats are a threat.



Cape gannet
***Morus capensis* fam.: Sulidae**

Status

Australian breeding population is Vulnerable (based on the small population should be listed as critically endangered but downgraded because it is a new colonist – first recorded in Victoria in 1981); globally, is Vulnerable.

Distribution

In Australia cape gannets breed on Wedge Light, in Port Phillip Bay and probably at Lawrence Rocks. They also breed off South Africa.

Ecology

Cape gannets lay a single egg on guano or seaweed mounds and feed on fish.

Main threats

The main threat to this species is hybridisation with the Australasian gannet.

Australasian gannet
***Morus serrator* fam.: Sulidae**

Status

The Australian breeding population and the visiting population are of Least Concern.

Distribution

Most breeding colonies of the Australasian gannet are in New Zealand. In Australia, breeding populations occur in Port Phillip Bay, Lawrence Rocks, Bass Strait islands and Black Pyramid, Pedra Branca and Eddistone Rocks, off southern Tasmania. Most non-breeding birds, perhaps with the exception of juveniles, disperse and often travel across the Tasman Sea, where they mix with brids from New Zealand. Most juveniles move west to near-coastal waters off South Australia and Western Australia.

Ecology

Australasian gannets nest on mounds built on rocks (or artificial structures) made of guano, seaweed and earth. They feed on fish and cephalopods in shelf waters.

Main threats

Drowning in longline fishing gear and competition with the fishing industry are threats at sea while on land, fox predation might have affected attempts at breeding. They also interbreed with cape gannets.

Imperial shag (Macquarie Island)
Leucocarbo atriceps purpurascens
fam.:Phalacrocoracidae

Status

Sub-population is Vulnerable (breeding at only two locations); globally species is of Least Concern.

Distribution

The imperial shag is endemic to Macquarie island, with breeding colonies on the western coast, they forage along the coast.

Ecology

Imperial shag nests are built on rocks in the spray zone. They feed on benthic fish from rocks and kelp in the limited area of shallow water surrounding Macquarie Island.

Main threats

Cats and increased subantarctic skuas may be a threat.

Subantarctic skua (southern)
***Catharacta lonnbergi lonnbergi* fam.: Laridae**

Status

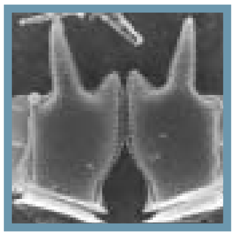
Australian breeding population is Vulnerable (breeding at only two locations); globally is of Least Concern (but no evidence of genetic interchange).

Distribution

In Australia, subantarctic skuas breed on Macquarie, Heard and McDonald Islands. Elsewhere, their distribution is circumpolar on subantarctic islands. After breeding they migrate north to the shores of southern continents. They regularly occur near Tasmania in winter.

Ecology

Subantarctic skuas nest in vegetation, each nest with two eggs, but occasionally more than one female lays in the same nest. They are predators and scavengers, feeding among penguin and seal colonies. They also take live rabbits and population numbers are likely to have been increased by high rabbit numbers in some areas.



Main threats

The main threat is likely to be the health of colonies/populations of seabirds on which they prey. At sea they are also recorded as bycatch in the longline fishery.

Pacific gull (eastern)

Larus pacificus pacificus **fam.: Laridae**

Status

Population is of Least Concern (although a small population and area of occupancy, there is no evidence of decline).

Distribution

Pacific gulls mainly occur in Bass Strait and the coasts of central Victoria and Tasmania. They are occasionally recorded as far north as Sydney (New South Wales) and further. They breed on 130 islands around Tasmania and across coastal Victoria.

Ecology

Pacific gulls inhabit sandy coastlines and also occur in estuaries, refuse tips and rocky coasts. They have well-spaced territories where they build nests (1-2 eggs) on rocky headlands or islands. They feed on molluscs, crabs and fish and scavenge on substantial quantities of refuse.

Main threats

Pacific gulls are prone to disturbance while feeding and breeding, however, most nests are well protected by inaccessibility.

White-fronted tern

Sterna striata **fam.: Laridae**

Status

Australian breeding population is Vulnerable (breeding at only few locations); population visiting Australia is of Least Concern (not substantial genetic interchange).

Distribution

In Australia, the white-fronted tern breeds around the Furneaux Islands Group. In winter, the non-breeding population is common in Bass Strait and off eastern Tasmania and New South Wales. There are a small number of records for South Australia and southern Queensland. They also breed in New Zealand.

Ecology

White-fronted terns lay 1–2 eggs in spring in shallow depressions on rocky stacks or islets, often among succulents. They feed on a range of small fish from coastal waters or at the wave break.

Main threats

The main threats for this species are unknown, although cats and other predators could pose a threat.

Antarctic tern (New Zealand)

Sterna vittata bethunei **fam.: Laridae**

Status

Australian breeding population is Endangered (between 50–250 mature adults); globally is Near Threatened (not substantial genetic interchange, as visiting birds are only vagrant)

Distribution

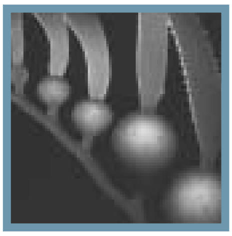
In Australia, antarctic terns breed on offshore stacks off the eastern and western coasts of Macquarie Island. Elsewhere, they breed on New Zealand subantarctic islands. Some individuals from Macquarie Island remain in proximity of breeding locations all year round, while others disperse as far north as continental Australia and New Zealand. Distribution is little known outside of the breeding season.

Ecology

Antarctic Terns nest among live vegetation and occasionally unvegetated areas. During summer they feed on fish, crustaceans and other marine invertebrates in kelp beds of inshore waters. During winter they feed at the ice edge and patches of unfrozen inshore waters.

Main threats

Predation by cats and Wekas may have impacted upon colonies breeding on the Macquarie Island in the past and restricted breeding to the offshore stacks. On the stacks, eggs and chicks are still vulnerable to rats.



Orange-bellied parrot
***Neophema chrysogaster* fam.: Psittacidae**

Status

Population is Critically Endangered (180 mature adults in a single sub-population and continuing to decline).

Distribution

Breeding orange-bellied parrots, while inhabiting south-west and central Tasmania in the past, are now restricted to the area from Birch's Inlet to Louisa Bay (southwestern Tasmania). Non-breeding birds occur on King Island as a stopover during migration to southeasern Australia.

Ecology

Orange-bellied parrots breed inland, in a mosaic of eucalypt forest, rainforest and moorland plains. They nest in hollows and feed on grass and sedge seed. Non-breeding birds disperse in a range of coastal habitats.

Main threats

Given the status of the species, any threat at any life stage may have catastrophic effects. On land, habitat fragmentation by grazing and competition with introduced seed-eaters are the main threats. At sea, during migration, disorientation from brightly-lit fishing vessels may also be a significant threat.

Flesh-footed shearwater
***Puffinus carneipes* Fam.: Procellariidae**

Status

This species is a listed Marine Species on the Commonwealth EPBC Act in addition to being a listed migratory species on the JAMBA agreement. It is listed as vulnerable in New South Wales and rare in South Australia.

Distribution

This shearwater is a migratory species. Its breeding grounds are in the southern Indian Ocean and the southeastern Pacific Ocean. At other times of the year this species has been sighted in the central and northern Pacific Ocean.

Ecology

The fleshy-footed shearwater feeds mainly on fish and squid. They have also been known to eat offal if the opportunity presents itself. Nests are made in burrows with the entrance often protected by vegetation. The shearwater has mainly been recorded in sub-tropical waters over continental shelves and the continental slope.

Main threats

In the past this species has been killed in large numbers for food, feathers and oil. Other threats include predation by introduced species such as cats and foxes, and the destruction of nesting sites by human settlements.

Little tern
***Sterna albifrons sinensis* fam.: Laridae**

Status

The Little tern is listed as endangered in Tasmania and New South Wales and vulnerable in South Australia. The species is listed on the Victorian Flora and Fauna Guarantee Act.

Distribution

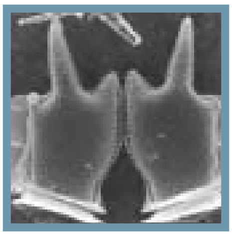
The little tern breeds on the northern and eastern coasts of Australia, including north and eastern Tasmania and the Victorian coastline through to South Australia's Gulf of St Vincent. The species is also resident in these same areas, although there is migration within this range.

Ecology

Little terns feed on fish and arthropods taken from inland waters. They nest between the high tide mark and shore vegetation in undisturbed and unvegetated sites. They will also nest near estuaries and adjacent fresh water lakes, on the continent, islands or cays.

Main threats

The exposed nature of nesting sites means that the species has a high breeding failure depending on climatic factors and tides. This is compounded by the encroachment of humans on nest sites and associated introduced pests such as dogs, foxes, cats and rats. Despite this, active management of breeding sites has been successful in increasing population numbers.



Common tern
***Sterna hirundo* fam.: Laridae**

Status

The common tern is listed as a Marine Species under Commonwealth legislation and is recognised as a migratory species under both the JAMBA and CAMBA agreements. It is listed as rare in South Australia at the limit of the species range.

Distribution

The common tern is a migratory species found globally. The species can be found on the northern, eastern and the southeastern coasts of Australia, with isolated populations in other areas.

Ecology

Common terns are about 35 cm in length and weigh approximately 120 g. Typically they lay three eggs per clutch. Marine terns usually breed on islands, sandspits or bars often in simple sandscrapes. Identifying this species from other members of the tern family can be difficult because of the habit of common terns to moult feathers and change colour patterns at different times of the year.

Main threats

The exposed nature of nesting sites means that the species has a high breeding failure depending on climatic factors and tides. This is compounded by the encroachment of humans on nest sites and associated introduced pests such as dogs, foxes, cats and rats.

Fairy tern
***Sterna nereis nereis* fam.: Laridae**

Status

The fairy tern is listed as rare in Tasmania and vulnerable in South Australia. Victoria has listed the species on the Flora and Fauna Guarantee Act.

Distribution

This species is found on the western and southern coastlines of Australia including all of coastal Tasmania, South Australia, Victoria and southern New South Wales.

Ecology

Fairy terns feed in inshore waters around islands and the mainland. They lays eggs in sand scrapes and nest in small colonies on coral, on beaches and around estuaries. Specific nest sites may vary within a certain area from year to year.

Main threats

The rate of nest failure may be quite high as a result of exposed breeding sites. The encroachment of human settlements and invasive pests such as foxes, dogs and rats have also damaged nesting sites and increased breeding failure.

White-bellied sea eagle
***Haliaeetus leucogaster* fam.: Accipitridae**

Status

The white-bellied sea eagle is listed as vulnerable in South Australia under the National Parks and Wildlife Act; threatened under the Victorian Flora and Fauna Guarantee Act and while not listed in Tasmania is considered to be of high conservation significance.

Distribution

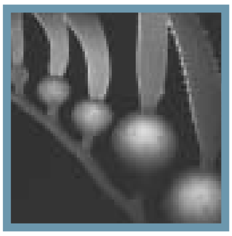
White-bellied Sea Eagles occur along the coastline of Australia and also range inland over large rivers and wetlands, often moving on a seasonal basis.

Ecology

Few studies of white-bellied sea eagles have been undertaken and little is known regarding their ecology. White-bellied sea eagles nest and forage mainly near the coast but also live near large rivers and lakes inland. Their huge nests are constructed of sticks, usually in tall eucalypts in large areas of old-growth eucalypt or mixed forests. White-bellied sea eagles lay one to two eggs every year but usually only one chick is reared to fledging. They hunt by a gliding attack from a prominent perch. Fish, eels or birds are snatched from the water's surface although lizards, small mammals and carrion are also eaten.

Main threats

Increased human presence has been detrimental to nesting White-bellied Sea Eagles because they are sensitive to disturbance and many may desert nests and young. Other possible threats include loss and disturbance to breeding and foraging habitat and direct persecution by shooting and poisoning.



Osprey

pandion haliateus **fam.: Accipitridae**

Status

The osprey is listed as rare in South Australia under the National Parks and Wildlife Act.

Distribution

The osprey occurs along much of the coastline of Australia and also ranges inland over large rivers and wetlands in some areas. Within the Region it is it is found in South Australia, parts of Western and eastern Victoria, in southern New South Wales and ranges to northern Tasmania.

Ecology

The osprey inhabits mangroves, rivers and estuaries, inshore seas, and coastal islands. It patrols over water and hovers, then plunges feet-first to catch the fish on which it feeds. The osprey builds its nests along rugged cliffs to protect its eggs.

Main threats

Coastal habitat modification.

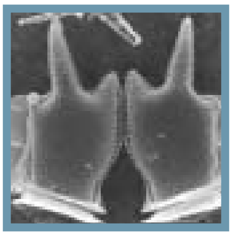
Mammals – pinnipeds

All ten pinniped species occurring in Australian waters are considered below, as they all breed or forage within the boundaries of the South-east Marine Region. Only three species (Australian sea lion, New Zealand and Australian fur seals) breed on the coasts of the Australian continent and Tasmania. Three other species breed on Macquarie Island and other subantarctic islands (Antarctic and Subantarctic fur seals and the southern elephant seal), and four species breed in Antarctic waters, on either pack ice (leopard, crab-eater and ross seals) or fast ice (Weddell seal). Approximately 12 colonies of the three species that breed on the Australian coasts (including Tasmania and Macquarie Island) are known to occur in the Region.

Populations of pinnipeds, particularly those species with mostly subantarctic distribution, were dramatically reduced by unregulated harvesting during the nineteenth and early twentieth centuries. Despite considerable recovery, conservation of pinnipeds is still a concern, with the most immediate threat being posed by the interactions with fisheries and fishing gear and the consequences of potential for competition for prey with human fisheries.

The sources of information below include comprehensive reference lists:

- Gales R and Pemberton D (1994) Diet of the Australian fur seal in Tasmania. *Australian Journal of Marine and Freshwater Research* 45: 653-664.
- Goldsworthy SD, He X, Tuck GN, Lewis M and Williams R (2001) Trophic interactions between the patagonian toothfish, its fishery, and seals and seabirds around Macquarie Island. Marine Ecology progress Series 218: 283-302.
- Shaughnessy PD (1999) *The Action Plan for Australian Seals*. Environment Australia, Canberra.



Subantarctic fur seal

***Arctocephalus tropicalis* fam.: Otariidae**

Status

Australian population is Endangered (low numbers); globally, is not listed.

Distribution

There is one breeding colony of subantarctic fur seals in Australia, on Macquarie Island. The main range of this species is the south Atlantic and Indian Oceans. They appear not to be migratory, but >50 individuals have been recorded along southern Australia (from Western Australia to New South Wales).

Ecology

Subantarctic fur seals interbreed with Antarctic fur seals. They prefer rocky coastal habitats and breed annually on open cobblestone beaches. When they are not breeding they also inhabit tussock slopes. They feed on pelagic myctophid fish and forage at night and at shallow depths.

Main threats

Entanglement in fishing gear, likely to increase as a result of fishery development near breeding locations is a primary threat with fishery development in the Macquarie Island EEZ possibly presenting a substantial threat. The potential for development of myctophid fisheries (eg *Electrona carlsbergi*) should be closely monitored as evidence shows that there may be direct competition for this species (Goldsworthy et al. 2001). Changes in genetic composition of the species from interbreeding with antarctic fur seals may also represent a threat.

Antarctic fur seal

***Arctocephalus gazella* fam.: Otariidae**

Status

Australian population is considered Lower Risk, conservation dependent; globally, it is not listed.

Distribution

There are two breeding colonies of antarctic fur seals on Macquarie Island and several on Heard Island. Females appear to migrate during haulout, but their range is unknown. Males remain in the vicinity of breeding colonies throughout the year. They are reported at sea from throughout the Southern Ocean.

Ecology

Antarctic fur seals interbreed with Subantarctic fur seals on Macquarie Island. They breed annually and feed mostly on myctophid fish.

Main threats

Entanglement in fishing gear, likely to increase as a result of fishery development near breeding locations is a primary threat, with fishery development in the Macquarie Island EEZ possibly presenting a substantial threat. The potential for development of myctophid fisheries (eg *Electrona carlsbergi*) should be closely monitored as evidence shows that there may be direct competition for this species (Goldsworthy et al. 2001). Changes in genetic composition of the species from interbreeding with antarctic fur seals may also represent a threat.

Australian fur seal

***Arctocephalus pusillus* fam.: Otariidae**

Status

Australian population is considered Lower Risk, conservation dependent; globally, it is not listed.

Distribution

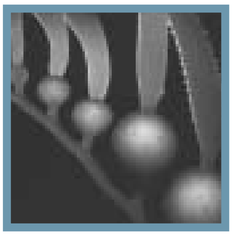
Australian fur seals breed on Bass Strait islands (five colonies occurring in Tasmania and four in Victoria) and their range extends to South Australia, southern Tasmania and New South Wales.

Ecology

Australian fur seals prefer rocky parts of islands with flat, open terrain (flatter areas than co-occuring New Zealand fur seals). They breed annually and feed on fish (predominant in winter) and cephalopods (predominant in summer). Studies of their diet have shown that key prey were red bait, leatherjackets and jack mackerel. They also attend fishing vessels.

Main threats

Illegal culling to prevent fishing competition is a threat to Australian fur seals as is entanglement in fishing gear and oil spills.



New Zealand fur seal
Arctocephalus forsteri **fam.: Otariidae**

Status

Australian population is considered Lower Risk, conservation dependent; globally, it is not listed; listed as Threatened under the *Threatened Species Act 1994 (Tas)*.

Distribution

In Australia the New Zealand fur-seal breeds in Western Australia, South Australia and on Maatsuyker Island (Tas; 50–80 pups being born each year). Pups have also been reported on Macquarie Island. Non-breeding animals are occasionally reported in Bass Strait, Victoria, New South Wales and Queensland and there may be movements from New Zealand to Australia.

Ecology

New Zealand fur seals prefer rocky parts of islands with mixed terrain and boulders. They breed annually and feed on fish, cephalopods (most important in summer) and seabirds (most important in winter) including Little Penguins. They also attend fishing vessels. Males defend territories vigorously during the breeding season (summer).

Main threats

Illegal culling to prevent fishing competition is a primary threat. They are also caught in the deep water trawl fishery (hoki) in New Zealand and small numbers are estimated to be caught as bycatch by the Australian SETF.

Australian sea lion
Neophoca cinerea **fam.: Otariidae**

Status

Australian population is Near Threatened (Lower Risk); globally is Rare.

Distribution

The breeding range of the Australian sea lion is from Houtman Abrolhos (Western Australia) to The Pages (east of Kangaroo Island, South Australia).

Ecology

Australian sea lions occur in small colonies (possibly to reduce competition on limited food sources). They prefer sheltered sides of islands, rock holes or among vegetation, and avoid exposed sites (eg headlands). A common feature of their habitat is shallow protected pools where pups aggregate. They breed every ~18 months and feed on cephalopods, fish, shark, rock lobster and seabirds. They also attend fishing vessels. Nursing females are benthic feeders at depths <150 m, ~20–30 km offshore.

Main threats: Entanglement in fishing gear (eg rock lobster pots can entrap and kill pups; monofilament netting in shark fisheries) is a primary threat to Australian sea lions. Human disturbance during breeding season, including white shark viewing tourism is also a threat. Australian sea lions are less vulnerable than other seals to oil spills, because they do not rely on fur for insulation (as in New Zealand fur seals).

Southern elephant seal
Mirounga leonina **fam.: Phocidae**

Status

Australian population is Vulnerable (sharp population decrease since 1950s, cause unknown); globally is not listed.

Distribution

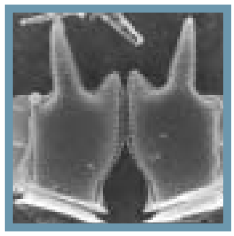
There are southern elephant seal breeding colonies on Heard Island and Macquarie Islands. They move south to the Antarctic from Macquarie Island. They visit Australia, particularly Tasmania, where births have been recorded. There are three records of southern elephant seals coming ashore in New South Wales andWestern Australia and records from South Australia and Victoria also include births.

Ecology

Southern elephant seals prefer beaches, tussock grass and wallows on subantarctic islands. During their annual moult they occupy mud wallows inshore from beaches. They breed annually and feed mainly on cephalopods and fish, foraging in cold Antarctic waters including along the Antarctic Polar Front.

Main threats

Population declines appear related to decreased survival of juveniles, but the causes are at present unknown.



LEOPARD SEAL
Hydrurga leptonyx **FAM.: PHOCIDAE**

Status

Australian population is of Lower Risk, Least Concern; globally, is not listed.

Distribution

Leopard seals have a circumpolar distribution. They breed on pack ice around the Southern Ocean and move seasonally north-south, with changes in pack ice extent. The largest population is on Heard Island (haul-out) and also on Macquarie Island. The Macquarie Island population is genetically different to the Heard Island population but no subspecies are recognised. Leopard seals are recorded frequently in southern Australia during winter, particularly in Tasmania.

Ecology

Leopard seals are pelagic and inhabit pack ice (to breed, moult and rest). They haul-out on subantarctic islands and southern continents and breed annually from late October to mid November. They have a varied diet including krill, penguins, seal, fish and cephalopods, with pups feeding predominantly on krill and adults on seals and penguins. Adults prey on crab-eater seal pups from November to February and they are mainly solitary predators.

Main threats

Harvesting of leopard seals is currently allowed under CCAS (Convention for the Conservation of Antarctic Seals) but not under Australian legislation. Krill fishing could impact leopard seals, as they feed directly on krill, and among krill-eating seals they are the least efficient and therefore more vulnerable.

CRAB EATER SEAL
Lobodon carcinophagus **FAM.: PHOCIDAE**

Status

Australian population is of Lower Risk, Least Concern; globally, is not listed.

Distribution

Crab eater seals havve a circumpolar distribution. They breed on pack ice around the Southern Ocean, moving seasonally north to south, with changes in the pack ice extent. They are associated with the continental shelf. There are about 20 records of crab-eater seals from the Australian mainland, 13 in Victoria and one each in of which Tasmania and South Australia. There are several records from Heard and Macquarie Islands. There is some indication that there may be six populations associated with the six areas of pack ice remaining in Antarctica during summer.

Ecology

Crab-eater seals are pelagic and inhabit pack ice at the edge of the continental shelf. They breed annually, from October to early November (maximum extent of pack ice). Crab eater seals feed mostly on krill and also eat small amounts of squid and fish. While breeding, family groups are dispersed over the pack ice. Crab eater seal pups are a key prey of leopard seals and killer whales, particularly between weaning and the onset of maturity.

Main threats

Crab eater seals have been reported as vulnerable to species-specific morbillivirus. Harvesting is currently allowed under CCAS but not under Australian legislation and a krill fishery could impact the population.

WEDDELL SEAL
Leptonychotes weddellii **FAM.: PHOCIDAE**

Status

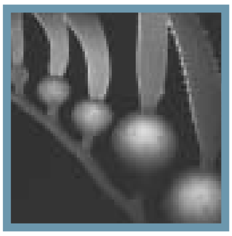
Australian population is of Lower Risk, Least Concern; globally, is not listed.

Distribution

Weddell seals occur in areas of suitable fast ice close to the Antarctic continent and peri-antarctic islands. Their distribution is circumpolar. There are several records from Heard and Macquarie Islands and one record from South Australia.

Ecology

Weddell seals inhabit fast ice, with pupping occurring along coastlines or ice shelves with tide cracks and openings. They breed annually from September to early November and feed primarily on fish, with their diet also including small amounts of cephalopods, krill and other invertebrates. Weddell seals mate underwater and males defend their territories under tide cracks where females and pups occur. They use upper incisive and canine teeth to excavate breathing holes in the ice.



Main threats

Restricted harvesting of Weddell seals is permitted under CCAS (it is illegal to kill pups and seasonal closures protect breeding stock), but not under Australian legislation. Fisheries may represent a potential impact.

Ross seal
***Ommatophoca rossii* fam.: Phocidae**

Status

Australian population is of Lower Risk, Least Concern; globally, is not listed.

Distribution

The distribution of ross seals is circumpolar. They breed on the pack ice of the Southern Ocean and are virtually unknown beyond that area except for one record from Heard Island and one record from South Australia.

Ecology

Ross Seals are pelagic and inhabit heavy pack ice.There is little information on breeding (probably annual). They feed on cephalopods, other invertebrates and fish and are primarily solitary. They make a wide range of bird-like noises.

Main threats

Fishery in the Southern Ocean may represent a threat to ross seals.

Mammals – cetaceans

Out of 80 species of cetaceans recognised worldwide, 43 species are known to occur in Australian waters. Of these, 33 species have been recorded within the Region and are considered below. All cetaceans are protected by State legislation to 3 nautical miles and, under Commonwealth legislation, to the limits of the Australian Exclusive Economic Zone. All species listed here are also subject to regulations by the International Whaling Commission and are protected within the Indian and Southern Ocean Sanctuaries. Many species are also listed under a number of international protection conventions including the Convention on the International Trade of Endangered Species (CITES) and the Convention on Migratory Species (CMS).

Generally, current knowledge of the biology and ecology of most species of cetaceans is insufficient for an adequate understanding of their conservation status. The Blue whale is the only species currently listed as Endangered by Commonwealth legislation, and the Humpback, the Fin and the Southern Right whales are all listed as Vulnerable.

Information in this Appendix was drawn predominantly from the publication below, which also includes a comprehensive list of selected references for each species.

- Bannister JL, Kemper CM and Warneke RM (1996) The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency, Canberra.

Spectacled porpoise
***Australophocoena dioptrica* fam. Phocoenidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

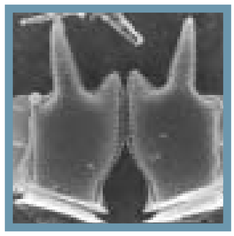
Spectacled porpoise are found only in the Southern Hemisphere. It has an apparently circumpolar distribution in subantarctic latitudes. It has been recorded at Macquarie Island and to the west in open ocean ca 56°S, 175°W. There are no records from continental Australian seas.

Ecology

Spectacled porpoise apparently prefer subantarctic waters (ca 1°C–8°C) and continental seas in cold temperate regions influenced by cold currents. Their maximum weight is around 80 kg and their maximum age is unknown. They can reach lengths of 2.24 m (males) or 2.04 m (females). Spectacled porpoise eat fish and squid. Their behaviour is not well known. They are unobtrusive, and are seen singly and in groups of 2–3, the latter comprising male, female and calf. Spectacled porpoise sometimes strand and are possibly vulnerable to predation by killer whales.

Main threats

Incidental capture in gill-nets set by fishers on the Argentine coast is a threat to spectacled porpoise, the extent of this is unknown but the fishery has been expanding since 1988. They are also vulnerable to



entanglement in drift-nets and other nets set, lost or discarded in international waters at higher latitudes. There is the potential for incidental captures in expanding fisheries of the Southern Ocean, especially in areas adjacent to subantarctic islands.

Hector's beaked whale
Mesoplodon hectori **fam.: Ziphiidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Hector's beaked whale has a southern circumglobal distribution in mid-latitudes, ca 35°C to 55°S, and also occurs in the eastern North Pacific off southern California. It is known from strandings in Argentina, Chile, Falkland Islands, South Africa, New Zealand and in Australia from South Australia and Tasmania.

Ecology

This species apparently prefers subantarctic (ca 1–8°C) and temperate (ca 10–20°C) deep oceanic waters, rarely venturing into continental seas. Maximum weight for this species is aroun 800 kg, and maximum length around 4.5 m; maximum age is unknown. Beaks of *Octopoteuthis deletron* (squid) and portions of an unidentified invertebrate were found in the stomach of a stranded animal in California. Diet is presumed to be mainly mid and deep water squid and some fish.

Main threats

Possible entanglement in drift-nets set, lost or discarded in international waters is a threat to this species. Competition from expanding commercial fisheries, especially on pelagic squid is a potential threat along with pollution leading to accumulation of toxic substances in body tissues.

Dwarf sperm whale
Kogia simus **fam.: Kogiidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List.

Distribution

Dwarf sperm whales have a cosmopolitan distribution apart from polar or sub-polar seas. They are primarily oceanic, but approach coasts more than pygmy sperm whales. They are not known to migrate or exhibit strong seasonal changes. Dwarf sperm whales have been recorded (as stranded animals) from Western Australia, South Australia, Tasmania, New South Wales, possibly the Northern Territory and there has been one live sighting from South Australia.

Ecology

Dwarf sperm whales are primarily oceanic, apart from colder waters. Their maximum length is around 2.7 m and their main food is squid although fish and crustacenas are also taken. They produce sounds believed to be similar to pygmy sperm whales. They are found in groups of up to ten animals. They are unobtrusive at sea, often found 'rafting' at the surface. They strand much less frequently than pygmy sperm whale.

Main threats

Possible direct threats to dwarf sperm whales include seismic operations, collisions with large vessels, entanglement in fishing gear, defence operations, pollution, including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues.

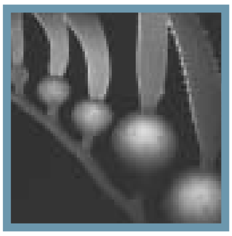
Southern right whale dolphin
Lissodelphis peronii **fam.: Delphinidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

The distribution of the southern right whale dolphin in the southern hemisphere is circumpolar, generally between about 30°S and 65°S (also found at low latitudes (to 12°S) off western South Africa and South



America related to the cold currents). It is found off southern continental Australia and has been found stranded in Tasmania. There are several sightings off the south and southwestern of Tasmania and off southwestern Australia and in the Great Australian Bight. There are no records from Heard or Macquarie Island. Northward migration of this species in winter and spring has been suggested off other continents.

Ecology

Southern right whale dolphins are pelagic, and usually found well offshore but if inshore, they are found in deep water. They are found in water temperatures ranging between about 2°C and 20°C. Their maximum length is around 2.97 m (male) and 2.3 m (female). Little is known of their diet but includes myctophid and other mesopelagic fish, squid and crustaceans. It is unknown whether this species feeds in surface or deeper waters. Southern right whale dolphins are capable of very fast swimming speeds with sustained speeds of up to 12 knots. When swimming rapidly, they leap high and dive shallowly. They are found in groups of 1-1000 individuals (mean of around 200 individuals) usually in tight groups. They are commonly reported swimming with many other species, eg pilot whales, common dolphins, hourglass dolphins, dusky dolphins and large whales. Their only known predator apart from humans is the Patagonian toothfish, but sharks and killer whales are likely. Many strandings have been recorded outside Australia. Mass strandings (up to 77 individuals) are known. Only three strandings have been recorded in Australia, all in Tasmania.

Main threats

Southern right whale dolphins could possibly be caught in drift-nets in international waters. They are commonly captured in gill-nets off Chile and have also been reported hooked by line fishing but there is no such information for Australian waters. Pollution leading to accumulation of toxic substances in body tissues is also a threat.

Pygmy right whale
Caperea marginata fam.: Neobalaenidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information; however, it is listed as possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

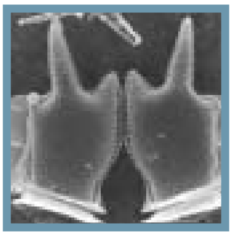
The pygmy right whale is found in the southern hemisphere between about 30°S and 52°S. There is one South African record from 23°S. Around Australia, their most northerly observation is Perth (32°30'S). There are strandings and sightings from southwestern Western Australia, South Australia, Victoria, southern New South Wales and Tasmania although no records from the Great Australian Bight proper. They have not been recorded from Macquarie or Heard Islands.

Ecology

Pygmy right whales have been seen in oceanic, pelagic and inshore situations. Stranding records suggest concentrations of this species in Bass Strait, southeastern Tasmania, Kangaroo Island, southern Eyre Peninsula and possibly southwestern Western Australia, close to habitats rich in marine life and possibly the zooplankton upon which they feed (eg probably copepods and euphausiids). Their maximum length is aound 6.4 m. Feeding grounds are unknown but they have been seen skimming surface waters off Fremantle,Western Australia. They are observed in groups of up to 80, but usually singly or less than 10. Extensive flexing of the entire body occurs during swimming. They have been observed swimming with pilot whales, dolphins, sei whales and minke whales. Thump-like sounds, mostly in pairs between 60 and 120 Hz, have been recorded. Many strandings occur in shallow, shoaling bays.

Main threats

There are no known cases of illegal capture of pygmy right whales in Australian waters. They are unlikely to be seriously affected by toxic contaminants because they feed at a low level in the food chain and because of their distribution. Entanglement in drift-nets set outside Australian Territorial Waters and in lost or discarded netting are a possible threat.



Minke whale

***Balaenoptera acutorostrata* FAM.: BALAENOPTERIDAE**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned to the diminutive form, because of insufficient information; however, the dark-shouldered form is considered secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Minke whales have a worldwide, oceanic distribution but sometimes recorded close to the coast. They undergo extensive migrations between cold water feeding grounds and warmer water breeding grounds, but are less predictable than most other rorquals and possibly not migrating as far into warm waters as other balaenopterids. Some populations, eg in the North Pacific, apparently do not migrate at all. Migration paths are presumably widespread and exact breeding grounds locations are not known. The dark-shoulder form's major southern hemisphere feeding grounds are in Antarctic waters, and individuals migrate further south than most rorquals except the blue whale. The range of the diminutive form extends north to at least ca 12°S on the east coast of Australia and possibly as far as 20°S on the west coast. This species has been recorded from all Australian states but not from the Northern Territory.

Ecology

Minke whales reach a maximum length of around 9.8 m (male) and 10.7 m (female) and have a maximum age of less than 50 years. Their mating season is from August to September with a gestation of around ten months with a calving season between June and July. They calve in temperate totropical waters, although specific areas have not been identified. Southern Hemisphere animals (dark-shoulder form) feed predominantly on Euphausia superba and some smaller euphausiid (krill) species. There is little evidence for echolocation in this species, although a variety of sounds have been reported, including frequency-modulated 'sweeps', grunts, whistles, and clanging bells. Diminutive form breaches regularly in northern Great Barrier Reef area. Minke whales often occur singly or in groups of two to three, though feeding concentrations may be encountered; diminutive form usually alone or in pairs. There is well-marked segregation of groups by sex and age. Minke whales may be heavily preyed on by killer whales in the Antarctic with one estimate that they form 85% of killer whales' diet.

Main threats

Direct disturbances of minke whales may include seismic operations, collisions with large vessels, entanglement in fishing gear, defence operations, pollution including increasing amounts of debris at sea, oil spills, and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues.

Sei whale

***Balaenoptera borealis* FAM.: BALAENOPTERIDAE**

Status

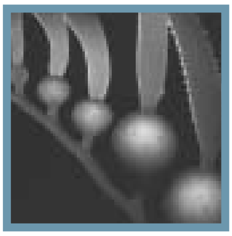
In Australia, is listed in the Action Plan for Australian Cetaceans and listed as Vulnerable. Listed as Vulnerable in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Sei whales have a worldwide, oceanic distribution, undertaking long migrations between warm water breeding grounds and colder water feeding grounds. In the southern hemisphere they do not migrate as far south as other baleen whales (except Bryde's whales). They are not not often found near coasts but have been infrequently recorded in Australian waters, from Western Australia, the eastern Great Australian Bight, Tasmania (some reported sightings recently to the south) and Queensland. In thesouthern hemisphere they are mainly found north of the Antarctic Convergence in summer, in the Indian Ocean in January to March where their northern limit is 35°S–40°S. They spend winter north of 30°S.

Ecology

The maximum age of sei whales is aroun 60 years and they reach a maximum length of around 17.7 m (male), 21 m (female).Their mating season is from April to August with a 12 month gestation. They calve between April and August in tropical seas although the exact calving localities have not been identified. Sei whales feed mainly on pelagic copepods (Calanus spp.), and occasionally on euphausiids and amphipods. Groups of



sei whales are highly segregated, with different age and sex classes migrating at different times within the general pattern. They migrate to colder waters later than blue or fin whales, with the pregnant females leaving first. Older and larger animals travel further south than smaller and younger animals. They are classified as 'skimmers', swimming through plankton swarms with open mouths. They can be found in large concentrations on feeding grounds, otherwise they generally occur in small groups of up to about six.

Main threats

Southern Hemisphere populations of sei whales were very severely reduced over a short period (around 1960–1977). The initial pre-whaling numbers, likely to have been around 100 000, were reduced to about 25 000. Current threats include seismic operations, collisions with large vessels, entanglement in fishing gear, pollution including increasing amounts of plastic debris at sea, oil spills, and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues.

Bryde's whale
***Balaenoptera edeni* fam.: Balaenopteridae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Bryde's whales are restricted to tropical and temperate waters, from the equator to ca 40°S and N. They have been recorded from waters of all Australian states but not from the Northern Territory. In Australia they are likely to be found along either the east or west coast, less likely along the south coast

Ecology

Bryde's whales are found in both oceanic and inshore waters, bounded by latitudes 40°N and S. Their maximum length, is around 15.5 m. They have a calving interval of around two years and their mating season is throughout the year for the inshore form of the species and autumn/winter for the offshore form. Gestation is around one year. Inshore forms feed largely on shoaling fish eg anchovies, while offshore forms feed on euphausiids (krill). Bryde's whales are not known to echolocate and the only sounds recorded seem to be powerful low frequency moans. They have been observed swimming at speeds of more than 10 kn while feeding, but their maximum speed likely to be greater. They are reported to blow four or five times before making prolonged dives, for up to 20 min, and rarely show their flukes on diving.

Main threats

Possible threats to Bryde's whales include seismic operations, collisions with large vessels (one recently recorded off northern Tasmania), entanglement in fishing gear, defence operations, pollution (including increasing amounts of plastic debris at sea, oil spills and the dumping of industrial wastes into waterways and the sea leading to bio-accumulation of toxic substances in body tissues), over-fishing of prey species (particularly commercial species such as anchovy).

Blue whale
***Balaenoptera musculus* fam.: Balaenopteridae**

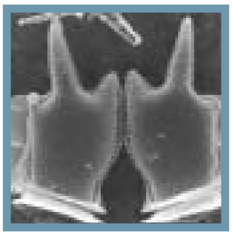
Two subspecies recognised: *B. musculus musculus* – the 'true' blue whale; *B. musculus brevicauda* – the pygmy blue whale.)

Status

In Australia, is listed in the Action Plan for Australian Cetaceans; the 'true blue' whale is listed as Endangered; no catergory has been assigned for the 'pygmy blue' whale because of insufficient information. Listed as Endangered in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Blue whales have a worldwide oceanic distribution and undergo extensive migrations between warm waters (low latitude) for breeding and cold waters (high latitude) for feeding grounds. In the Southern Hemisphere, they are found between latitudes of approx 20°S and 60°S–70°S. The pygmy blue subspecies occurs only in the southern hemisphere, particularly in the Indian Ocean, and migrates less far south. This species has been recorded from all Australian states. Migration paths of the blue whale are widespread and do not obviously following coastlines or oceanographic



features. They have been sighted in the Great Australian Bight, off South Australia and western Victoria, off southeastern Victoria, in Bass Strait, off southeasern New South Wales and off east and west Tasmania. Strandings have occurred in Victoria, South Australia, Tasmania, Western Australia, and Queensland.

Ecology

Blue whales sometimes occur relatively close to coast. They can reach a maximum age of 80–90 years and a maximum length of 30.5 m (pygmy blue maximum length of 24.4 m). They calve every 2–3 years and their mating season is in winter. Gestation takes 10–11 months. 'True' blue feeding is restricted to colder (Antarctic) waters, almost exclusively on *Euphausia superba* (Antarctic krill). Pygmy blue whales feed further north, on smaller euphausiids. Evidence of echolocation in blue whales is equivocal. Their commonest sounds are low frequency moans, presumably for communication. Current estimates of blue whale swimming speeds are 2–6.5 km/hr while feeding, 5–33 km/hr cruising or migrating and 20–48 km/hr when chased. Blue whales are usually solitary or in small groups of two to three. In one day blue whales may consume 2–4 t of food.

Main threats

Southern Hemisphere populations of 'true' blue whales were drastically reduced through the twentieth century by overfishing, mainly in the Antarctic. Recent Antarctic sighting surveys have found little or no evidence of an increase in 'true' blues since their total protection in 1965. Direct disturbances are possible from seismic operations, collisions with large vessels, entanglement in fishing gear, defence operations, pollution (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues).

Fin whale
Balaenoptera physalus **fam.: Balaenopteridae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans listed as Vulnerable (V), following extreme reduction through whaling. Listed as Vulnerable in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

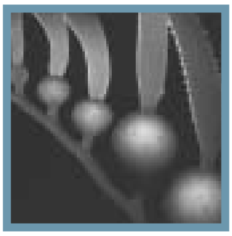
Fin whales have an oceanic, worldwide distribution. Extensive migrations occur between warm water breeding grounds and cold water feeding grounds. In the Southern Hemisphere they do not go as far south as blue or minke whales. Fin whale migration paths are oceanic, and do not obviously following coastlines, at least off Australia. They have been recorded from all states except New South Wales, and the Northern Territory.

Ecology

Fin whales are generally found in deeper waters. They can reach a maximum age of 90–100 years and a maximum length of 25 m (male) or 27 m (female). They calve every 2–3 years and the mating season is from April to August with an 11.25 month gestation. They calve from April to August in tropical waters. In the Southern Hemisphere they feed largely on Euphausia superba (Antarctic krill). Fin whales produce a range of sounds from high frequency downward-sweeping pulses to low frequency rumbles. They are one of the faster rorquals with speeds of over 30 km/hr recorded. On migrations they have been calculated to cover 90 nautical miles/day. Fin whales are sometimes found singly or in pairs but can form larger groupings, up to 100 or more, on feeding grounds. Groups are segregated by sex and class, with males preceding females on migration, pregnant females in advance of others, immatures last.

Main threats

Fin whales were severely depleted in the Southern Hemisphere by 20th century whaling. They were second in commercial importance to blue whales. Direct disturbances to fin whales are possible from seismic operations, collisions with large vessels, entanglement in fishing gear, and pollution (including increasing amounts of debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues).



Humpback whale

Megaptera novaeangliae **fam.: Balaenopteridae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans listed as Vulnerable (V). Listed as Vulnerable in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Humpback whales have a worldwide distribution. They are found off coastal Australia in winter and spring, and have been recorded from all states but not from the Northern Territory. Humpback whales migrate between warm water breeding grounds, ca 15–20°S (but some records much further north), and summer colder water (Antarctic) feeding grounds, to 60–70°S. Humpback whales may approach close to the coast during migration, eg within a path not more than 10 nautical miles wide off Shark Bay, Western Australia, and Stradbroke Island, Queensland. Humpback whales are seen in the eastern Great Australian Bight in early winter, eg at Head of the Bight, and near Kangaroo Island, South Australia. Not all animals migrate south each year as there are some summer sightings, eg in Coral Sea and Torres Strait near Murray Islands, although Coral Sea animals may be late migrants.

Ecology

Humpback whales reach a maximum age of around 50 years and a maximum length of around 18 m. they calve every 1–3 years and the mating season is from June to October with an 11–11.5 month gestation. Calving occurs between June and October in tropical coastal waters. Humpback whales feed mainly in Antarctic waters, ie south of ca 55°S, almost exclusively on *Euphausia superba* (Antarctic krill). Outside of the Antarctic waters they feed on small shoaling fish and occasionally benthic organisms. Humpback whales produce a variety of sounds, with 'songs' on breeding grounds and possibly elsewhere. Their songs are different between populations but are apparently the same within one population in one year (changing slightly between years). Songs thought mainly to be from breeding males. Humpback whales can average 8 km/hr on migration. Social groups of up to seven animals may form, predominantly males with antagonistic/threat behaviour common. Humpback whales segregation on migration with immature animals and females with yearling calves first in the northward migration, followed by adult males, non-pregnant mature females and pregnant females in the rear. Southward migration is similarly segregated, with cow/calf pairs travelling last. Strandings are uncommon.

Main threats

Possible threats to humpback whales include disturbance from whale watching and research vessels (aircraft, pleasure craft, swimmers and divers), coastal seismic operations, defence operations, collisions with large vessels, entanglement in fishing gear/shark nets, pollution (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues).

Gray's beaked whale

Mesoplodon grayi **fam.: Ziphiidae**

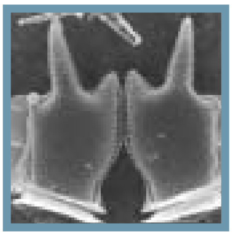
Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Gray's beaked whale has a circumglobal distribution at higher latitudes of the Southern Hemisphere. They are widely recorded from strandings in Argentina, Chile, South Africa, New Zealand and Australia, from southern Western Australia to southern New South Wales and including Tasmania, and by sightings in the Indian Ocean, to latitudes as low as 25°S south of Madagascar.

Ecology: Gray's beaked whales prefers temperate (ca 10°C–20°C) to subantarctic (ca 1°C–8°C) oceanic waters, deeper than 1800 m. Their maximum length is around 5.5 m and their diet is assumed to consist of mid- and deep water squid and fish. Groups of two to three have been sighted and stranded and larger social aggregations also occur. They are probably fast and active in pursuit of prey, but their mode of capture unknown. The ecology of gray's beaked whales is little known.



Main threats

Threats to Gray's beaked whales include possible entanglement in drift-nets and other nets set, lost or discarded in international waters and potential Competition from expanding commercial fisheries, especially on pelagic squids. They may also be impacted by pollution leading to accumulation of toxic substances in body tissues.

Andrew's beaked whale
Mesoplodon bowdoini fam.: Ziphiidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Andrew's beaked whlaes have mostly been recoreded from temperate waters of the South Pacific and Indian oceans and their population centres may be far from land. There have been a few strandings within this range, in Chile and the Falkland Islands, but most have occurred in New Zealand and in southern Australia (Western Australia, South Australia, Victoria and New South Wales and one at Macquarie Island). Most records are from spring and summer and are possibly related to a movement into warmer coastal waters for calving and mating.

Ecology

Anrdrew's beaked whales prefer deep oceanic waters (around 10°C–20°C). Their maximum length is around 4.57 m (male) or 4.67 m (female), their diet is little known, but assumed to be mid- and deep water squid and fish. They are active predators, and are presumed to be strong swimmers capable of deep dives in pursuit of prey. Little is known of their ecology.

Main threats

Threats include possible entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding commercial fisheries, particularly on pelagic squids in temperate waters and pollution leading to accumulation of toxic substances in body tissues.

True's beaked whale
Mesoplodon mirus fam.: Ziphiidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Distribution of True's beacked whale in the northern hemisphere appears to be limited to the North Atlantic north of ca 30°N to ca 50°N, off USA, Nova Scotia, Ireland and the Outer Hebrides. In the Southern Hemisphere there are records (all of strandings) in South Africa and in southern Australia (Western Australia, Victoria and Tasmania). They probably do not migrate.

Ecology

True's beaked whales are assumed to prefer deep oceanic waters. Their maximum length is around 5.34 m (male) or 5.18 m (female) and their diet appears to be made up of squid and small fish. There are no confirmed observations of living animals in the wild. They are probably fast and active in the pursuit of prey, but the mode of capture is not known and they are possibly capable of deep dives. They do not commonly strand.

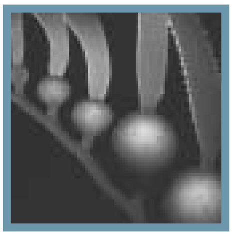
Main threats

Threats include possible entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding commercial fisheries (especially on pelagic squids) and pollution leading to accumulation of toxic substances in body tissues.

Cuvier's beaked whale
Ziphius cavirostris fam.: Ziphiidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.



Distribution

Cuvier's beaked whales are circumglobal in their distribution except for polar waters (ie Tropical to sub-polar 1°C–32°C). They range far from continental land masses. There have been two strandings at Macquarie Island and in all Australian states and the Northern Territory, mostly from January to July, suggesting some seasonality of occurrence. They are apparently year-round residents in some parts of their range, eg off New Zealand and Japan.

Ecology

Cuvier's beaked whales reach a maximum age of around 47 years (male) or 28 years (female) and a maximum length, of around 6.93 m (male) or 6.60 m (female). Their diet seems to be primarily a wide variety of oceanic squid although remains of morid fish *Antimora* sp., crustacean fragments (cf *Gnathophausia*) and flotsam, including plastic debris, pumice stones and a large seed have also been found in stomach contents. They appear to be wary of boats and therefore are uncommonly observed at sea. Group sizes vary from one to seven (up to 25 reported), but solitary animals are most frequently encountered and are generally adult males. Mass strandings of five and six individuals have been recorded. They are apparently capable of deep dives and can remain below for at least 30 minutes. They are presumed to actively pursue prey and strand quite frequently.

Main threats

Threats include possible entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding commercial fisheries, especially on pelagic squids and pollution leading to accumulation of toxic substances in body tissues.

Southern bottlenose whale
Hyperoodon planifrons **fam.: Ziphiidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Southern bottlenose whales have a circumglobal distribution in the southern hemisphere, at mid- to high latitudes south of 29°S to the edge of the polar pack ice. They are commonly sighted in some sectors of the Southern Ocean (south of 60°S). They may also occur in the central to eastern tropical Pacific (5°N–15°S, 80°W–170°W) and in the North Pacific from (20 to 34°N, 130 to 142°W). There have been relatively few strandings recorded, but mainly in New Zealand and on the southern coasts of Australia.

Ecology

Southern bottlenose whales apparently prefer deep oceanic waters in temperate (ca 10–20°C) to Antarctic (ca 0–5°C) regions. Their maximum length is around 7.14 m (male) or 7.80 m (female) and their maximum age is believed to be around 50+ years (male) or 37+ years (female). Their diet appears to consist primarily of squid. Stones, fish-netting and plastic bags have been found in stomachs. They have been sighted off Southern Africa and in Antarctic waters in small social groups of three to ten. Southern bottlenose whales are powerful and active predators, observed to remain below the surface for long periods and assumed to dive deeply in pursuit of prey, possibly to greater than 1000 m, and can stay down for periods of more than an hour. The massive forehead (melon) of this species may be used to concentrate bursts of high energy sound to acoustically stun prey. Strandings are uncommon.

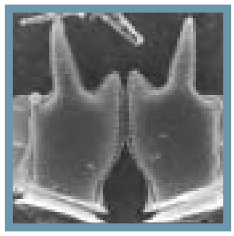
Main threats

Threats include incidental captures in pelagic drift-net fishery in Tasman Sea, entanglement in drift-nets and other nets set, lost or discarded in international waters at higher latitudes, potential competition from expanding commercial fisheries, especially for pelagic squids at higher latitudes and pollution leading to accumulation of toxic substances in body tissues.

Sperm whale
Physeter macrocephalus **fam.: Physeteridae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but status indeterminate until surveys conducted, particularly off south-west Australia. Listed as Insufficiently known in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.



Distribution

Sperm whales have a worldwide distribution in deeper waters off the continental shelves (ie beyond 200 m depth). They have been recorded from all Australian states. Females and young males are restricted to warmer waters (north of around 45°S) in the Southern Hemisphere, while adult males travel to and from colder waters. Sperm whales are concentrated in a narrow area only a few miles wide at the shelf edge off Albany (Western Australia) moving westwards through the year. There are similar concentrations elsewhere, eg south-west of Kangaroo Island, South Australia. Off the Western Australian coast, where the shelf slopes less steeply. They are more widely dispersed offshore. In the open ocean sperm whales have a generalised movement southwards in summer, and corresponding movement northwards in winter.

Ecology

Sperm whales are found in the pelagic offshore in deep water only. Population centres are found in temperate/tropical waters where breeding/nursing schools and groups of young males occur. Concentrations of sperm whales are found where the seabed rises steeply from great depth, eg on 'steep-to' coasts and near oceanic islands, probably associated with concentrations of major food (deep-sea cephalopods) in areas of upwelling. Only adult males, usually solitary or in small loose groups, are found in cold waters (south of ca 45°S). Their maximum age is around 60 years for both sexes with maximum lengths of 18.3 m (male) or 12.5 m (female). They calve every 4–6 years from November to Mach after a 14–15 month gestation and the mating season is from September to December. Aside from medium to large deep sea squid they also eat deep-sea angler fish and mysid shrimps. Sperm whales produce a variety of sounds including clicks or sharp, broadband pulses. Clicks can carry up to 10 km under water and comprise a series of multiple pulses, unique to sperm whales. These are probably used for both echolocation and communication, the latter classified as: contact calls, usually during deep diving; social sounds, at the surface; identity codas, unique for each whale; generalised codas, common to all animals in an area. Sperm whale's swimming speeds rarely exceed 7.5 km/hr at the surface and they are often almost motionless, but can reach up to 30 km/hr when disturbed. They have prolonged and deep dives, often over an hour with one record of a group diving for 138 mins. The longest and deepest divers are large males. Maximum dive depths reached are between 1135 m (entangled in deep-sea cable) and 3195 m (from field observations and stomach contents), although dives are generally much shallower. There are two kinds of groups observed, breeding and bachelor. The former includes females of all ages and immature and younger males. Large, socially mature males accompany schools only during breeding season, and then for short periods of possibly only a few hours. The average school size is about 25 animals, although aggregations of such schools have been reported, sometimes up to low thousands. Sperm whales strand relatively frequently but without likely effect on their population status. In 160 years' strandings records from Tasmania, they are the second most frequen species recorded – 31 events with ten herd strandings.

Main threats

Possible direct disturbances to sperm whales include collision with large vessels on shipping lanes beyond the edge of the continental shelf, seismic operations in the same area, net entrapment in deep-sea gill-nets, pollution, (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues). Indirect disturbance is also possible through global and ocean warming, and depletion of the ozone layer, leading to altered distribution and abundance of prey species.

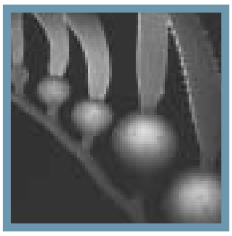
PYGMY SPERM WHALE
***Kogia breviceps* FAM.: KOGIIDAE**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List.

Distribution

Pygmy sperm whales have a cosmopolitan distribution in oceanic waters, apart from polar or sub-polar seas. They are not known to migrate or exhibit strong seasonal movements. They have been recorded (as stranded animals only) from all states but not from the Northern Territory.



Ecology

The maximum length of pygmy sperm whales is around 3.3 m. They calve every two years after a gestation period of 9–11 months, mating in summer and calving in spring, probably in temperate to tropical waters. Their main food has beem reported as squid, benthic fish and crabs. Pygmy sperm whales produce sounds associated with echolocation (clicks, buzzes, grating sounds), but they are apparently not highly vocal. They occur individually or in small groups of up to six animals and frequently lie almost motionless at the surface. Strands are relatively frequent, often as cow-calf pairs.

Main threats

Possible direct threats to pygmy sperm whales include seismic operations, collisions with large vessels, entanglement in fishing gear and pollution (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways, leading to accumulation of toxic substances in body tissues).

Dusky dolphin
Lagenorhynchus obscurus fam.: Delphinidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

The dusky dolphin occurs only in the southern hemisphere, from about 55°S to 26°S but with extensions well north of this in association with cold currents. There are unconfirmed sightings from south of continental Australia and confirmed sightings near Kangaroo Island, South Australia and off Tasmania, with a recent stranding in Tasmania. Dusky dolphins are not known to be migratory, but may have small seasonal movements.

Ecology

Dusky dolphins are primarily an inshore species but are also pelagic at times. They are resident inshore for much of the year and may seek out colder waters (<18°C) as the inshore temperatures rise in summer. Around New Zealand, their distribution is believed to be related to the Subtropical Convergence, with numbers declining north and south of this oceanic feature. Their maximum age is greater than 21 years and maximum length is around 2.11 m (male) or 1.93 m (female). Their diet consists of fish and squid, particularly schooling fish including southern anchovy. Dusky dolphins occur in groups of hundreds in summer and less than 20 in winter and they rest in shallow water. They are known to dive to at least 150 m. Mass stranding of six animals have been reported although none from Australia.

Main threats

Threats to dusky dolphins include the pelagic drift-net fishery in the Tasman Sea. They are taken as part of an uncontrolled gill-net fishery off Peru and fished illegally off Chile. There is also potentialfor for entanglement in drift-nets set outside the Australian EEZ and in lost or discarded netting. Pollution is another potential threat (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea leading to bio-accumulation of toxic substances in body tissues).

Hourglass dolphin
Lagenorhynchus cruciger fam.: Delphinidae

Status

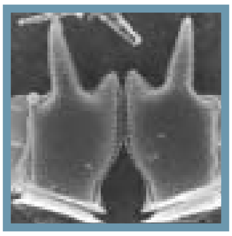
In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Hourglass dolphins are found in the southern hemisphere, in waters generally south of 45°S. They are seen to the south-east of New Zealand and from outside territorial waters south of Australia. There is a confirmed record (skull) from Heard Island and they have been sighted in the vicinity of Macquarie Island.

Ecology

Hourglass dolphins are pelagic and oceanic, living in the cold waters of polar and subantarctic zones in waters of about 0°C–12°C. Most sightings occur in water temperatures of <7.0°C and they are rarely seen near



land. In the Antarctic they are usually seen away from pack ice. Their maximum length is around 1.74 m (male), or 1.83 m (female). Based on limited data, their diet consists primarily of fish and squid. Thet occur in school sizes of 1-100, with most being up to eight individuals. They have been seen in association with several other cetacean species including pilot whales, southern bottlenose, Arnoux's beaked whales, killer whales, southern right whale dolphins, sei whales and fin whales. They make click and whistle sounds. Few strandings are known.

Main threats

Potential threats include incidental catch, impact of present and future fisheries on prey species, global and ocean warming, and depletion and holing of the ozone layer, possibly leading to altered distribution and abundance of prey.

Risso's dolphin

Grampus griseus **fam.: Delphinidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Risso's doilphins are found in all oceans, from the equator north and south but not at very high latitudes (to about 50–55°). In Australia, they have been recorded from southwestern Western Australia, South Australia, Victoria, New South Wales and Queensland. Stranding records range from around 23°S to 39°S. Fraser Island has the only known 'resident' population in Australia

Ecology

Risso's dolphins have been sighted in both inshore areas and well offshore (although they are generally considered pelagic and oceanic) in sea temperatures from 15°C–30°C. Their maximum age is around 17 years and maximum length around 4.1 m. They feed in pelagic waters, primarily on squid, some octopus and possibly fish. They are observed living in groups of between 25 and several hundred but may also be solitary. They have been seen in company with striped dolphins, pilot whales, common dolphins and other pelagic cetaceans. Very few strandings are recorded in Australia and all single animals although mass strandings are known elsewhere.

Main threats

Possible threats to risso's dolphins include illegal and incidental catches in northern Australian waters and there is concern in Sri Lanka because of high proportion (25%) in incidental gill-net fishery catch. Risso's dolphins are also captured in small numbers in directed fisheries in several parts of the world, including Indonesia and Solomon Islands. There is potential for Entanglement in drift-nets set outside Australian Territorial Waters and in lost or discarded netting. Pollution is another possible threat (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea leading to bio-accumulation of toxic substances in body tissues).

Bottlenose dolphin

Tursiops truncatus **fam.: Delphinidae**

Status

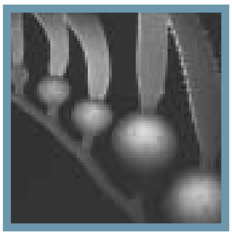
In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Bottlenose dolphins have a cosmopolitan distribution, but are not found in polar seas (ie 65°N and 55°S). They have been found in all states and the Northern Territory, also Norfolk Island. They can be migratory in temperate waters.

Ecology

Bottlenose dolphins are found in coastal, estuarine, pelagic and oceanic waters. Their maximum age is around 42 years (male) or 43 years (female) and maximum length around 3.12 m (male) or 2.92 m (female). They calve every 3–6 years in summer after a 12.3 month gestation period. They have a broad diet including teleosts, cephalopods, elasmobranches and crustaceans. They may feed in association with human activities, eg prawn trawling or fish farming. Their variety of sounds includes clicks, whistles, burst-pulses



and low frequency narrowband sounds. Their ability to echolocate has been demonstrated experimentally. Bottlenose dolphins can occur in groups of >1000. Mean group size from studies in Australia were between five and ten individuals

Main threats

Threats to bottlenose dolphins include habitat destruction and degradation, including noise pollution, harassment (particularly close to major cities), incidental capture in aquaculture nets (high rates in South Australia), shark nets, trawl-nets and drift-nets, especially in Taiwanese shark gill-netting just outside northern Australian EEZ. Illegal killing, particularly by people killing for sport, eg spearing or shooting dolphins, for bait or because of perceived predation on commercial fish stocks. They are also threatened by live capture in Queensland (permits granted for up to 12 per year at present), overfishing of prey species and pollution (organochlorines, particularly PCBs) is a serious potential threat because of the species' inshore nature. Bottlenose dolphins are also subject to some epizootic diseases (pathogens) and may be disturbed by further tourism development of dolphin watching, dolphin feeding, dolphin swims.

Common dolphin

Delphinus delphis **fam.: Delphinidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

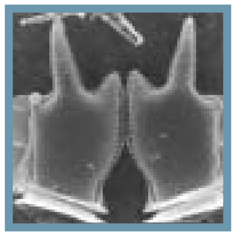
Common dolphins are found in the northern and southern hemisphere and in all oceans. They are not found in higher latitudes, with the furthest south records around the Subtropical Convergence. In Australia, they have been recorded in all states and the Northern Territory. Tehre is a short-beaked form recorded from at least Tasmania and two forms exist in Queensland and South Australia but it is not known whether these represent the short- or long-beaked types.

Ecology

Common dolphins are neritic, pelagic and oceanic. The long-beaked species (*D. capensis*) seems to have a nearshore distribution whereas the short-beaked species (*D. delphis*) is both nearshore and offshore. There are very few records from tropical regions around Australia, which may not truly reflect distribution, considering its common occurrence in tropical habitats elsewhere. Common dolphins may be associated with high topographical relief of the ocean floor, escarpments and areas of upwelling. Their maximum age is around 22 years (male) or 20 years (female) and maximum lenth around 2.32 m (male) or 2.18 m (female). They feed on shoaling and mesopelagic fish, and cephalopods, and are largely pportunistic, with diet varying according to stock and season. Some aggregations observed in Australian waters number thousands, or even 100 000 individuals; the latter may be smaller groups combined into one unit temporarily. They are acrobatic, ride bow waves of boats and large whales, and are seen with other species of dolphin, including bottlenose, as well as larger cetaceans (fin, humpback, blue, southern right whales). They are highly mobile and may move long distances. They feed at surface and at depth (at least 280 m). There is some evidence of competitive interactions with spotted and spinner dolphins. May move inshore/offshore following food, and are known to aggregate with tuna possibly in a feeding association. Produce the entire acoustic repertoire of most delphinids. Strandings are common along the Australian coast, usually single animals but one mass stranding (34 animals) reported for Victoria and several (up to 109 individuals enmasse) for Tasmania. Predators include killer whales.

Main threats

Intentional killing (usually by shooting) occurs in most states. In South Australia, one conviction for killing common dolphins for use as cray bait. True extent of intentional and unintentional deaths is unknown because many cases go unreported. Incidental catches are also of concern in the eastern tropical Pacific and possibly other regions. In Australia, deaths in nets has been recorded in South Australia and Tasmania, and more commonly in Western Australia. Bio-accumulation of organochlorines and some heavy metals is evident in moderate levels in some common dolphins from



Australian waters. They are taken in small, directed fisheries in several parts of the world. There is potential for entanglement in drift-nets set outside Australian Territorial Waters and in lost or discarded netting. Pollution is also a threat including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea.

Fraser's dolphin
Lagenodelphis hosei fam.: Delphinidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Fraser's dolphins are found in low latitudes of all three major ocean basins with most records being from between 30°N and 30°S. Records outside low latitudes may represent vagrants. Records from Southern Africa suggest the species may move to the higher latitudes in warmer months. In Australia, strandings recorded in Western Australia, Queensland, northern New South Wales and Victoria (Corio Bay 38°S).

Ecology

Fraser's dolphins are pelagic and oceanic in subtropical and tropical waters, occasionally temperate. All sightings in Southern Africa are in waters >1000 m and associated with the warm Agulhas Current. They are found in waters characterised by a stable, shallow mixed layer and thermocline ridging, also upwelling areas. In captivity, Fraser's dolphins are very distressed in shallow water. Their maximum ageis around 16 years and maximum length around 2.70 m. Their diet includes mesopelagic fish, squid and crustaceans. Some recorded prey are deep-sea or benthic, suggesting that Fraser's dolphins either feed at depth (250–500 m) or when prey surface at night. They are seen in schools from less than 10, to about 1000. They have been observed with striped and spotted dolphins, false killer whales and sperm whales and especially melon-headed whales. Swimming behaviour is like other pelagic dolphins, although less acrobatic. In some parts of the world considered shy. Usually strands as a single animal but in Australia one group of three stranded at Corio Bay (Victoria).

Main threats

Threats to Fraser's dolphins include incidental capture in gill-net fisheries in the Philippines (econd most frequently caught species there) and also harpoon fisheries in Indonesia, Sri Lanka, Taiwan and Japan. Incidental catches also occur in Sri Lanka and purse-seine deaths in the eastern tropical Pacific. There is potential fir incidental and illegal captures within Australian waters of northern Australia and entanglement in drift-nets set outside Australian Territorial Waters and in lost or discarded netting. Pollution is another threat (including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea leading to bio-accumulation of toxic substances in body tissues).

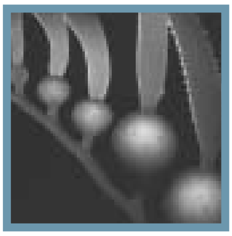
Southern right whale
Eubalaena australis fam.: Balaenidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans as Vulnerable. Population has been very severely reduced; it is probably increasing but not yet secure. Listed as Vulnerable in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Southern right whales have a circumpolar distribution in the southern hemisphere between approximately 30°S and 60°S. they have a generalised movement from higher latitudes where feeding occurs in summer to warmer, lower latitudes for breeding in winter. They approach coasts in winter and in Australia are distributed around the southern coastline from Perth, Western Australia to Sydney, New South Wales, including Tasmania. Their range is possibly extending with recent sightings from Shark Bay and North West Cape, Western Australia and north of Sydney to Cape Byron, New South Wales.



Ecology

Southern right whales are pelagic in summer, feeding in the open Southern Ocean, and inshore in winter, particularly calving females which usually remain very close to the coast. Their maximum age is around 50 years (presumed) and their maximum length is around 17.5 m (males slightly less than females). They generally calve in july to August every three years after an 11–12 month gestation period. Preferred calving localities include Doubtful Island Bay (Point Ann and Point Charles) and east of Israelite Bay,Western Australia; at Head of the Bight, South Australia; and intermittently (and smaller) off South Australian gulfs and Warrnambool, Victoria). Their baleen structure and recent observations suggest that their prey is mainly smaller plankton, eg pelagic larval crustacea (*Munida gregaria*) and copepods, taken primarily in open ocean in summer. They produce a variety of sounds including short, relatively low frequency belches, moans, and pulses. Their swimming speeds near shore are generally slow, but they are capable of 15+ km/hr over short distances. Migration speeds unknown but medium range coastal movements indicate 2.7-4.2 km/hr over 24 hours for cow/calf pairs. Southern right whales rarely strand.

Main threats

Direct disturbances to southern right whales are possible, particularly in near-shore concentration/calving areas from whale watching and research vessels/aircraft, pleasure craft, swimmers and divers and low-flying aircraft. Other threats include coastal industrial activity, eg seismic, drilling, sandmining and shipping operations, defence operations, collisions with large vessels, particularly on shipping routes on eastern seaboard, in Bass Strait, across the Great Australian Bight, entanglement in fishing gear (at least three recent examples). Pollution is also a threat, including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues, though less serious for species rarely feeding in low latitudes.

False killer whale
Pseudorca crassidens fam.: Delphinidae

Status

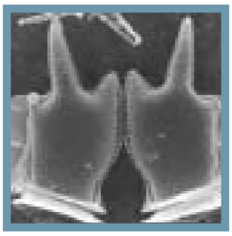
In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

False killer whales have a circumglobal distribution, from the equator to ca 45°S and 45°N. North-South and inshore seasonal movements appear to occur in the north-eastern Pacific and in some other areas, apparently associated with warm currents and seasonal availability of prey. They are widely recorded by strandings and some sightings in waters of all Australian states and the Northern Territory. Strandings occur in all months, but the majority of herd strandings occur from May to September on the south and south-eastern coasts, indicating a seasonal movement inshore or along the continental shelf.

Ecology

False killer whales prefer tropical (ca 22°C–32°C) to temperate (ca 10°C–20°C) oceanic waters, approaching close to land only where the continental shelf is narrow, possibly attracted to zones of enhanced prey abundance along the continental slope. Their maximum length is around 5.96 m (male), or 5.06 m (female).They calve approximately every six years although this increases with age. Mating and calving occurs year round and the gestation period is around 15 months. Their diet includes squid and large pelagic fish. False killer whales occur in socially cohesive herds of ca 20 to 50 in which both sexes are equally represented. Large aggregations of ca 100 to 800+ also occur, which appear to be temporary associations of several smaller herds, congregating to exploit locally abundant prey. They are often seen with other cetaceans, eg bottlenose dolphins. They are very fast and athletic species and will approach vessels and bow-ride, and are capable of high leaps. A mass stranding in Tasmania, ca 1868 included long-finned pilot whales and killer whales, but the circumstances are unclear. Mass strandings on Australian coasts occur relatively frequently, on average one per 2.5 years since 1970, and have involved between 20 and 250 individuals.



Main threats

False killer whales have occasionally been taken incidentally by gill-net and tuna purse-seine fisheries and may be vulnerable to predation by killer whales. Culling occurs to protect finfish fishery off western Japan, also incidentally captured in tuna purse-seine and in other net and long-line fisheries elsewhere in Pacific Ocean. Other possible threats include entanglement in drift-nets lost or discarded in international waters, and potentially competition from expanding commercial fisheries. Pollution leading to accumulation of toxic substances in body tissues is also a threat.

KILLER WHALE

Orcinus orca **FAM.: DELPHINIDAE**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Killer whales have a cosmopolitan distribution from polar regions to the equator in all oceans. They have been recorded from all states but not the Northern Territory. Concentrations are believed to occur around Tasmania and there are frequent sightings in South Australia and Victoria. They are also frequently seen in the Antarctic south of 60° and recorded from Heard and Macquarie Islands. They are not known to be migratory but seasonal movements may occur, possibly related to food supply.

Ecology

Okiller whales are oceanic, pelagic and neritic and may be more common in cold, deep waters. Off Australia, they are often seen along continental slope and on shelf and near seal colonies. Their maximum weight is >4000 kg (male), or >3100 kg (female), maximum age of around 40 years, and a maximum length, of around 9.8 m (male) or 8.5 m (female). Killer whales calve every 3–8 years after a gestation period of 12–17 months, mating and calving occur year-round. Killer whales are top-level carnivores and their diet differs seasonally and regionally including fish, squid, birds and mammals (other cetaceans and seals). Killer whales have been observed in groups of up to several hundred although usually less than 30. Killer whales often hunt in packs, especially when attacking schools of fish and large whales. Their communication is visual, tactile and acoustic.

Main threats

Illegal killing, of concern in some areas (eg Tasmania) with reliable reports of fishers shooting killer whales plundering catch. Because killer whalesa re long-lived and are top predators they are highly susceptible to accumulating heavy metals and organochlorines. Reduction of food resources by overfishing of prey species is also a threat along with entanglement in drift-nets set outside Australian EEZ and in lost or discarded netting.

LONG-FINNED PILOT WHALE

Globicephala melas **FAM.: DELPHINIDAE**

Status

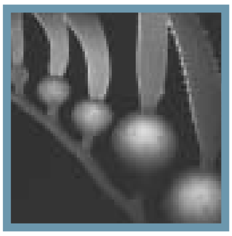
In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Long-finned pilot whales are found in the northern and southern hemispheres. They are found near all the major land masses and in oceanic waters. They are widely recorded in waters off southern Australia, and at Macquarie and Heard Islands with the southernmost sighting from 67°41'S. Long-finned pilot whales are migratory, apparently in relation to seasonal abundance of favoured prey species. Strandings have been recorded from all states, and at Lord Howe Island, but not in the Northern Territory.

Ecology

Long-finned pilot whales prefer temperate (ca 10°C–20°C) and subantarctic (ca 1°C–8°C) deep oceanic waters and zones of higher productivity along the continental slope, apparently venturing into the shallower waters of the shelf (<200 m) in pursuit of favoured prey species. Their maximum age is around 46 years (male) or 59 years (female). Maximum length is around 7.20 m (male) or 6.00 m (female). They calve



every 3-4 years (interval increasing with age). Mating seasonis from spring to summer and they have a 12 month gestation. Geographical associations between these whales and squid have been widely reported. Stomach contents confirm squid are the main prey, although some fish are also taken. Long-finned pilot whales usually travel in small, socially cohesive groups of between ten and 50 animals, but are also encountered in large herds of several hundred and occasionally of 1000+. Most animals remain within natal pod centred on reproductive females. Matings occur between pods with no evidence of male dominance or competition, but scars suggestive of intraspecific aggression have been reported. They are fast active predators and possibly cooperate in herding schools of prey. They are capable of deep dives (1000+m), but generally feed at much shallower depths during dives of 5–10 minutes. Entire herds may rest motionless at the surface. They are prone to mass strandings and a mass stranding in Tasmania ca 1868 included false killers and killer whales, but the circumstances are unclear.

Main threats

Possible entanglement in drift-nets and other nets set, lost or discarded in international waters. Potential competition from expanding commercial fisheries, especially in mid- to higher latitudes. Pollution leading to accumulation of toxic substances in body tissues.

Short-finned pilot whale
Globicephala macrorhynchus **fam.: Delphinidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Short-finned pilot whales have a circumglobal distribution from the equator to ca 41°S and ca 45°N. Their distribution in the Australian region includes oceanic waters and continental seas, with strandings in the Northern Territory and all states except Victoria. Elsewhere, seasonal inshore-offshore movements occur of known groups, apparently in response to abundance and spawning of prey.

Ecology

Short-finned pilot whales are found in waters from 10°C–32°C. Their maximum weight is around 2 tonnes (male),or around 1.5 tonne (female). Maximum age is around 46 years (male), or 63 years (female) and maximum length is around 5.89 m (male), or 4.8 m (female). They calve every five years after a 14.9 month gestation period. Mating and calving occurs year-round. Their diet consists mainly of squid, cuttlefish and octopus and some fish. They have been reported to herd and possibly attack Stenella dolphins and common dolphins escaping tuna purse-seine nets in eastern tropical Pacific. They are socially cohesive, in small groups of around ten to 30, but commonly in herds of several hundred. The mating system is polygynous; males migrate between schools after weaning. Large males can be aggressive towards human swimmers. Capable of diving to at least 600 m. Males at periphery of groups possibly more prone to attacks by killer whales.

Main threats

Threats include entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding commercial fisheries, and pollution leading to accumulation of toxic substances in body tissues.

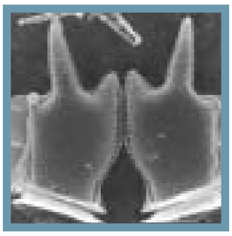
Shepherd's beaked whale
Tasmacetus shepherdi **fam.: Ziphiidae**

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Shepherd's beacked whales are possibly circumpolar in distribution in mid-latitudes of the southern hemisphere from 33°S to 50°S. Known from only 19 stranded specimens and two unconfirmed sightings, mostly from New Zealand, elsewhere from Australia (South Australia, Western Australia), Tristan da Cunha, Argentina and Chile.



Ecology

This species apparently prefers subantarctic (ca 1˚C–8˚C) and adjacent temperate (ca 10˚C–20˚C) deep oceanic waters. Their maximum length is around 7.10 m (male), or 6.60 m (female). Little is known of their ecology. They are believed to feed primarily on fish. They are powerful and active predators and are presumed to be able to dive deeply in pursuit of prey.

Main threats

Threats include possible entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding commercial fisheries in higher latitudes, and pollution leading to accumulation of toxic substances in body tissues.

Arnoux's beaked whale
Berardius arnuxii fam.: Ziphiidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix I of the Convention on International Trade of Endangered Species.

Distribution

Arnoux's beaked whales have a circumglobal distribution in the southern hemisphere only, south of about 34˚S to the Antarctic ice edge and are uncommon in continental seas. They strand quite frequently on New Zealand coasts, but there have only been three strandings in Australia (Western Australia, South Australia and Tasmania) and possible sightings inshore off South Australia and south coast of New South Wales. Most strandings at sea are from the Tasman Sea and around the Albatross Cordillera in the South Pacific Ocean.

Ecology

Arnoux's beaked whale occurs primarily in deep oceanic waters, particularly in the vicinity of seamounts and submarine escarpments which generally are regions of higher prey densities. Their maximum age is estimated at 50+ years with a maximum length of 9.34 m (male), or 9.33 m, but possibly ca 10 m (female). Their ecology is little known. Their diet is believed to include squid and fish. They are often found in groups of 6–10 (possible sightings of groups of 2–16 off south coast of New South Wales and of lone animal off South Australia) and occasionally up to 50 or more. They are powerful and active predators and capable of deep dives of around 15-30 minutes and possibly to depths greater than 1000 m. Adults of both sexes have erupted teeth, consisting of two pairs at the tip of the lower jaw, which are possibly used as weapons during agonistic encounters, resulting in heavy scarring of older animals. Arnoux's beaked whales do not commonly strand.

Main threats

Threats include possible entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding commercial fisheries, particularly in higher latitudes and pollution leading to accumulation of toxic substances in body tissues.

Blainville's beaked whale
Mesoplodon densirostris fam.: Ziphiidae

Status

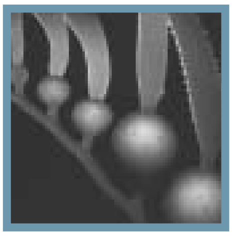
In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Blainville's beaked whales have an oceanic and circumglobal distribution in low to mid-latitudes in all oceans in both hemispheres. There are stranding records from northern and southern Australia (at 40˚50'S in Tasmania) except in South Australia and Northern Territory. Strandings on western and eastern coasts may be linked to south-flowing warm currents, ie Leeuwin and East Australian currents, respectively.

Ecology

Blainville's beaked whales are found in oceanic waters (10˚C–32˚C), 700–1000 m deep, adjacent to much deeper waters of 5000 m. Their maximum length is around 5.8 m, possibly closer to 6.4 m (male), 4.71 m



(female) Little known of their ecology although their diet appears to consist of mid- and deep water squid and fish. Groups of three to seven have been reported off Hawaii; four to six off Point Lookout, Queensland. They are generally wary of vessels. They are presumed to actively pursue prey and are apparently capable of deep dives. Strandings of this species are uncommon.

Main threats

Threats include unreported incidental captures in fisheries, possible entanglement in drift-nets and other nets lost or discarded in international waters, potential competition from expanding commercial fisheries, especially on pelagic squid at lower latitudes and pollution leading to accumulation of toxic substances in body tissues.

Strap-toothed beaked whale
Mesoplodon layardii fam.: Ziphiidae

Status

In Australia, is listed in the Action Plan for Australian Cetaceans but no category has been assigned, because of insufficient information, however, it is possibly secure. Listed as Insufficiently known in the IUCN List. Listed in Appendix II of the Convention on International Trade of Endangered Species.

Distribution

Strap-toothed beaked whales are only found in the southern hemisphere and have a circumpolar distribution between 25°S and 60°S, based mainly on reports of strandings in South Africa, South America, New Zealand and in Australia (all states except Northern Territory, but most have been on the southern and eastern coasts) and also from Macquarie and Heard Islands. They occur south of 38°S throughout the year, while their occurrence north of 38°S appears to be seasonal. The majority of strandings in Australia occur from January to April, indicating a seasonal influx during mid- to late summer.

Ecology

Strap-toothed beaked whales appear to prefer deep oceanic temperate to subantarctic waters (1°C–20°C). They may feed seasonally in zones of higher productivity adjacent to the continental slope as well as using adjacent waters for calving. Their maximum length is around 6.13 m (male),or 6.25 m (female) while maximum age is unknown. They calve in summer-autumn after a 9–12 month gestation period. Calving areas: none known for. Their diet consists mostly of pelagic squid, but fish and crustaceans are also eaten. Their ecology is little known. They occur singly, in female/calf pairs and in small groups of two or three, which may be all female or include one or two males. They are generally wary of ships, either sinking slowly or diving with a lateral roll exposing a flipper, but not the flukes, rising 10–15 minutes later at least 400 m away. They are probably fast and active in the pursuit of prey, but the mode of capture is not known ane they are apparently capable of deep dives. Individuals of all ages strand.

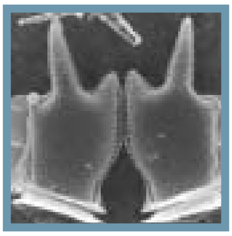
Main threats

Threats include possible entanglement in drift-nets and other nets set, lost or discarded in international waters, potential competition from expanding fisheries, especially on pelagic squids and pollution leading to accumulation of toxic substances in body tissues.

Mammals – sirenians

The order Sirenia is made up of four living species placed in two families, the manatees and the dugong. Only one of these is found in Australian waters, the dugong. The three closest relatives of the dugong all belong to the manatee family and include the Amazonian manatee, the West Indian manatee and the West African manatee. Dugongs are included here as they are considered to be very occasional visitors to the Region.

Specialised human cultures based on dugong hunting have developed in several parts of the world including the Torres Strait, between Australia and New Guinea, where an estimated 750 animals are still killed annually. The dugong has been hunted for food throughout its range. In many areas, the dugong has declined greatly in numbers, and fears have been expressed that it might become extinct through continued hunting pressure. Populations along the coasts of India, south-western Asia, Africa, and Madagascar are thought to be in critical danger. The species is classified as vulnerable by the IUCN and is on Appendix 1 of the CITES, except for the Australian population, which is on appendix 2.



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Dugong
Dugong dugon fam.: Dugongidae

Status

Dugongs are protected, except where traditionally hunted by Aboriginal people. Under the *Environment Protection and Biodiversity Act 1999* they are a listed marine and migratory species.

Distribution

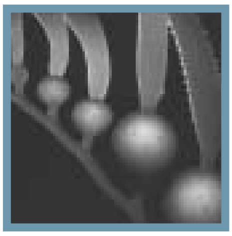
Dugong's international distribution spans 40 countries, in Australia it is found in northern Australian waters from Moreton Bay in the east to Shark Bay in the west. Dugongs are only very occasional visitors to the Region.

Ecology

Adult dugongs reach lengths of more than 3 m and weigh up to 420 kg. Their lifespan is approximately 70 years. A female usually bears a single calf every 3–5 years, with gestation taking 13 months. Dugongs spend a large proportion of their daily activities feeding on seagrass, eating approximately 21–36 kg of seagrass per day.

Main threats

In Australia, dugongs are accidentally drowned in fish and shark nets, and are occasionally killed by boat strikes. Habitat modification, such as the destruction of seagrass meadows through dredging and smothering by soil washed into the sea during heavy storms and cyclones can also effect the species.



Appendix E: Working Group Membership and Terms of Reference

The Working Groups were established to assist with the Assessments Phase of the South-east regional marine planning process, specifically the Bioregionalisation and Ecosystem Function Working Groups are part of the Biological and Physical Characteristics Assessment.

Bioregionalisation Working Group

Terms of Reference

- Contribute to and advise on any further refinement of the work program for the development of an Interim Bioregionalisation of the South-east Marine Region (as a priority)
- Contribute to and advise on the development and implementation of the work program for the bioregionalisation of Australia's Exclusive Economic Zone

Table 5: *Bioregionalisation Working Group membership.*

Colin Creighton (CHAIR)	National Land and Water Resources Audit
Alan Butler	CSIRO Marine Research
Chris Simpson	WA Department of Conservation and Land Management
Peter Doherty	Australian Institute of Marine Science
Peter Harris	Geoscience Australia
James Scandol	University of Sydney
Brian Lassig	Environmental Resources Information Network
Jon Day	Great Barrier Reef Marine Park Authority
Gary Poore	Museum Victoria

- Assist and provide technical and expert advice on the development of an Interim Bioregionalisation for the South-east Marine Region (as a priority) and Australia's Exclusive Economic Zone
- Provide peer review of the outcomes of the Interim Bioregionalisation, including individual projects and the methods for deriving the Interim Bioregionalisation.

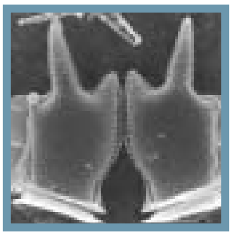
Ecosystem Function Working Group

Terms of Reference

- Contribute to and advise on any further refinement of the ecosystem function work program for the for the South-East Marine Region
- Contribute to and advise on the development of a conceptual model of the ecosystem (s) of the South-east Marine Region
- Provide high level technical and expert advice on the scope and development of dynamic computer models of the ecosystem(s) of the South-east Marine Region that can be used to demonstrate the dynamic, integrated nature of the ecosystem(s) and their potential response to natural and human impacts
- Assist and provide technical and expert advice on the development of operational objectives and performance indicators for the ecosystem(s) of the South-east Marine Region that may be used to evaluate the implications of alternative management options for the South-east Marine Region.

Table 6: *Ecosystem Function Working Group membership.*

Alistair Gilmour (Chair)	Consultant
Tony Smith	CSIRO Marine Research
Bill De la Mare	CSIRO Marine Research
John Parslow	CSIRO Marine Research
Simon Goldsworthy	LaTrobe University
Craig Johnson	University of Tasmania
Katherine Short	Worldwide Fund for Nature



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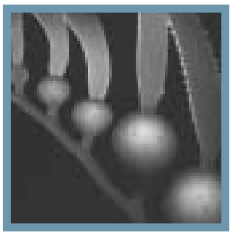

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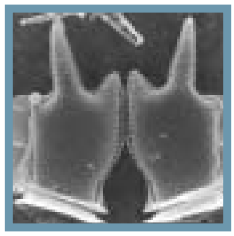

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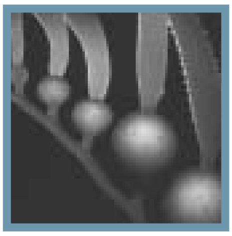

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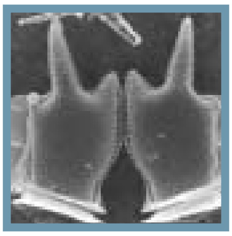

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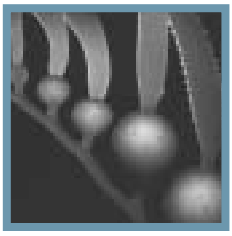

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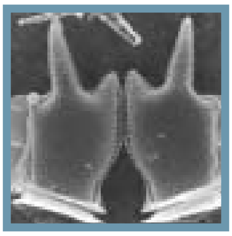

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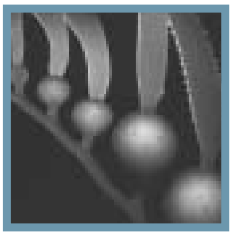

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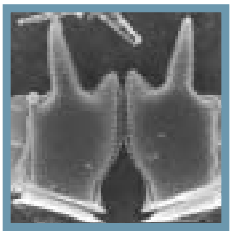

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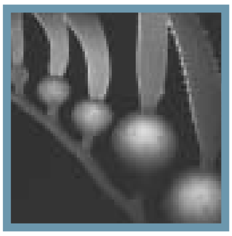

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