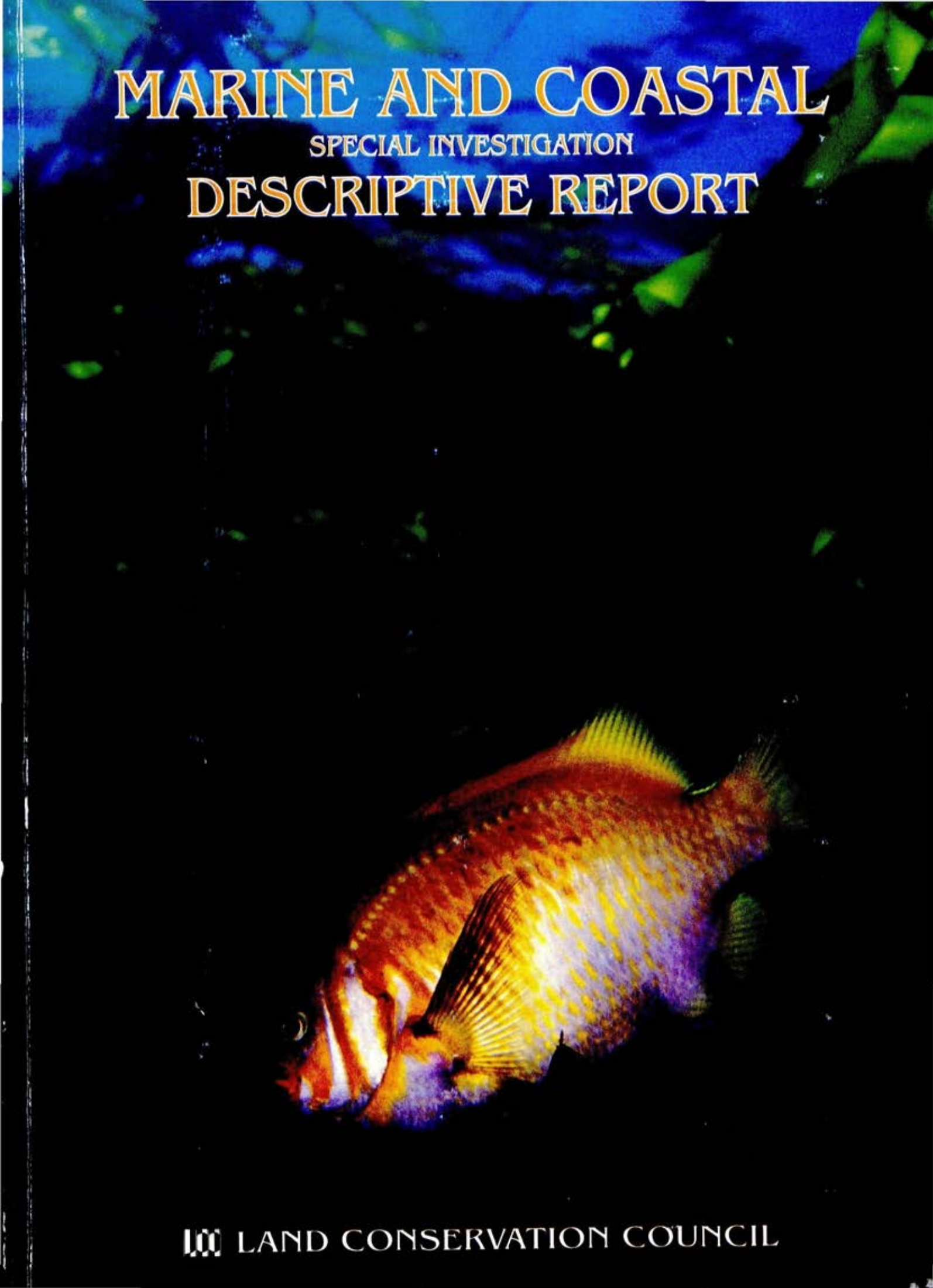
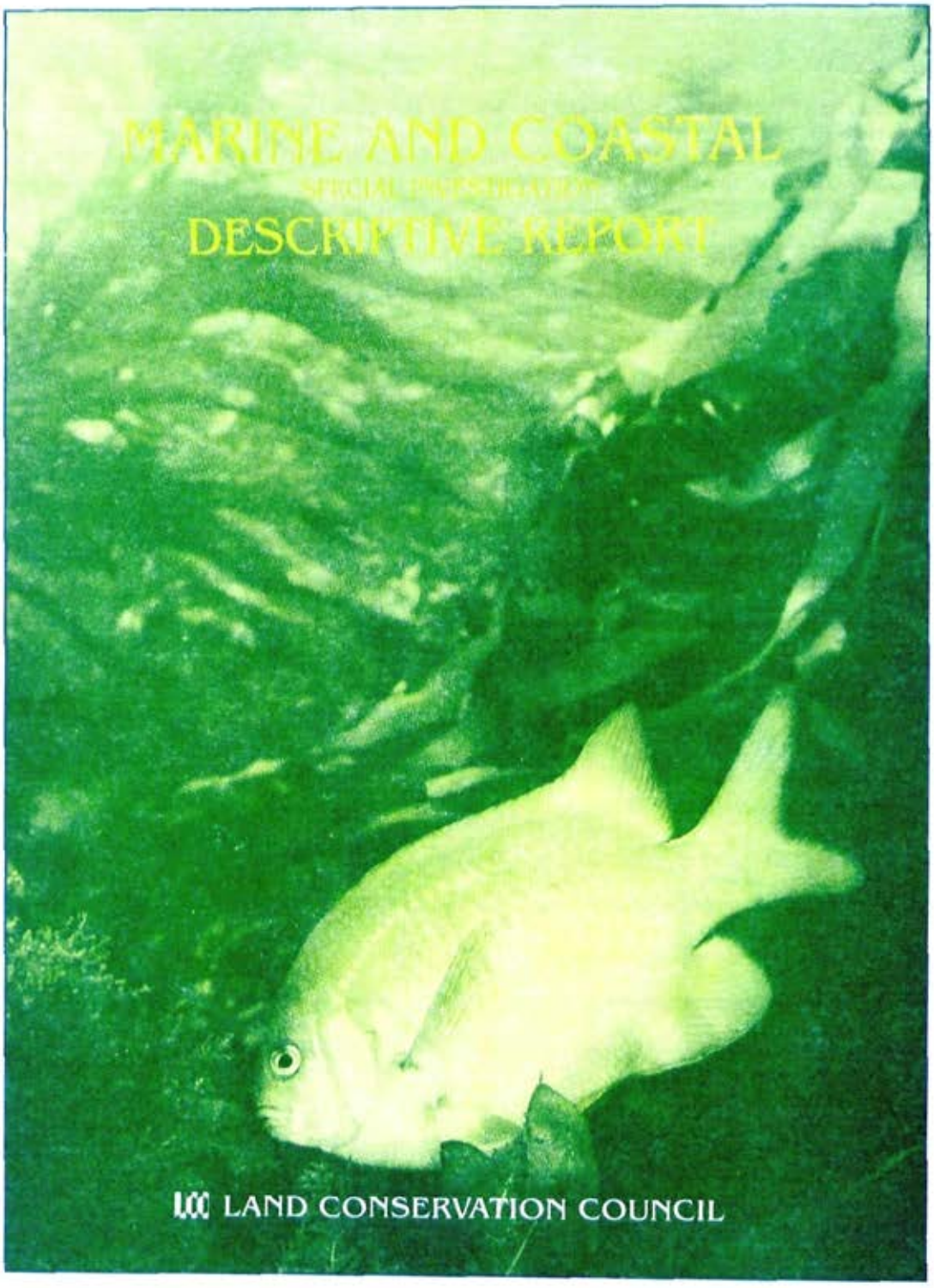
MARINE AND COASTAL

SPECIAL INVESTIGATION

DESCRIPTIVE REPORT



LAND CONSERVATION COUNCIL



Keeping You Informed of the Land Conservation Council's Marine and Coastal Special Investigation

CONTACTS: Don Hough or Hania Bibrowska ISSUE NO 2
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SUBMISSIONS INVITED UNTIL 9 SEPTEMBER 1993

LAND CONSERVATION COUNCIL

The Land Conservation Council is an independent statutory body established under the *Land Conservation Act* 1970. It makes recommendations on the use of public land to the Victorian Government.

STUDY AREA - LAND AND SEA

The study area includes foreshore land and coastal waters.

The land area included in this investigation extends approximately 1 km inland from high water mark. Private land and the area within cities and rural cities are excluded.

The waters and bed of our bays, inlets, estuaries, and out to the territorial limit (5.5 km) offshore are included, with the exception of the Gippsland Lakes.

THE DESCRIPTIVE REPORT

The report contains the following chapters.

* Background
* Atmospheric and ocean systems
* Biology
* Cultural resources
* Landscape resources
* Marine and estuarine fish resources
* Earth resources
* Recreation
* Tourism
* Transport and communication
* Waste discharges
* Defence
* Coastal engineering
* Education and research
* Other uses
* Social and economic context
* Adminstrative and legislative context
* Approaches to coastal conservation and resource use

The report has about 360 pages, contains 5 maps including colour maps that describe earth resources, biological, habitats, and sites of significance. It also contains numerous other illustrations.

This report is the first stage in Council's investigation progress.

WHAT HAPPENS NEXT?

Public submissions are now invited on the Report. The submission period is 90 days. After considering these submissions, Council will prepare its proposed land-use recommendations. These Proposed Recommendations will then be released for public comment in early 1994. This will be followed by a second submission period after which the Council will prepare its final Recommendations. These are presented to the Victorian Government by 30 November 1994.

* Resources Report (released June 1993)
* Close of first submission period (September 1993)
* Proposed Recommendations (early 1994)
* Close of second submission period
* Final Recommendations to government (November 1994)

SUBMISSIONS WELCOMED

Who should be involved?

Anyone with an interest in the use of Victoria's foreshore land, bays, inlets, estuaries, territorial waters and their associated values and resources.

How to be involved

Make a submission

It is a positive way for you to participate in the Council's land-use investigation by:

* supplying information on one or more particular areas
* supplying information on physical and biological resources
* describing values and uses of public land in the study area
* any other land and sea use issues along the Victorian coast you wish Council to consider

How to make a submission:

* Make sure your comments are clear - it would help us if you list points or break up your submission into subject headings.
* It can be brief, or even in point form - your information and ideas are more important than presentation.
* If you wish to make a confidential submission, or discuss particular issues of concern to you, or have difficulty preparing a written submission, please contact the Council.
* Submissions are important and each will be receipted, so please write your name, address and the date on them.

What happens to your submission?

Submissions are welcomed and all are actively considered. It is a legislative requirement that the Land Conservation Council only makes recommendations after considering submissions.

Submissions are important and we acknowledge their receipt, so please write your name, address, and the date on them.

Send your submission to:

Secretary
Land Conservation Council
1st Floor, 477 Collins Street
Melbourne 3000
Fax: (03) 628-5080

SUBMISSIONS CLOSE

Submissions must reach the Council's offices by Thursday, 9 September 1993.

COPIES OF THE REPORT

Copies may be inspected at:

* Department of Planning and Development - Library
  477 Collins Street, Melbourne
* Regional Libraries servicing the coast
* Shires Offices for coastal municipalities

Copies may be purchased over the counter from:

* Information Victoria Bookshop
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* Department of Planning and Development - Bookshop
  477 Collins Street, Melbourne
* Department of Conservation and Natural Resources offices at:
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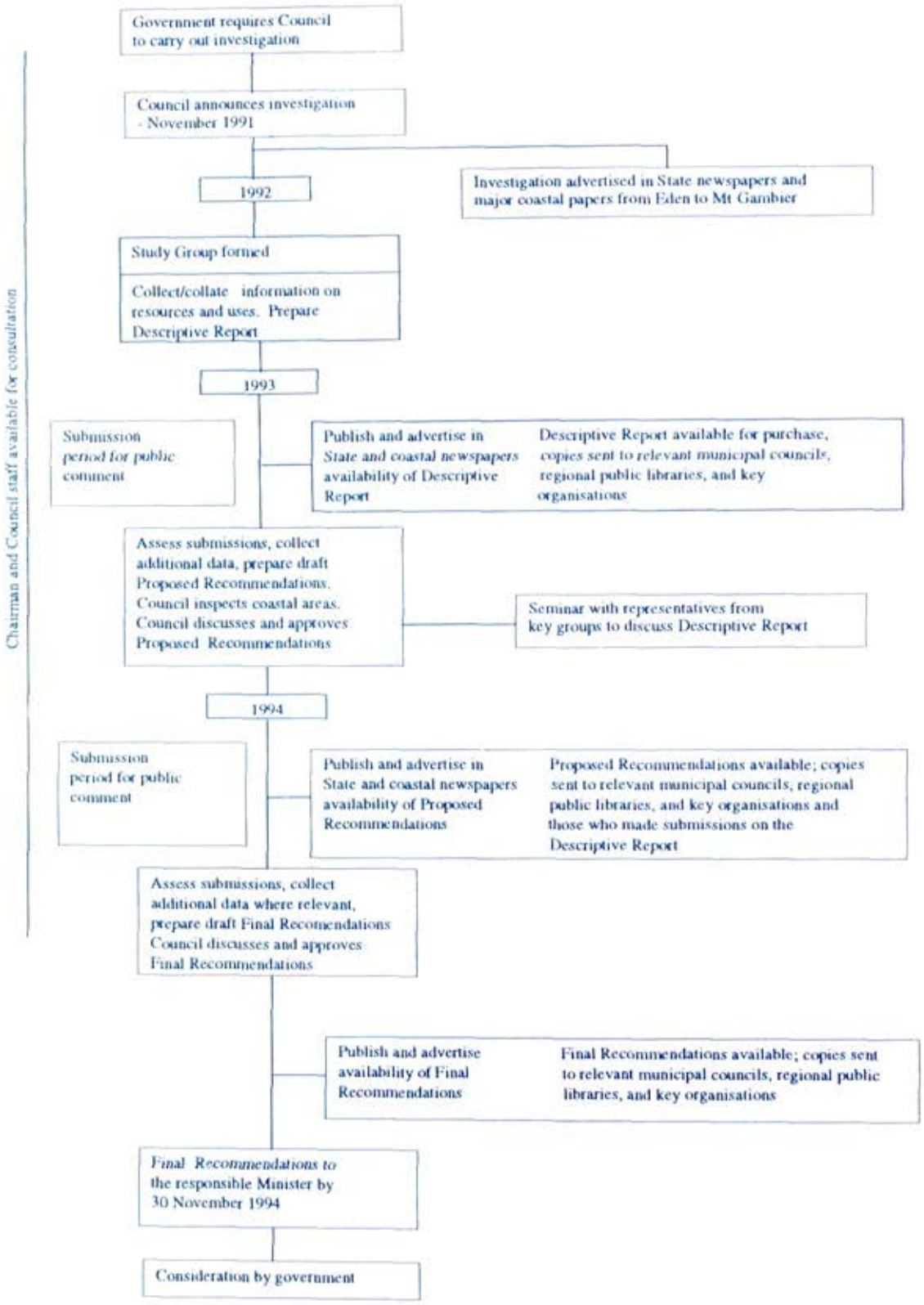
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MARINE AND COASTAL SPECIAL INVESTIGATION - VICTORIA



MARINE AND COASTAL

SPECIAL INVESTIGATION

DESCRIPTIVE REPORT

JUNE 1993



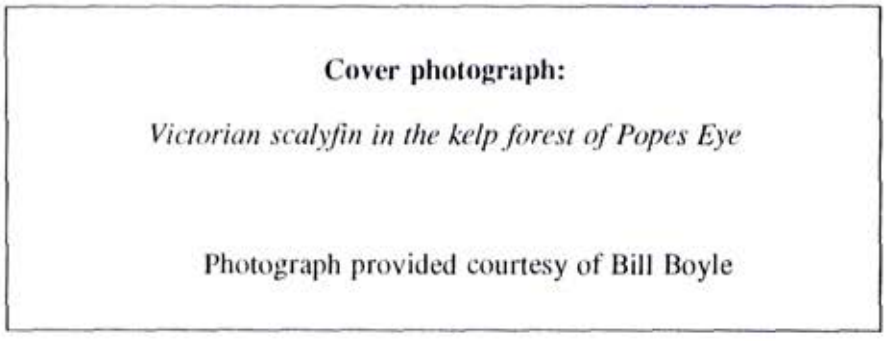
LAND CONSERVATION COUNCIL

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Victorian scalyfin in the kelp forest of Popes Eye



Photograph provided courtesy of Bill Boyle

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FOREWORD

The Land Conservation Council was established under the *Land Conservation Act* 1970. The primary function of the Council is to carry out investigations and make recommendations to the Minister for Planning with respect to the use of public land in order to provide for the balanced use of land in Victoria.

Council, in meeting the Government's request to carry out an investigation of marine and coastal areas in the State of Victoria, is required to identify significant environmental values and the range of uses that may be carried out in the area under review. It will, therefore make recommendations on the protection of important values and the sustainable use of such areas. It is important that the recommendations are based on the best information available.

This report provides a factual basis for the preparation of submissions to the Council. It describes the physical, biological, and cultural values of the study area, identifies current and potential uses and outlines the broad social, economic, legislative, and conservation context for planning.

Victoria's coastline stretches for about 2000 km, its character ranging from sandy beaches, to rocky headlands. Bays, inlets, estuaries and open Victorian coastal waters cover more than 8000 sq.km. and contain mud flats, intertidal and sub-tidal rocky reefs, seagrass beds, kelp forests and pelagic systems. They form one of the State's most valuable natural assets, of incomparable importance for recreation, tourism, commerce and industry, scientific research, and education as well as for their own intrinsic value.

Much of the coastline and all of the sea-floor is publicly owned. The Victorian coastline and offshore areas are coming under greater pressure from different uses as population, leisure, and tourism increase. These interests and activities may sometimes conflict and place parts of the coast in danger of degradation or permanent damage. It is essential to integrate conservation measures with development of the coastline so that its unique features and attractions are protected and use and enjoyment of them can be sustained.

Council is aware that numerous community and industry groups and individuals possess information about the values and uses of such areas. It is, therefore, seeking their involvement in expanding its information base and identifying land or sea use issues, before developing its proposals.

Submissions are now invited and should be forwarded to the Secretary of the Land Conservation Council by the closing date for submissions, as notified in the *Victoria Government Gazette*, and advertised in State and regional newspapers. The Council will prepare its proposed recommendations after due consideration of these submissions. There will be another period for public response, following publication of the proposed recommendations before Council makes its final recommendations to Government.



DAVID SCOTT
Chairman

Land Conservation Council
1st Floor
477 Collins Street
Melbourne 3000

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ABBREVIATIONS

ANZECC	Australian New Zealand Environment and Conservation Council
CBA	Cost benefit analysis
CNR	Department of Conservation and Natural Resources
DASET	Department of Arts, Sport, Environment, and Tourism
DASETT	Department of Arts, Sport, Environment, Tourism, and Territories
DEST	Department of Environment, Sport, and Tourism
EPA	Environment Protection Authority
LCC	Land Conservation Council
MPA	Marine protected area
PMA	Port of Melbourne Authority
SECV	State Electricity of Victoria
SEPP	State Environment Protection Policy
TAC	Total allowable catch

Measurement units

%	per cent
^{o}C	degrees Celsius
$	dollar
cu. m	cubic metre
ha	hectare
km	kilometre
ML	million litres
MW	million watts
sec	second
sq. km	square kilometre
sq. m	square metre
GWH	thousand million watts
kw	thousand watts

GLOSSARY

aquaculture	farming of plants or animals in water of any kind
ascidians	sessile chordate animals of the class Ascidiacea, may be solitary or colonial and there is usually a free-swimming larva
benthos (benthic)	the flora and fauna of the bottom of the sea
broken reef	patches of usually low profile reef interspersed with sand. Broken reef can be worn bed-rock or calcified sediments and/or hard coral growths. Non bed-rock reef may be vulnerable to impact by some fishing methods
bryozoans	sessile colonial animals of the invertebrate phylum Bryozoa, sometimes known as 'moss animals' which form tuft-like or moss-like aggregate masses
by-catch	species that are also caught when fishing for a particular species (or size). It may be retained or discarded
cephalopods	group of highly organised molluscs characterised by distinct head with arms or tentacles attached (includes cuttlefish, octopus, etc.)
cnidarians	animals of the invertebrate phylum Cnidaria, possessing nematocysts or stinging cells, and including hydroids, corals and sea anemones
community	assemblage of plant and animal species living together in a particular place
crustaceans	arthropod animals, mostly aquatic, characterised by a hard close fitting shell which is shed periodically (includes crabs, lobsters, shrimps etc)
demersal	living on or near the sea bottom
epibenthos	benthic organisms living on (not within) the sea bottom
estuarine water	found in estuaries usually having variable salinities sometimes well below that of ocean water and sometimes above
estuary	tidal mouth of a river where salinity is usually less than that of the sea
euphausids	shrimp-like pelagic marine organisms, for example, krill
filter feeding	a feeding strategy sieving plankton from the water. It is used by many molluscs and a very few species of fin-fish.
fin-fish	teleost fish
grow-out stage	final stage of mariculture in which the adult form is on-grown or fattened prior to harvest.
hatchery stage	process of producing seed, sometimes including the care of early planktonic stages of larvae.
heavy reef	continuous unbroken reef, usually of protruding bed-rock, often deeply dissected and featuring a relatively steeply changing gradient or areas of high relief. Heavy reef is not highly vulnerable to damage by fishing methods
high energy coastline	areas of coast subject to the effects of storms and large waves
hydroids	animals of the class Hydrozoa, order Hydroida, often occurring as sessile colonies of polyps
inter-tidal mariculture	aquaculture taking place between the high and low tide marks. Usually structures are stabilised by having foundations buried in the sand or mud
larva	a pre-adult developmental stage of many invertebrates which hatches from the egg and often leads a different life from that of the adult
low profile reef	relatively flat reef which does not rise at a steep gradient. Low profile reef may be subject to damage from sediment inundation
mariculture	a form of aquaculture in which the crop is grown in sea or estuary water
molluscs	group of soft bodied animals which usually have a hard shell (includes snails, bivalves, limpets, tooth shells as well as cephalopods)

near-shore mariculture	aquaculture taking place in sea or estuarine water to the seaward of the low tide mark. Structures may be the same as those used for inter-tidal or off-shore mariculture
nursery stage	where a second, separate stage of care is needed between the hatchery and grow-out stages
off-shore mariculture	in deeper sites with support structures floating in, or on, the water or submerged and resting on the seabed.
on-shore mariculture	where activities take place to the shore-ward side of the high tide line, usually with the crop in artificial containers and with seawater pumped from nearby sea or estuarine areas.
pelagic	living in the water column as distinct from near the bottom
photic zone	surface waters to the depth to which sunlight penetrates
phycology	study of algae
phylum	high level taxonomic division, containing plants or animals of the same general form, ideally reflecting common ancestry
phytoplankton	planktonic plant organisms collectively
planktonic	occurring in the water column, movement controlled by currents and tides
polychaetes	class of worms characterised by numerous bristles on the footstumps
purse seine	seine net which is also bought together from underneath to prevent fish from escaping downwards in deeper water
ranching	a form of aquaculture where juveniles are released into the wild, allowed to grow and harvested at a later date
re-circulating systems	where water is re-used after having metabolic pollutants removed, usually by mechanical and biological filters
seed	first stage of mariculture farm animal
seine	fishing net which hangs vertically in the water, the ends being bought together to enclose the fish
serial spawning	spawning which takes place several times over the breeding season
sessile	attached to the substrate, immobile
shellfish	fish living within biologically produced shells and exo-skeleton: molluscs and arthropods.
spat	first sessile stage of a mollusc, where small adult-like forms are found fixed to a hard surface. The term probably reflects a visual similarity of juveniles to sputum
species	populations of animals or plants that are able to interbreed and produce fertile offspring
stenohaline	species are adapted to a narrow range of salinities, usually those found in the open sea
stock	genetically similar group of fish that can be managed as a single entity
superfamily	taxonomic division above the level of family and below order

PART I

INTRODUCTION

1. BACKGROUND

The coast is unquestionably a very special place for Australians; it plays a large role in the national consciousness and supports intense economic and social activity. More than 75% of the Australian population live within 50 km of it. Population densities can be as high as 6000 per sq. km in metropolitan areas, yet vast stretches of coastline are sparsely populated or uninhabited.

Over the last decade the media, particularly television, have made the public aware of the diverse riches of the coastal lands and sea - its fish, whales, other wildlife, and mineral resources such as oil and gas, as well as the recreation, tourism, and conservation values. They have also highlighted the hazards associated with use of coastal land and the marine environment. The dumping of toxic materials and other wastes, oil spills, overfishing, and the clearing of coastal wetlands are a few of the hotly debated issues along with the impacts of tourism, recreation, transport, coastal engineering, and run-off and discharges as a result of agricultural, urban, and industrial activities.

This debate has emphasised the need to improve the knowledge of coastal and marine environments and to transmit that knowledge to the wider community. The latter is essential for informed discussion about the appropriate use of coastal land and water and the resources they contain. Other issues such as economic or social returns to present or future generations, conservation of flora, fauna, and cultural heritage, and provision of recreational opportunities - also form part of the ongoing debate.

Too often in the past, the coast and adjacent off-shore areas have been viewed as a resource with an unlimited capacity to support human activities. Native vegetation has been cleared, wetlands and estuaries filled in and developed, fish and wildlife utilised with little regard to their long-term conservation, and wastes dumped in near-shore waters.

Sustainable development is fundamental to the continued well-being of the coast and the marine environment. Development is sustainable when it can continue to provide social and economic benefits for as long as they are desired. It must not only be economically viable, but also ensure that:

* the type and intensity of use is properly matched to the characteristics of the ecosystem
* renewable resources are used at rates that maintain the resource bases and allow for future use
* ecological diversity is maintained so that species can flourish, retain their potential for evolutionary development in the wild, and adapt to and survive environmental change
* the direct and indirect environmental impacts of developments are controlled

The last few decades have also seen major technological changes that affect the way in which the marine environment can be used. Weather-monitoring systems have been extended and forecasting prediction improved. Satellite navigation systems and deep-water drilling equipment have been introduced. Mono-filament lines make possible the manufacture of fishing nets tens of kilometres long, sea-going vessels with fishing capacity between 50 and 100 tonnes now operate, and fishing operations have been upgraded with sophisticated equipment such as the recently introduced electronic fish-finding equipment. Mariculture technology is constantly being refined. Super-tankers with a capacity of 500 000 tonnes or more pose potential risks to the marine and coastal environment.

The Earth's land and oceans are now photographed from space, emphasising the size and importance of the seas compared with land masses and the notion of the One Earth. Earth's population has also increased from 2.656 billion (1950) to 5.333 billion (1990) with a resultant increase not only in the demand for the resources in the coastal lands and waters, but in competition between different uses, such as tourism, indigenous fishing, and protection of marine ecosystems.

At a national level, discussion of coastal planning and management has been addressed recently in a 1991 Commonwealth report *The Injured Coastline: Protection of the Coastal Environment*.

The Commonwealth government's response to this report was to develop an integrated policy on the management and protection of the coastal zone and to formulate a National

Table 1.1: Events that have Shaped the Use and Management of the Coast

+40 000 years ago	Aborigines occupy 'Victoria' and established a vigorous and complex hunter–gatherer economy that involves the use of coastal lands, estuaries, wetlands, and shoreline resources.
18 000 years ago	Global sea-level is about 140 m below present level and the area between 'Victoria' and 'Tasmania' can be crossed on foot.
10 000 to 6000 years ago	Sea rises to about the present level; the current coast forms with the flooding of the bays and inlets and the formation of Bass Strait. The flooding of 'Port Phillip Bay' is recorded by Aborigines.
1770	Hicks on Captain Cook's *Endeavour* sights the 'Victorian' coast.
1797	Colonial expansion from Sydney Cove commences.
1797	Bass explores Bass Strait.
1800	Sealing had commenced in Bass Strait, forming a basis for international trade, and ceases within about 50 years due to the collapse of seal stocks; a similar situation applied to the whaling industry.
1803	Colony established at Sorrento and abandoned within 7 months. Convict William Buckley escapes and lives within Wathaurung, to become the first European settler in 'Victoria'.
1835	Batman 'signs' a treaty with the Wurundjeri, who cede 600 000 acres around Port Phillip.
1859	First telecommunication link laid across Bass Strait.
1881	Government reserves all unalienated land within one-and-a-half chains of inlets, loughs, and straits. (Throughout the 1870s, sections of the Port Phillip Bay, Western Port, and Bass Strait coastline had been reserved.)
1889	Artificial entrance to Gippsland Lakes created.
1946	Abalone fishing industry commenced at Mallacoota.
1952/53	Systematic bathymetric surveys of off-shore areas.
1963	Commercial scallop fishery commenced in Port Phillip Bay (scallops were discovered off Lakes Entrance in 1970).
1965	Oil and gas discovered in the Gippsland Basin off the Victorian coast.
1967	Port Phillip Bay regional environmental study commenced; the first of its kind in Victoria. A regional study in Western Port follows in 1973.
1967	Prince Charles considers that swimming at Elwood is like swimming in sewage.
1972	High mercury levels recorded in school shark, and size limits are introduced to protect customers.
1977	Health warnings on the consumption of flathead from Port Phillip Bay contaminated with mercury. The health warnings are lifted in the years to follow.
1979	Harold Holt Marine Reserve - first marine reserve - declared in Victoria.
1979	Off-shore Constitutional Settlement between the States and the Commonwealth reached. Among other outcomes it provided for the States to have title to the sea-bed of the adjacent territorial sea.
1982	Victoria's population passes 4 million.
1988	The number of visitors to the Penguin Parade passes 400 000 a year.
1991	In response to community concerns, a 3 year study of the impact of scallop fishing in Port Phillip Bay commences.
1991	Supreme Court finds that the *Fisheries Act* 1968 has no head of power to prohibit commercial fishing in an area on broad conservation grounds.
1992	Following extensive consultation and involvement of business and community organisations, the Council of Australian Governments endorsed the National Strategy for Ecologically Sustainable Development.
1993	Off-shore gas discoveries (La Bella and Minerva) in the Otway Basin.

Coastal Zone Management Strategy, to be pursued in co-operation with all levels of government and involving extensive community consultation.

In Victoria, the debates have been similar to those raised at the national and international forums, covering issues such as the discharge of sewage to coastal waters, the concentrations of heavy metals and hydrocarbons in the marine sediments (such as those of Port Phillip Bay), algal blooms, changes to coastal estuaries as a result of vegetation clearance and river regulation, the status and allocation of fish stocks, and the conservation of marine flora and fauna. These debates are necessary to understand the value of our coastal resources and the need to use them on a sustainable basis, and to ensure that appropriate planning and management decisions are taken.

A summer holiday by the sea is a part of the lifestyle of many Australian people and it is important that water be suitable for swimming and the fish safe to eat. Victorian fish and shellfish industries make a valuable contribution to the economy. The little penguins, the southern right whale, and other marine animals are significant tourist attractions. The waters are used for shipping and the ports are vital for trade.

In Victoria, much of the coastline is public land and therefore accessible for the enjoyment of all. At the same time, as population, leisure time, and tourism increase, the coast is coming under greater pressure from different users.

Despite those increased pressures, our coast and marine areas at present remain relatively undisturbed by major and destructive developments compared with many highly polluted and disturbed places in other parts of the world. In Thailand many mangrove nurseries have been devastated. In Norway toxic algae periodically poison cultured fish. Puget Sound and San Francisco, and San Diego Bays, U.S.A., have concentrations of hydrocarbon in sediments that correlate strongly with cancerous tumours in fish. In the Baltic Sea swimming is a health hazard. It is therefore timely to plan for the wise use and management of the Victorian coast and sea and to ensure protection of natural resources, sustainable harvesting of fish, and environmentally sensitive development.
Coastal planning for such diverse uses on a sustainable basis has not yet been applied to the whole of the State's coast. Some of these issues were discussed in the report by the Victorian government (1989). Table 1.1 identifies some of the major events that have shaped the use and management of the coast.

During the Land Conservation Council's review of the East Gippsland study area, the paucity of biological information for the State's off-shore waters made it difficult to assess the conservation significance of specific areas. Council recommended (1986) 'that a State-wide survey of marine ecosystems be undertaken as a matter of priority to identify representative and significant marine environments'. This recommendation was repeated in the Final Recommendations (1987) for the review of the Melbourne Area, District 1, and was noted as an issue in Council's 1988 *Statewide Assessment of Public Land Use*.

The previous Government in its 1987 conservation strategy, 'Protecting the Environment: a Conservation Strategy for Victoria', made a commitment to undertake a major environmental survey of the State's coastal marine ecosystems with a view to protecting, where necessary, representative examples of these ecosystems in marine parks or reserves. In September 1991, it required the Land Conservation Council to carry out an investigation of marine, coastal and estuarine areas in the State and to make recommendations on the protection of significant environmental values and the sustainable use of these areas.

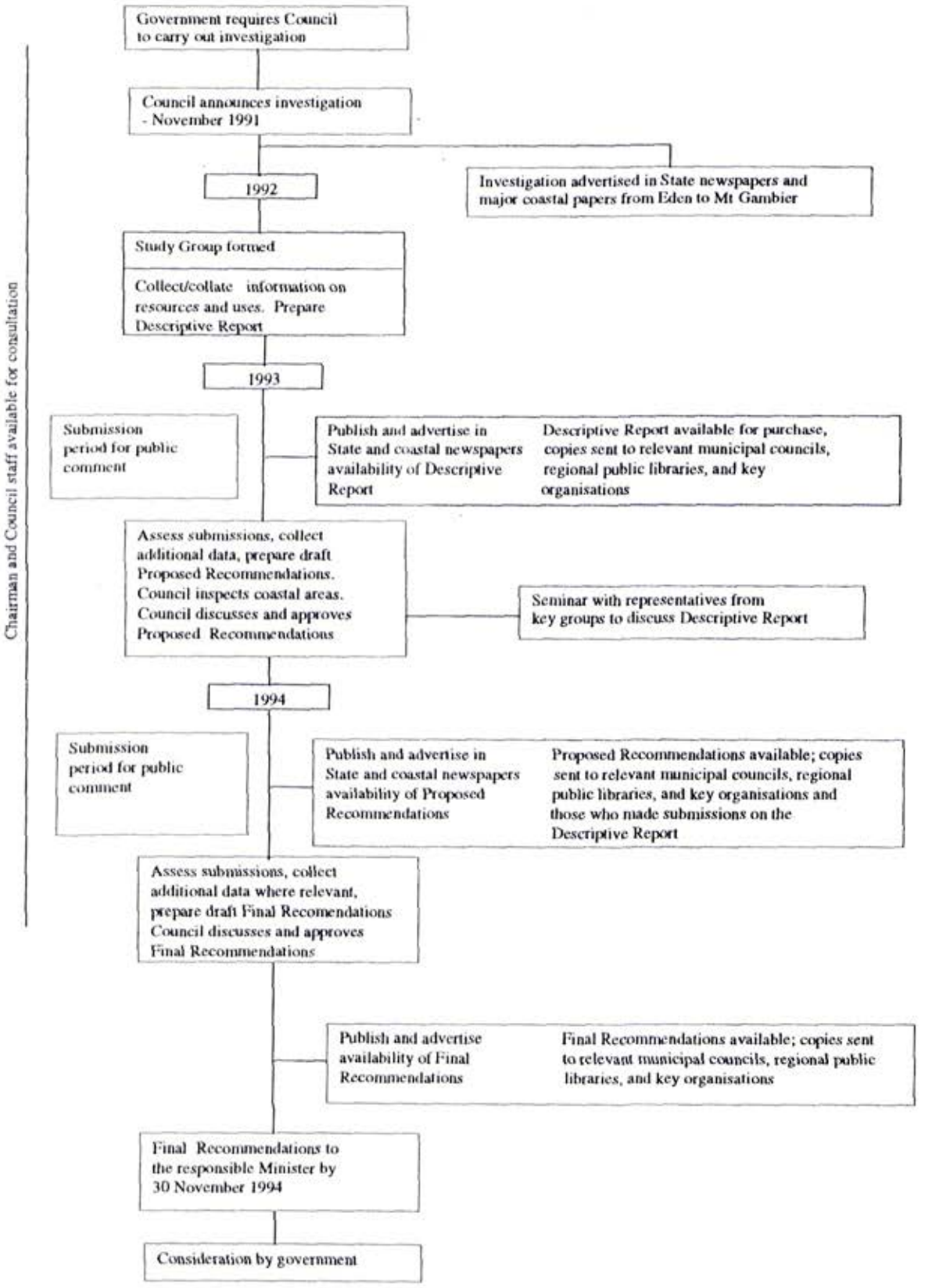
THIS INVESTIGATION

Terms of reference

On 24 September 1991, the Land Conservation Council was required by the Victorian Government, to conduct the following investigation:

> 'The Governor in Council under Section 8 of the *Land Conservation Act* 1970, requires the Land Conservation Council to carry out an investigation of marine, coastal and estuarine areas in the State of Victoria and to make recommendations by 30 November 1994 on the protection of significant environmental values and the sustainable use of these areas.
>
> The area to be investigated extends from the Victorian off-shore territorial limit (5.5 km) to a distance of approximately 1 km inland from the high-water mark; it includes the land (terrain, and overlying

MARINE AND COASTAL INVESTIGATION - VICTORIA



water) affected by marine, estuarine, and coastal processes. Islands surrounded by marine and estuarine waters are included in the investigation. On French and Phillip Islands the landward boundary of the area is approximately 1 km inland from the high water-mark.

The bed and associated waters of the Gippsland Lakes are excluded from the Investigation.

Recommendations will apply only to public land.

In making recommendations to provide for the balanced use of land in Victoria, the Council is to have regard to the social and economic implications relevant to its recommendations.'

Scope of the investigation

The general area covered by this Investigation is shown in Figure 1.1. In accordance with the *Land Conservation Act* 1970, this investigation covers 'public land' as defined by that Act. Freehold land is therefore not subject to its recommendations. Crown land within the following cities and rural cities is not included: Portland, Warrnambool and South Barwon, as well as Geelong, Geelong West, Werribee, Altona, Williamstown, Port Melbourne, St Kilda, Brighton, Sandringham, Edithvale, Chelsea, and Frankston within Port Phillip Bay. Although the Gippsland Lakes are excluded, to provide a complete picture, information about the Lakes is included where relevant.

Process

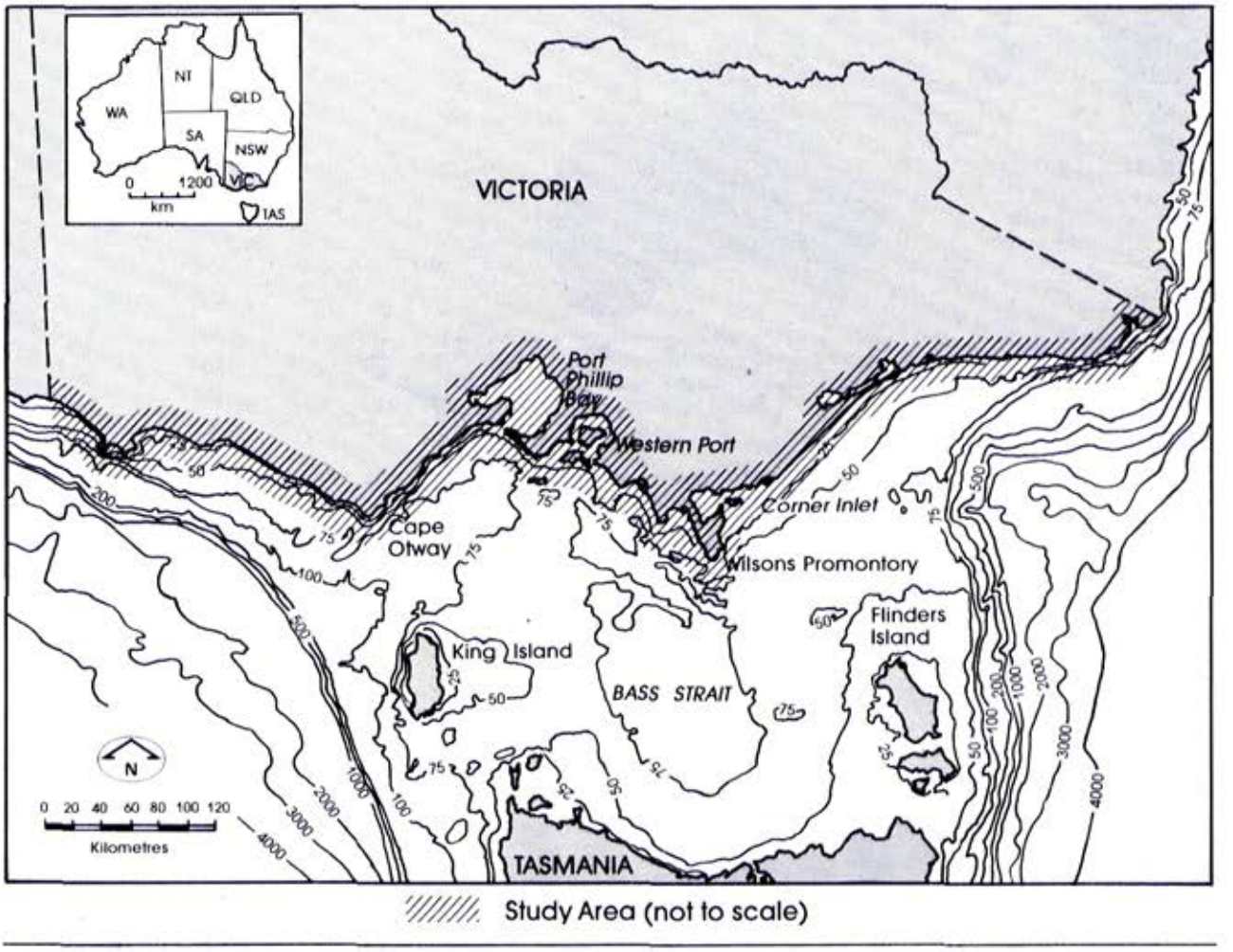
The process for this investigation is outlined on the opposite page. This report represents the first major stage of the Council's investigation.

Other investigations

A number of other major programs, studies, or enquiries currently in progress cover the Victorian coast or adjoining waters. Their aims are outlined in Table 1.2.

In June 1992, the State Government responded to the Parliament of Victoria - Natural Resources and Environment Committee (1991)

Figure 1.1: Study Area



report, stating that this investigation would address seven of the 51 recommendations (Recommendations 8, 13, 16, 42, 46, 47 and 49).

THE VICTORIAN COAST

The Victorian coast ranges some 190 km in latitude between $37^{O}31'$ and $39^{O}12'$ S and extends east--west about 790 km between the 141^{O} and 150^{O} E meridians.

It lies along the south-east corner of the Australian continent that stretches thousands of kilometres to the north. Its shores are lapped by waters which, except for the presence of Tasmania, extend uninterrupted for thousands of kilometres across the Southern Ocean and Tasman Sea (see Figure 1.2). These circumstances have a profound affect on the Victorian coast and are described in Chapter 2.

The area contains more than 80 named islands (see Table 1.3). They range in size from one hectare or less (Lawrence Rocks, for example), to the largest (French Island) at 17 318 ha. It also contains numerous semi-enclosed waters: the bays, inlets, and estuaries. In these 'enclosures' the fresh-water draining from south of the Great Dividing Range meets that of the sea. They vary in size from Port Phillip Bay, which is the largest at 1950 sq. km, to those, such as the estuary of the Benedore River in Croajingolong of less than 1 sq. km.

Figure 1.2: Globe centred on Victoria

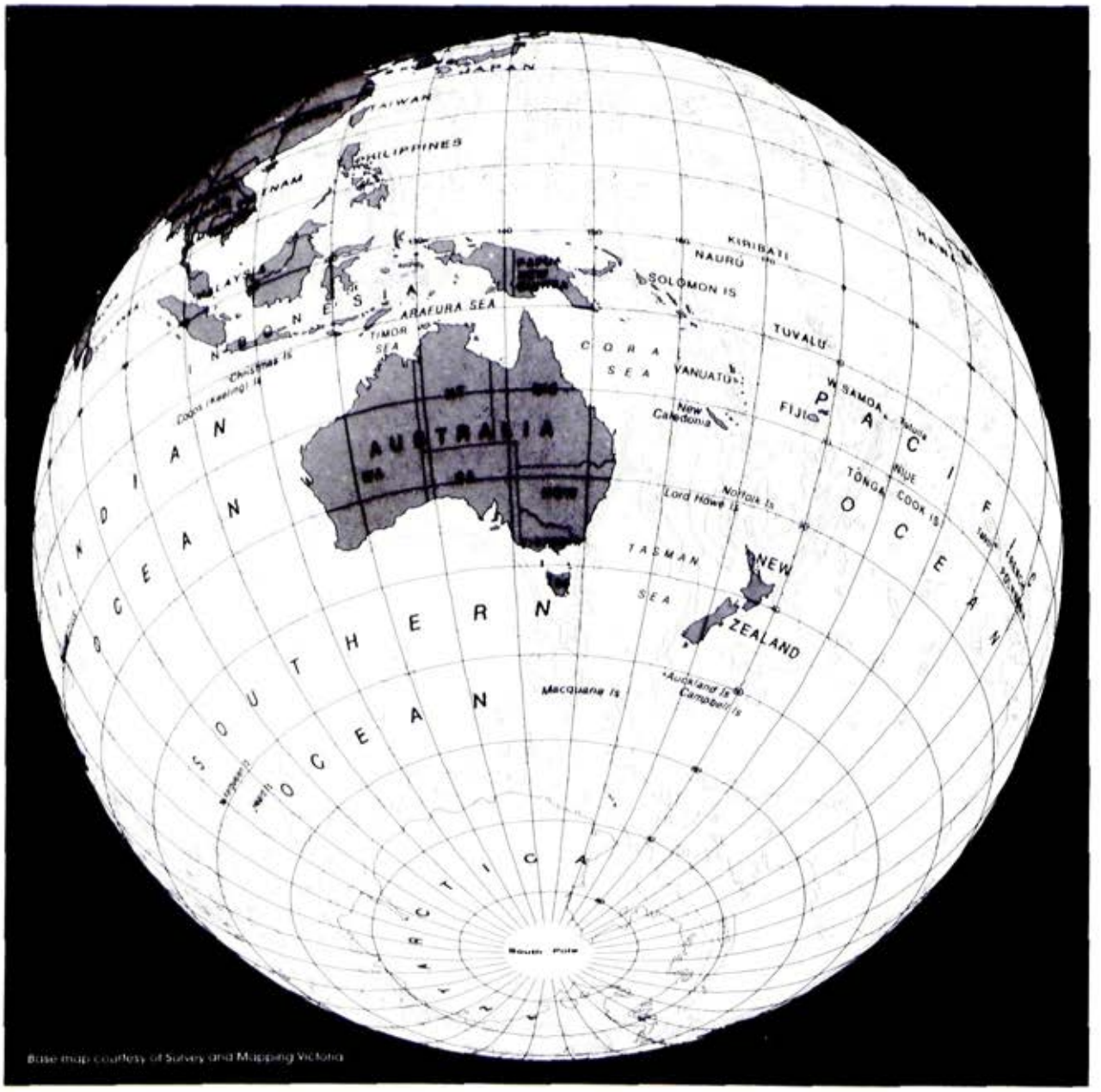


Table 1.2: Major Projects Relevant to Victorian Coastal Planning

Project (agency)	Area	Aims	Status
Coastal Zone Enquiry* (Resource Assessment Commission)	Australia's coast	To identify and assess options for managing Australia's coastal resources with emphasis on achieving integrated management by means of regulatory and economic instruments and appropriate institutional arrangements; particular reference will be made to buildings, tourism, mariculture, and associated development, outside metropolitan areas	Final recommendations to the Prime Minister November 1993[1]
Ocean Rescue 2000* (DEST, ANPWS, GBRMPA)	Coastline to 200 miles off-shore	Three of the five key elements of the program include: - preparation of a State of the Marine Environment Report - establishment of a National Representative System of Marine Protected Areas - development of an Australian Marine Conservation Strategy	Decade-long program; 1991-2001
National Ecological Sustainable Development Strategy*	Australia and 200 miles off-shore	Core aims are: - to enhance individual and community welfare by following a path of economic development that safeguards the welfare of future generations - to provide for equity within and between generations (i.e., intragenerational and intergenerational equity - to protect biological diversity and maintain ecological processes and systems Key principles to achieve these are: - effective integration of economic, environmental, and social considerations - *paying due regard to the precautionary* principle - recognition of the global dimension - development of a strong, growing, and diversified economy - adoption of cost-effective and flexible policy instruments - acknowledgment of the value and necessity of consulting and involving the broad community	Sectoral (including fisheries) and intersectoral (including coasts) working group reports have been released; National Strategy 1992
Marine and Coastal Investigation (Land Conservation Council)	Victoria's marine and coastal environment - 'public land' only (land up to 1 km inland and the seafloor and overlying *water up to 3 nautical miles* off-shore	Recommendations on the use of public land	Final Recommendations to the Victorian Government due in November 1994
Melbourne Area, District 2, Review (Land Conservation Council)	The following coastal area is included within the District: Mornington Peninsula—Western Port—Cape Paterson	Recommendations on the use of public land. (The coastal and marine area will, however, be covered by the Marine and Coastal Investigation.)	Final Recommendations to the Government expected late in 1993[2]
State of the Environment Report: Victoria's Coastal and Marine Environment (Office of the Environment)	Victoria's marine and coastal environments	Provide an overview of current conditions and trends	Stage 1 completed 1991[3]
Port Phillip Bay Environmental Study	Port Phillip Bay	Determine the environmental status of Port Phillip Bay in relation to nutrients and toxicants; provide the basis for the long-term management of point source and diffuse inputs	To be completed in 1996[4]

Notes:

* Other national strategies cover fisheries, oil and gas exploration and conservation issues - see *'A Draft Policy' for Commonwealth Responsibilities in the Coastal Zone'*.

1. Resource Assessment Commission (1992). 'Coastal Zone Inquiry: Draft Report.' (Australian Government Publishing Service: Canberra.)
2. Land Conservation Council (1993). Melbourne Area, District 2, Review Proposed Recommendations. (Land Conservation Council: Melbourne.)
3. Colman, R., Gwyther, D., Keogh, M., Quinn, G., and Smith, J. (1991). 'Assessment of Indicators, Data and Environmental Monitoring Programs for Victorian Coastal and Marine Environments.' Consultants report to the Office of the Commissioner for the Environment .
4. CSIRO INRE Project Office (1992). 'Port Phillip Bay Environment Study - Project Design.' Report to Melbourne Water.

Table 1.3: Islands along the Victorian Coast

Island	Area (ha)	Island	Area (ha)
Lawrence Rocks	1	Sand Is	2
Lady Julia Percy Is	133	Mangrove Is	15
Griffith Is	45	Little Snake Is	518
Green Is	<1	Possum Is North	1
Merri Is	<1	Possum Is South	6
Middle Is	<1	Snake Is	4475
Mutton Bird Is	2	Rabbit Is	26
Bridge Is	<1	**Seal Islands**	
Duck Is	13	Seal Is	19
Swan Is	283	Notch Is	10
Mud Is	104	Rag Is	8
Tip Is	<1	Cliffy Is	7
Popes Eye[1]	<1	Roberts Is	51
South Channel Is[1]	<1	Sunday Is[2]	1133
Round Is	1	Bullock Horn Islet	54
Seal Rocks	2	Dog Is	154
Churchill Is	53	Big Dog, Little Dog Is	274
Quail Is	521	Bullock Is	25
Chinaman Is	42	Drum Is	115
Charing Cross Is	<1	Kangaroo Clump	24
Sandstone Is	18	Clonmel Is	99
Barralliar Is	<1	St. Margaret Is	1882
Long Is	4	Pelican Is	27
Pelican Is	1	Sheep Is	9
French Is[2]	17318	Shag Is	5
Ram Is	<1	Rescue Is	2
Elizabeth Is	23	Old Man Clumps	13
Reef Is	9	Horn Is	7
Gull Is	<1	Scrubby Is	101
Jessie Is	<1	Bobs Is	3
Phillip Is[2]	9924	Mop Is	2
Arch Rock	1	Waddy Is	3
Digger Is	<1	One Tree Is	12
Norman Is	50	Calf Is	18
Ramsbotham Rocks	<1	Snaggy Is	6
Glennie Group		Jephson Is	2
Great Glennie Is	142	Spec Is	21
Dannevig Is	20	Hunter Is	88
Citadel Is	21	Cyril Is	12
McHugh Is	10	East Scrubby Is	132
Anser Group		Mud Is	14
Anser Is	81	Honeymoon Is	8
Anderson Islets	1	Second Is	6
Cleft Islet	7	First Is	20
Kanowna Is	51	Goat Is	13
Wattle Is	30	Horse Is	12
Rodondo Is	110	Rabbit Is	6
Shellback Is	34	Gabo Is[3]	157
Bennison Is	4	Tullaberga Is	2
Granite Is	1		
Doughboy Is	2		

1. Popes Eye and South Channel Island are artificial islands.
2. These islands contain private land.
3. Gabo Island is Commonwealth land.
4. Areas calculated from the VICMAP 1:25 000 map series.
5. Listing derived from Register of Place Names
6. Islands are listed from west to east.

Victorian coast from Rabbit Island.

How long is the Victorian coast?

Defining the length of the coast involves practical decisions regarding the location of the shorelines in areas of extensive intertidal flat containing mangrove and saltmarsh, such as Western Port. On aerial photographs, from which the maps are produced, it may be difficult to judge where the land stops and the sea starts. Decisions must also be made as to whether the shorelines of bays, inlets, estuaries, and islands are to be included or only the open coast.

The 'length' of the coast also depends on the map scale used to measure it. Using Lake Tyers as an example, the length of shoreline measures from 40 km (at 1:500 000 scale) to 80 km (at 1:250 000 scale), 97 km (at 1:100 000 scale), and 130 km (at 1:25 000 scale). The more 'crinkly' the coast, the longer it will become when measured from more detailed map scales.

Consequently, the different lengths given for the coast do not mean they are in error but more than likely different assumptions and map scales have been used. Unless otherwise stated, coastline lengths in this report are derived from maps of 1:500 000 scale, and are listed in Table 1.4:

Table 1.4: Coastline Length

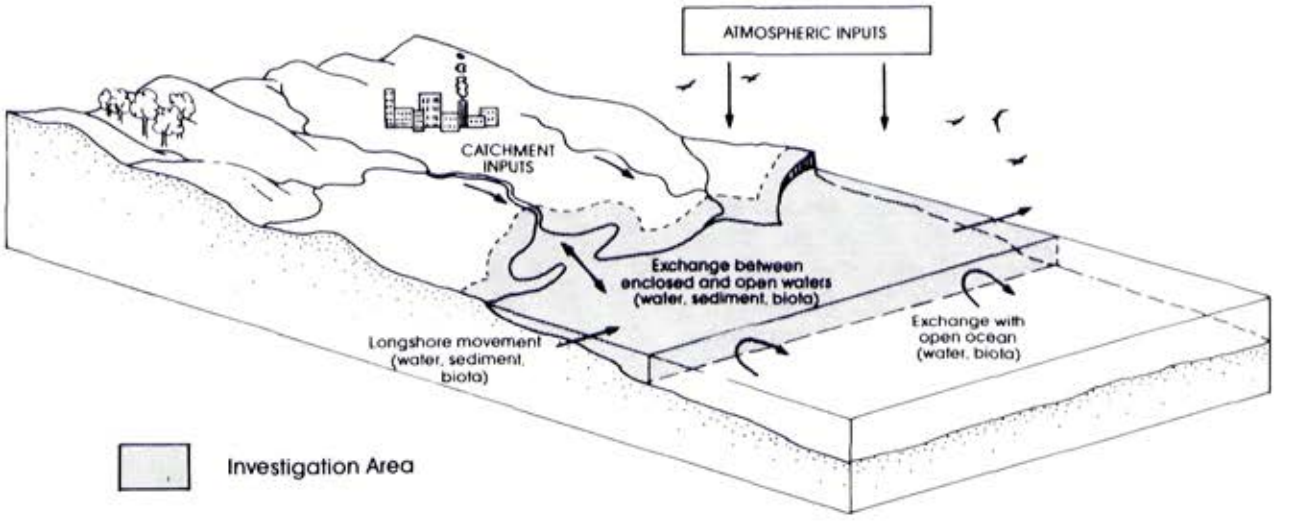
Coastal segment	Coastline length[1] (km)
Open coast (excluding Port Phillip Bay, Western Port, and the Corner Inlet/ Nooramunga area)	1100
Port Phillip Bay	250
Western Port (excluding French Island)	140
Corner Inlet/Nooramunga (excluding islands)	120
Total length of coastline excluding most islands	1610

Note:
Coastline length is measured at 1:500 000 map scale and rounded to the nearest 10 km.

Boundaries

Land or sea planning exercises must consider how actions outside the planning area will affect the planning proposals, and vice versa.

Figure 1.3: Connectedness of Terrestrial and Marine Ecosystems



This is of particular importance for marine and estuarine areas because of the connectedness of the marine systems and the land—sea interface, as shown on Figure 1.3. The following examples illustrate the impact of land activities on the sea and the problems associated with the notion of boundaries within marine waters.

* The southern right whale annually travels thousands of kilometres across the oceans of the Southern Hemisphere and some animals may spend some of that time in the waters off Warrnambool.
* Activities in the catchments of coastal streams, such as water diversions and agricultural practices, may reduce stream-flows, increase sedimentation, or increase nutrient loads in an estuary, thereby affecting its physical and biological characteristics (for example, the breeding of some organisms). Figure 1.4 shows the major drainage basins affecting terrestrial inputs to the Victorian coast.
* Floating plastics can be washed for hundreds of kilometres, eventually trapping wildlife or affecting the visual amenity far from the point where they were discarded.
* Toxic material that bio-accumulates (such as mercury), when discharged to the sea, may make fish unsafe for human consumption.

Urban, industrial, forestry, agricultural, and other human activities can add to and modify the dissolved and particulate material that rivers carry to the coast. This material may initially affect the bays, inlets, estuaries, then near-shore waters and eventually the ocean. In addition to these human impacts, the land-based natural processes also modify the coastal waters and landscapes. For example, nutrients washed into estuaries provide food for young fish, and weathered rocks provide sediments for the formation of sandy beaches and other coastal depositional features.

As the coastal land has impacts on the sea, so the off-shore waters influence the coastal land. Material is carried along the coast by longshore currents, depositing biota and sediments into estuaries. Waves, tides, and storm events constantly modify the coastal landscape.

The land—sea interface is therefore a transition zone for many natural processes rather than the boundary it is often considered to be in both State and Commonwealth legislation.

Some fauna - penguins, for example - have both terrestrial and marine requirements as part of their life cycle and move back and forth across the land—sea interface. People likewise - for many recreational activities, such as a day on the beach - use both the land and sea sections and the conditions of both are equally important. In addition, in areas of sandy beach, the sand may move back and forth between the foreshore and off-shore areas depending on seasonal and other conditions.

Data

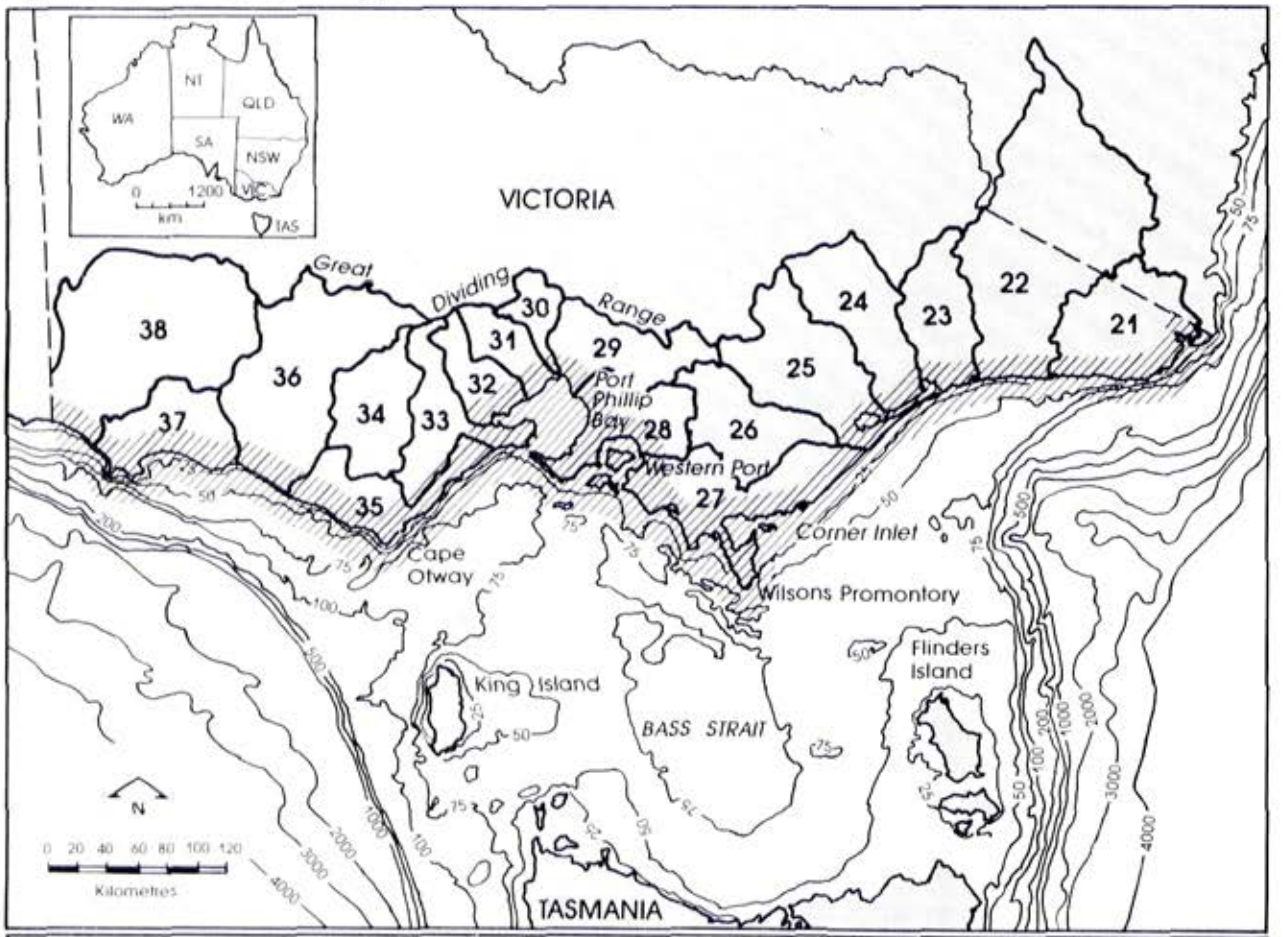
The area that this investigation covers contains diverse physical and biological features, and has a wide range of uses and values. So all levels of government, industry, recreation and conservation groups, and the wider community have an interest in and hold data of various types concerning it.

Data resolution and coverage for the area vary considerably. More data are available for the terrestrial, intertidal, and shallow waters of the bays and inlets than for the open coastal waters, as they are generally easier and cheaper to collect. Data for open coastal waters and underlying terrain tend to be at a coarse level of resolution, focus on resources of commercial interest, or, if of high resolution, are localised in occurrence. Broad-scale flora and fauna surveys, which are available for most of Victoria's terrestrial systems, do not exist for the State's marine areas. It is also common for data to be collected and processed to meet the immediate requirements of the organisation collecting them and therefore may not be of the type or format that is readily available or usable for this investigation or other purposes.

The data used in this investigation therefore come from a variety of sources, including published records, internal government and industry reports, unpublished manuscripts, anecdotal sources, or reports compiled especially for this investigation. Data sources and, where relevant, the appropriate qualifications on the information they contain, are given. An increasing amount of information is now held in computerised databases that are regularly updated and where these are used they are also listed.

This report is the first consolidation of the data required for the State-wide land and sea planning of the Victorian coast and the marine environment. It demonstrates that, despite gaps for some areas, or some resources or values, a considerable amount of data has been accumulated over the years. And the synthesis of these data provides the information base for the present investigation.

Figure 1.4: Coastal Drainage Basins



Study Area (not to scale)

Drainage Basins for Victoria as defined by the Australian Water Resources Council. South-East Coast Division

21 East Gippsland	27 South Gippsland	33 Barwon River
22 Snowy River	28 Bunyip River	34 Lake Corangamite
23 Tambo River	29 Yarra River	35 Otway Coast
24 Mitchell River	30 Maribyrnong River	36 Hopkins River
25 Thomson River	31 Werribee River	37 Portland Coast
26 Latrobe River	32 Moorabool River	38 Glenelg River

The report completes the first stage in the decision-making process for the future use of Victorian coast and territorial sea. It does not contain recommendations, but aims at providing a factual basis on which recommendations for the use of these environments will be formulated.

It is divided into six main parts: Part I is an introduction; Part II describes the physical, biological, cultural, and landscape features of the study area; Part III deals with current and potential land uses; Part IV broadly covers the social and economic context of the coast; Part V covers the administrative and legislative context; and Part VI the approaches to coastal conservation and resource use. Explanatory tables, maps, and appendices complete the report.

ISSUES

This report focuses on the values of the coast and the current range of uses rather than on conflicts between different uses or with the environment. These will be covered in the next stages of the Investigation with preparation of reports on the proposed and final recommendations. A list of issues have, however, been provided at the end of some chapters. These issues have emerged as a result of preparing the report. They are not listed in order of importance nor is the importance necessarily comparable from chapter to chapter.

The national State of Marine Environment Report, expected to be released in the coming months as part of the Commonwealth's Ocean Rescue 2000 program, will provide a systematic coverage of coastal issues.

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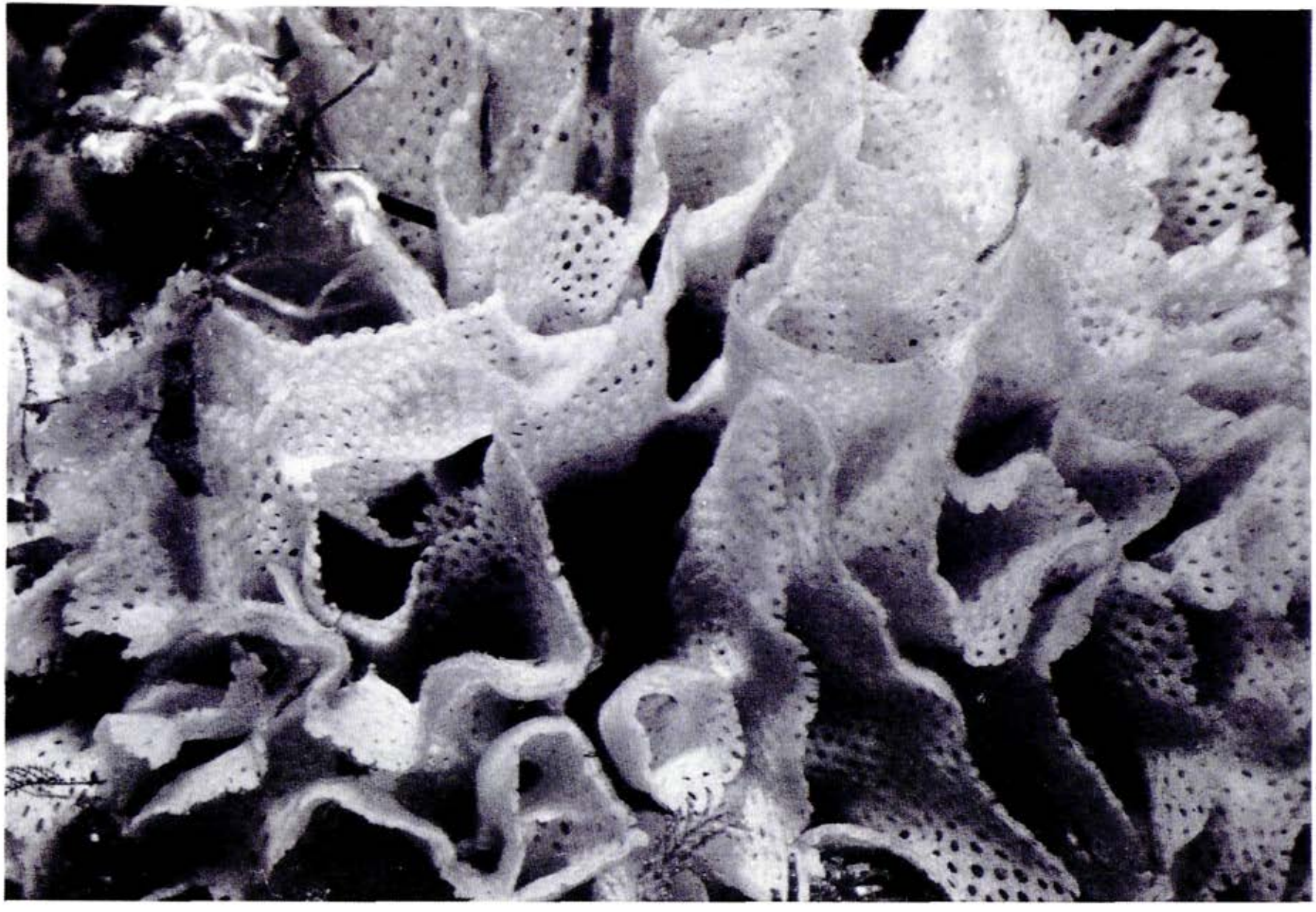
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A coral-like bryozoan



PART II

PHYSICAL, BIOLOGICAL, CULTURAL AND LANDSCAPE VALUES

2. ATMOSPHERIC AND OCEAN SYSTEMS

This chapter describes the atmospheric and ocean systems that affect the Victorian coastline. The coastal climate is first described and then climatic change, bathymetry, waves, tides, and ocean currents and water circulation.

THE COASTAL CLIMATE OF VICTORIA

Climate is an important consideration when planning for coastal uses. Foremost in most people's minds is the way in which it affects their work and recreational activities. For outdoor activities, daylight climate is particularly important, with the extent of importance depending on the activity. Surfers prefer an off-shore breeze, a strong breeze is required for sailing, too much wind makes power-boating unpleasant, while a breeze in warm weather may be cooling and in cool weather chilling.

Seasonal variations have relevance, too; sunny, warm weather enhances many beach activities, such as sunbaking and swimming, and comes into calculations when determining the calendar for spectator activities such as triathlons. However, ideal beach-going conditions may make it too hot for the more strenuous activities such as bushwalking. Variations in rainfall throughout the year and between nearby localities must be considered when siting industrial activities such as salt-production, which requires low rainfall. For the construction industry, delays may result from inclement weather and neighbouring locations may differ markedly in the extent to which this occurs. And public expectations of fine weather certainly enhances the popularity of coastal towns as tourist destinations.

Climate is also an important determinant of coastal biological communities. The terrestrial communities vary according to rainfall seasonality and diurnal and seasonal temperature ranges, and to the strength and occurrence of on-shore winds that will carry salt spray on-shore, while temperature and sunlight can strongly influence the extent to which intertidal communities become desiccated at low tide.

Victoria's coastline extends east—west through a latitude zone 37^{0}S to 39^{0}S and consequently the variation in climate is not great in a continental or global perspective.

The following details are based on material prepared by the Bureau of Meteorology. The Bureau used data collected from its network of land-based stations, some of which are run by Bureau staff, and from ships that ply Australian waters.

Tables in this chapter list only stations with a minimum of 20 years of reliable records with respect to rainfall and 10 years for temperature and other information. Tables list the number of years of data available for each station.

Many climatic parameters, such as temperature, rainfall, etc., vary on a daily and seasonal basis and from place to place. This section focuses on data averaged over monthly or yearly time periods. Shorter-term temporal variations will be discussed where relevant. Climate also varies over the longer term, from year to year and over decades; these longer-term variations are difficult to predict, as is their effect on particular locations on the coast.

The Victorian coast lies at the south of continental Australia. As Figure 1.2 shows, it encompasses a wide variety of topographic features - peninsulas, bays, lakes, islands, and, in parts, significant elevated areas with dominant ridge-lines parallel to the coastline, such as the Otways. Some 240 km to the south lies Tasmania, which contains a large elevated plateau. The effect of these features are described following an outline of the broad-scale climate systems that influence Victoria.

BROAD-SCALE CLIMATIC INFLUENCES

Southern Australia's climate, like that of any part of the world, is controlled by the position of the sun in relation to the earth and the way in which it is heated by the sun.

Thus, as the sun moves north of the Equator towards the Tropic Of Cancer, during March—July, high-pressure belts move north over the continent. Embedded in this broad belt, individual high-pressure cells move from west to east. Also affecting climate are day-to-day synoptic features such as 'Lows', with their associated cold fronts, and 'Highs'

moving from west to east. During the southern summer, when the sun moves over the Tropic of Capricorn, the land mass becomes warmer, causing the high-pressure belt to move south over the relatively cooler ocean. Cold fronts find it comparatively difficult to move northwards at this time.

During the transition months in spring, the Antarctic pack ice moves northwards as it begins to melt. The temperature gradient in the Southern Ocean increases and, consequently, more bursts of cold air break away from the Antarctic and move north. This means that cold fronts arrive at the coast more frequently than in the other seasons and the weather changes more frequently.

The location of Victoria at the northern edge of the westerly wind belt (known as the roaring forties) has a number of meteorological consequences, the most important of which is seasonal variation.

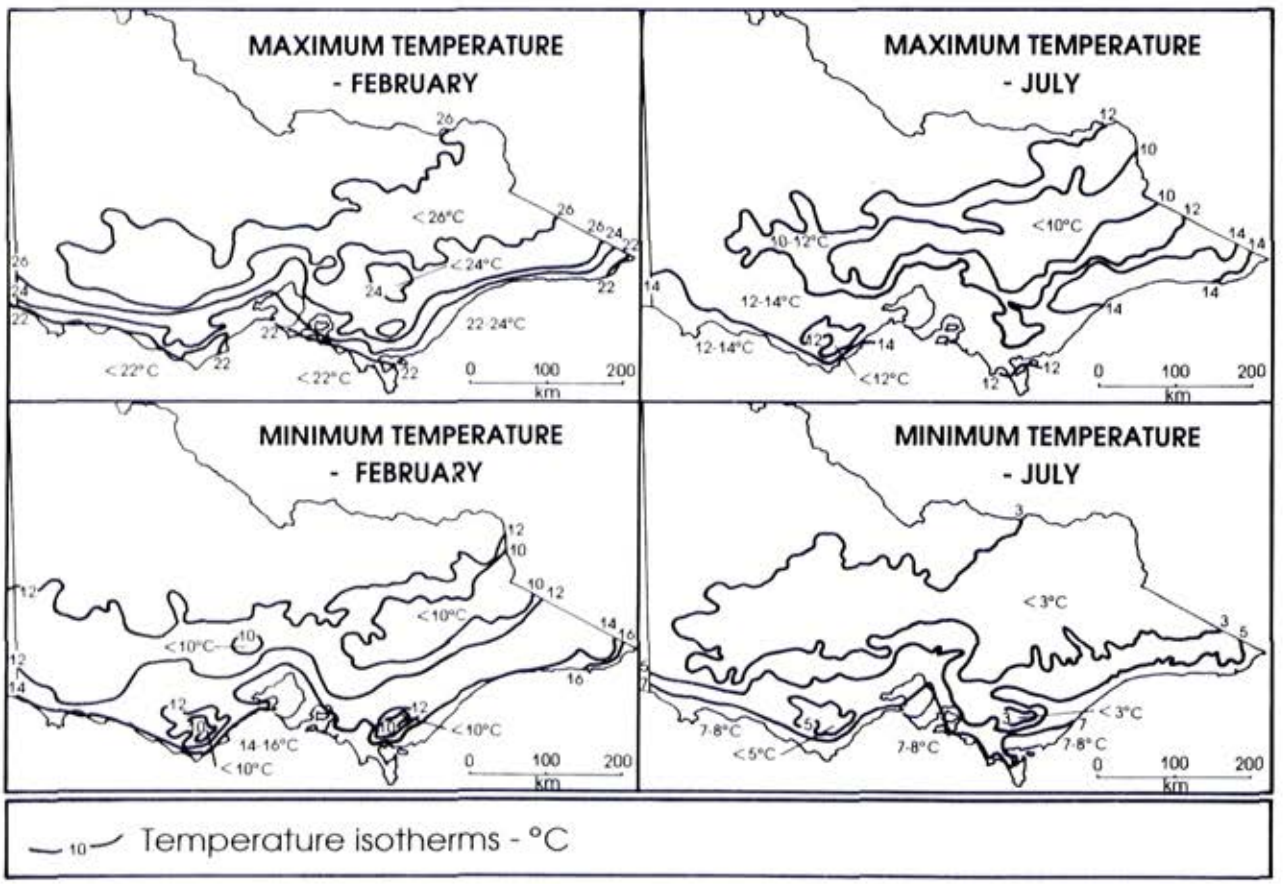
Over the winter, prevailing winds are westerly. They tend north-west ahead of cold fronts and then swing sharply south-west as the fronts pass. During summer the retreat of the westerly wind belt southwards allows the sub tropical high-pressure belt to dominate. As high-pressure systems migrate eastward over Victoria within this belt the weather is dry. Winds come from south to south-west when the High is to the west and north to north-east when it is east of Victoria. As a result, the west coast has a distinctly Mediterranean character to its climate - that is, maximum rainfall in winter with drier summers.

The east coast is also affected by cold fronts, but receives a significant contribution to its rainfall from easterly winds produced by Lows off the south-east coast of Australia. So this part of the coast has a fairly uniform rainfall throughout the year.

That ocean areas cool down and warm up only slowly, whereas land areas do so rapidly, has a number of meteorological consequences for Victoria in general and its coast in particular.

Firstly, it is located on the southern side of a large subtropical continent, where the sun directly above the Tropic of Capricorn during the summer leads to substantial heating of the land mass. As a result, the coastal region suffers outbreaks of extreme heat, of continental origin, when the airstream is from the north to north-west. In these conditions temperatures in excess of 40^{0}C have been

Figure 2.1: Coastal Temperatures



reported right along the coast. Secondly, coastal Victoria, has an extensive ocean area to the south, which moderates the severe cold outbreaks in winter; thus the impact of these outbreaks is less severe here than in regions of similar latitude with a continental connection to polar regions - for example, northern United States and southern Europe. During winter the angle of the sun above the horizon is also high enough to prevent the continent from becoming excessively cold. The moderating influence of the water can also be seen locally, where coastal morning temperatures are about 2 to $3^{o}C$ higher than places further inland (see Figure 2.1).

In addition, the presence of a very large island (Tasmania) to the south produces local variation in the climate of the central and Gippsland coasts. When the wind is strong west to south-westerly, funnelling occurs between Tasmania and the mainland and thus the winds east of Wilsons Promontory reach gale force regularly. Winds also reach gale force in an easterly flow when high-pressure ridges lie east of Tasmania. By contrast in a southerly flow the lee effect of Tasmania's ranges often leads to cloud and shower-free conditions for a few hours after dawn about the central coast including Melbourne.

Thus the characteristics of the Victorian coastal climate result from its location at the southern edge of a huge land mass that provides a continental influence, while the large ocean area to the south provides a moderating influence.

Pressure systems and their effect on climate

As the high-pressure belt becomes established over the continent in winter, a predominantly westerly air-flow affects Victoria. Local winds shift north to north-westerly, freshen ahead of fronts, and then shift abruptly south to south-west at similar strength as the fronts move eastward. They abate as the next upstream High moves into the area, then freshen again from the north to north-west as the next front moves eastward.

During summer, the high-pressure belts shift south of the continent. Weather is still affected by migrating Highs and Lows; cold fronts, however, find it harder to reach the continent than in winter and spring and many pass to the south. Rain and sometimes thunderstorms may precede each front. Showers and occasionally more thunderstorms are usually evident after the passage of each front.

CLIMATE VARIABLES

Wind

The wind frequency diagrams published by the Bureau of Meteorology describe the frequency of winds according to direction and speed. Figure 2.2 illustrates the variation in speed and direction (at 9.00 am) along the coast and between summer and winter.

Specifically, wind direction and speed depend on the position and movement of synoptic systems. Thus the wind can come from any direction and have any speed, although speeds exceeding 70 knots are most unusual. During summer, when the average mean sea-level pressure chart shows a High centred over the waters to the south of the Great Australian Bight, with a ridge extending eastward to the Victorian coast, the average wind impacting on the coast comes from the southerly quarter. In winter, the average mean sea-level chart shows the High over central Australia with a westerly flow across Victoria. As a result, the average wind in coastal districts is from the north-west quarter. As indicated by Table 2.1, wind is very much a function of local topographic effects - for example, exposed localities, such as Cape Nelson, Cape Otway, Wilsons Promontory, and Gabo Island have stronger winds. Sea-breeze effects during the summer are reflected in a freshening of the southerlies during summer afternoons. Throughout the year, average wind speeds are lighter in the morning due to the decoupling effect of radiation inversions.

In all seasons, the winds often freshen to gale-force from the north/north-west ahead of approaching fronts, then swing south/south-west abruptly behind the front at about the same speed and then abate till they again freshen ahead of the next front. Gale-force wind is more common in winter, because of the westerly flow referred to earlier. Gale-force east-north-easterlies affect the Gippsland coast when mobile Highs pass to the south of Tasmania.

Westerly and easterly winds tend to undergo 'funnelling' through Bass Strait and occasionally exceed gale force.

Wind direction and speed are relevant to a variety of uses. Surfers prefer off-shore winds to provide steeper breaking waves, while hang-gliders prefer onshore winds to give them the required lift. Wind speed has relevance for boating, as in exposed areas strong wind,

Figure 2 2: Windspeed and Direction 9 am

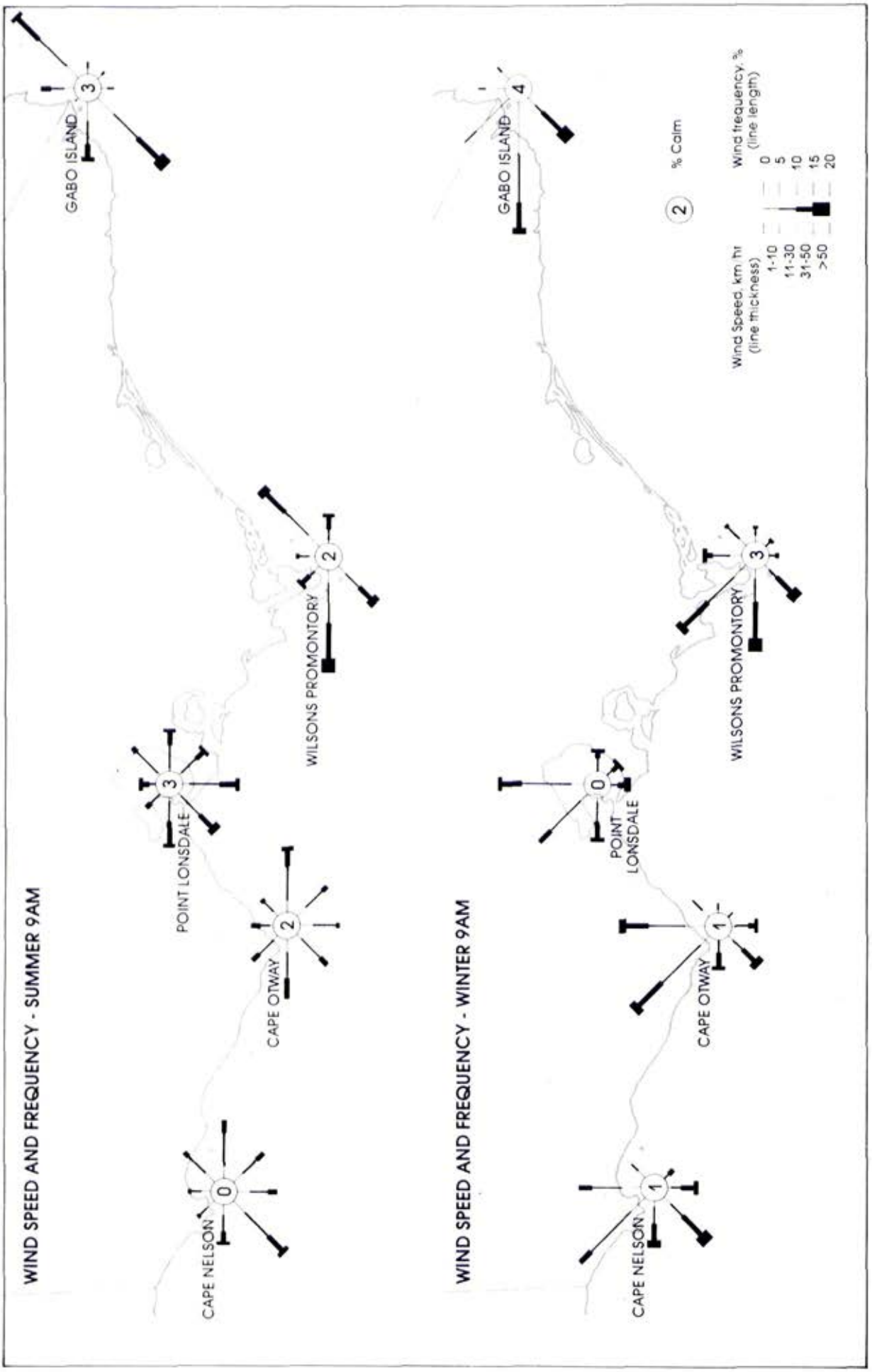


Table 2.1: Strong and Gale-force Wind*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cape Nelson - 1957–91											
5	4	5	6	6	7	9	10	10	8	7	7
1	0	1	1	1	1	2	2	2	1	1	1
Warrnambool - 1957–83											
1	1	1	1	1	2	3	3	3	2	2	2
0	0	0	0	0	0	0	0	0	0	0	0
Cape Otway - 1957–91											
8	6	7	8	10	10	12	12	12	10	10	9
1	0	1	1	1	1	2	2	2	1	1	1
Lorne - 1969–86											
7	5	5	3	2	3	4	5	4	3	5	5
7	5	5	3	2	1	1	1	1	0	1	0
Geelong - 1964–70											
3	1	2	3	2	1	3	4	5	3	5	3
0	0	0	1	0	0	0	0	1	0	1	0
Melbourne - 1955–91											
0	1	0	1	1	1	1	2	2	2	1	1
0	0	0	0	0	0	0	0	0	0	0	0
Queenscliff - 1957–68											
2	2	1	1	2	2	3	3	2	4	3	3
0	0	0	0	0	0	0	0	0	0	0	0
Wilsons Promontory - 1957–91											
17	14	15	14	15	14	15	16	15	16	17	17
5	4	4	5	5	5	5	6	6	7	6	6
Lakes Entrance - 1965–91											
4	3	3	2	2	3	2	4	4	4	5	5
0	0	0	0	0	0	0	0	0	0	0	0
Gabo Island - 1957–1991											
15	12	12	11	11	9	11	12	12	15	15	16
3	2	2	3	3	3	3	4	3	4	4	3

* For each location the first row indicates strong winds (22–33 knots) while the second shows gale-force winds (>33 knots).

Source: Bureau of Meteorology

can create unpleasant conditions. Windsurfers will, however, seek areas of strong wind, but only those with limited fetch. One such area, Shallow Inlet, with its water surface protected by Sandy Point, is well known to enthusiasts. Here high wind speeds often occur as a result of the funnelling effect between the elevated areas on Wilsons Promontory and the Strzelecki Ranges to the north (Laughlin, 1990). Wind speed is also relevant to the generation of electricity from wind turbines (see Chapter 8), and the estimated annual average wind speeds for areas 30 m above flat open grasslands. The coast is of particular interest for this use because it has higher wind speeds than inland areas (Figure 2.3).

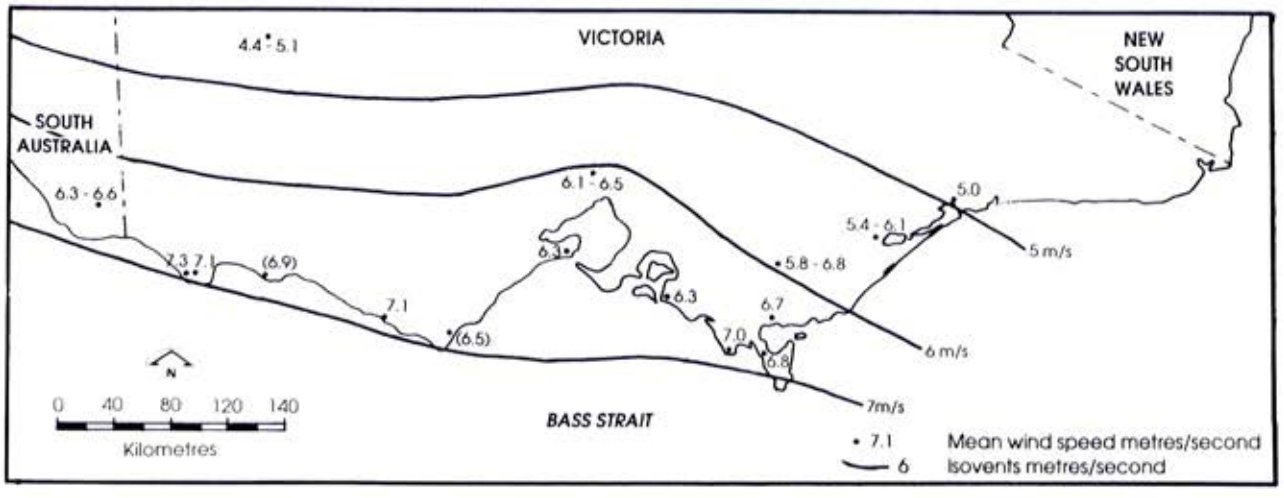
Temperature

February is the warmest month (being the month of highest sea surface temperatures), while July is the coolest (slightly ahead of August, the month of lowest sea surface temperatures). Variation in average minimum and maximum summer and winter temperatures along the coast is about 2 to 3°C (Figure 2.1).

Specifically, temperatures in the summer rise from early morning minima in the range 12—15°C to about 22—24°C in the afternoon. Afternoon temperatures average a little higher alongside bays, such as Port Phillip and Western Port, but are a little lower at exposed locations, such as Wilsons Promontory. When high-pressure systems block over the Tasman Sea, temperatures more than 30°C can occur for up to 3 or 4 days in a row.

Winter temperatures are more uniform along the coast than summer ones. Early morning readings average about 6°C right along the coast, rising to 12—15°C in the afternoons. When a moist north to north-westerly airflow crosses Victoria, temperatures are quite often higher along the Gippsland coast than the rest of the State, creating Gippsland's reputation as the Victorian Riviera. This is due to the Fohn effect: the Great Dividing Range causes the

Figure 2.3: Average Wind Speed (calculated for areas 30 m above flat open grassland)
Source: Dear (1991)



airflow to rise and condense, producing rain on the windward side, while the rainshadow region experiences resultant warm weather. Eddies from the East Australian ocean current bring warmer water into eastern Bass Strait, also contributing to higher coastal temperatures in this area.

Sea surface temperature (SST)

From west to east, SST varies by about 2 to 3°C (see Figure 2.4). The SST of open coast beaches peaks in late summer (February—March), when it ranges from about 17—18°C in the west to near 19—20°C in the east. In late winter (August—September) SST fall to a minimum and range from about 13°C in the west to near 15°C in the east.

Naturally, the sea-water temperature cycle lags the atmosphere temperature cycle because water has a very much higher specific heat than air, resulting in a slow response in its temperature change. Consequently, swimmers can be quite surprised in the first warm days of summer to find the water, particularly on the open coast, colder than expected.

The east—west variation in water temperature reflects the different water masses that enter Bass Strait, as described below. For example, the East Australian Current brings relatively warm water to eastern Victoria and its influence depends upon the extent of its penetration into the Tasman Sea.

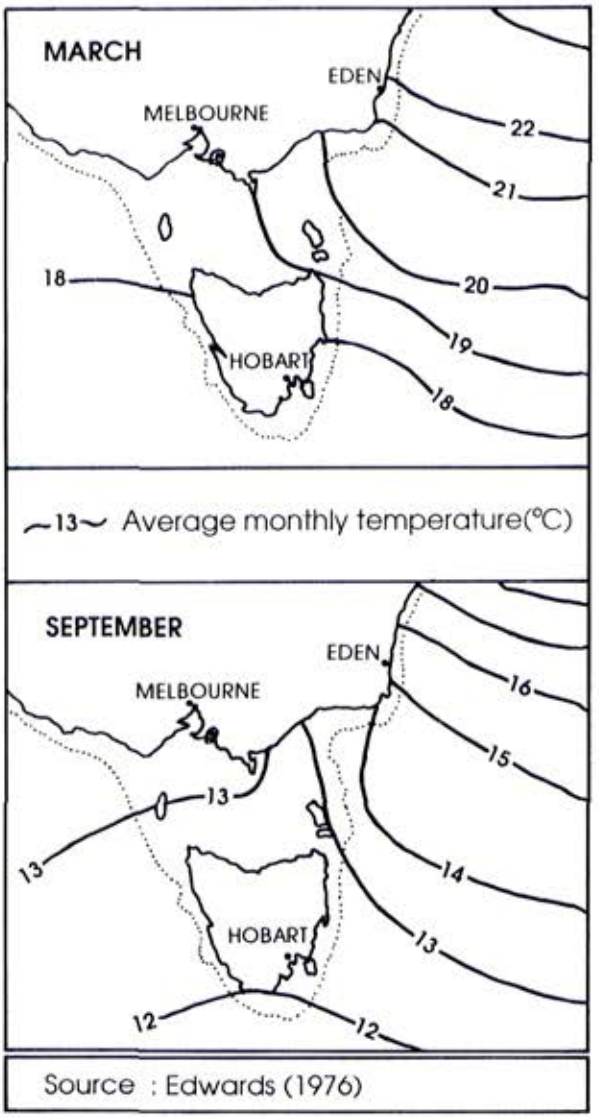
Smaller bodies of water in the bays have a greater temperature range than the oceans because the smaller volume of water allows for a faster temperature response. In Port Phillip Bay, for example, the summer maximum is about 21°C while the winter minimum is 10°C.

Humidity

The humidity pattern varies both daily and seasonally. This is to be expected, as relative humidity is the ratio (as a percentage) of the actual amount of water vapour in the air to the maximum possible amount that could be held at a particular temperature.

So, on a particular day, as the temperature rises (provided the absolute amount of moisture held in the atmosphere is constant) the relative humidity falls. Similarly, it falls with the temperature rise from winter to summer (again, provided the amount of moisture remains constant). This characteristic is reasonably close to the true situation for the Victorian coast, although the amount of moisture held by the atmosphere increases slightly from winter through to summer.

Figure 2.4: Sea Surface Temperature



Along the coast, humidity on summer mornings is about 70% and drops back to about 60% in the afternoons. Winter mornings have about 80 % humidity, and the afternoons about 70%. However, a slight change, in the annual average occurs from west (Cape Nelson - 77%) to east (Gabo island - 80%), due to the higher sea surface temperatures in the east. Relative humidity is also slightly lower in the larger bays than on the coast as a result of the continental effect of the surrounding land mass, with Melbourne, for example, having an annual average of 60.5%.

Cloud and sunshine

Spring and summer mornings are usually overcast but the afternoons become partly

Table 2.2: Rainfall Features

Centre	Average annual rainfall (mm)	Average number of raindays a year	Winter/ summer rainfall ratio
Nelson (1884–91)	759	171	2.4
Cape Nelson (1908–91)	785	190	2.1
Portland (1851–91)	842	184	2.2
Port Fairy (1898–91)	769	164	1.8
Warrnambool (1897–91)	744	168	1.8
Port Campbell (1885–90)	910	171	1.9
Cape Otway (1862–91)	896	179	1.8
Apollo Bay (1898–91)	1061	158	1.9
Lorne (1882–70)	924	147	2.0
Anglesea (1968–90)	659	139	1.5
Barwon Heads (1904–90)	631	105	1.5
Geelong (1870–70)	545	124	1.4
Lara Lake (1899–69)	477	100	1.3
Laverton (1941–91)	566	145	1.1
Melbourne (1855–91)	659	147	1.2
Queenscliff (1896–91)	606	137	1.5
Mornington (1868–91)	735	135	1.4
Wonthaggi (1911–91)	929	145	1.6
Inverloch (1968–91)	951	141	1.6
Wilsons Promontory (1872–91)	1050	178	1.7
Toora (1905–91)	956	143	1.4
Sale (1943–91)	625	143	1.1
Seaspray (1898–91)	596	110	1.1
Lakes Entrance (1881–80)	729	106	1.0
Marlo (1903–1963)	780	101	1.1
Point Hicks (1983–91)	993	147	1.5
Gabo Island (1880–91)	952	146	1.2

Note: The Winter (May–October) to summer (November–April) ratio is based the median monthly rainfall

cloudy (3/8—4/8), while autumn and winter days are generally cloudy (5/8—6/8) throughout.

Bright-sunshine averages vary from about 4 hours per day in winter (mid-winter days are about 9.5 hours from dawn to dusk) to 5 hours in autumn and spring to 8 hours in summer (mid-summer days last about 14.5 hours). This trend is fairly constant along the coast and, in general, cloud tends to persist within the first 10 km of the coastline compared with further inland. The more exposed locations such as the major capes and promontories tend to be more cloud-prone, while the areas along the shorelines, the larger bays, and inlets tend to be less cloud-prone because of the effect of the surrounding land. Most coastal recreational activities are enhanced by bright sunshine, particularly scuba-diving or snorkelling, as it gives better illumination of underwater scenery. Sunshine duration and day length also regulate plant and animal behaviour.

Rainfall

Along the coast average annual rainfall varies from less than 500 mm along the western shore of Port Phillip Bay (Lara Lake 477 mm) to more than 1000 mm along parts of the Otway Coast (Apollo Bay 1061 mm) - see Table 2.2 and Figure 2.5. These variations are very much a function of local orographic effects. Major orographic features that affect rainfall are:

* the Otway Ranges
* the Strzelecki Ranges
* the Great Dividing Range

These features force moist air to rise, allowing water to condense and produce rain on their windward side, with rainshadow areas on the leeward side (the Fohn effect). Thus along the coast the heaviest rain falls on the Otways, while the area to the west and south-west of Melbourne is in the rain-shadow region. In the same way, the Strzelecki Ranges and the Great Dividing range combine to form a rain-shadow along the Ninety Mile Beach in Gippsland.

The geographic variations in rainfall can be quite sharp and have implications for the siting of various activities, such as salt production, with major areas of salt production in the low-rainfall areas along the west and north shores of Port Phillip Bay.

Along the coast east of Wilsons Promontory and in parts of Port Phillip Bay, the rainfall has a fairly uniform seasonal distribution (see Table 2.2). A winter maximum (typical of Mediterranean-type climates) is, however, observed along the west coast: the reason lies in the fact that during winter the prevailing winds are from the westerly quarter, and that coast is the most exposed to such a flow.

The Gippsland coast gets much of its rain from low-pressure systems that form off the east coast. These Lows can form at any time of the year and often drift south down the New South Wales coast to the east of Tasmania. When this happens, the predominant easterly wind brings continuous rain over eastern Victoria for 3—4 days, with totals of more than 100 mm. This often causes flooding. However, Lows from the west might have re-intensified here, also, producing heavy rainfall. Consequently rainfall intensities are comparatively higher east of Lakes Entrance than along rest of the coast.

Figure 2.5: Coastal Rainfall

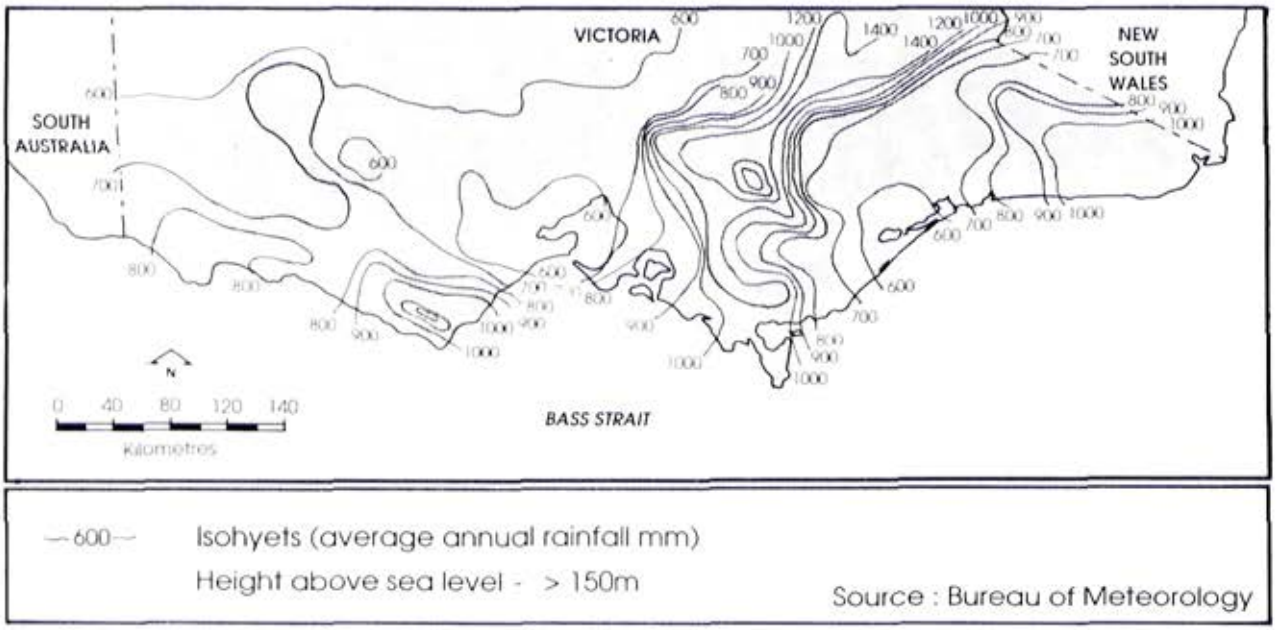


Table 2.2 also lists the number of raindays (days on which more than 0.2 mm of rain falls). In part, this number is associated with total rainfall, with the low-rainfall areas such as those along the Gippsland Lakes and in Port Phillip Bay averaging 100 rainy days a year. However, the coast west of Lorne has an average of 160—180 rainy days and the remainder 135—145, except the high-rainfall area of Wilsons Promontory, which has 180 rainy days.

Rainfall characteristics, as reflected by variations in average annual rainfall, seasonality, and intensity, are recognised as important inputs to bioclimatic analysis.

Severe storms

Severe storms can produce flash flooding, hail greater than 2 cm in diameter, and wind greater than 150 km per hour and may spawn tornadoes or waterspouts. These rare events occur more frequently in summer when sea and land surface temperatures are relatively high, but they usually happen only in situations that have fronts and troughs with associated cold air in the upper atmosphere, resulting in maximum instability.

Fog

Fog can form on the coast or over the adjacent sea at any time of year, although it does so more frequently during winter. It is recorded when visibility is reduced to less than 1 km, and creates a navigation hazard for air and sea traffic.



Fog off Wilsons Promontory.

Radiation fog, which usually forms over land at night or in the early hours of the morning, is a feature of stable situations such as occur in association with strong ridges of high pressure or near the centre of Highs. It usually dissipates by late morning, but has been known to persist all day on a few occasions.

Advection fog results when warm moist air flows over a cooler surface. (Persistent sea fog is a typical example.) It is more prevalent to the east of Wilsons Promontory (see Table 2.3); where the presence of the warm East Australian Current makes the sea surface temperature comparatively high; fog commonly occurs when easterly winds blow from this warm water across the cooler water of Bass Strait.

Inadequate charts and navigation aids combined with fog made navigation around the promontory particularly hazardous last century

Table 2.3: Fog

	Highest occurrence in any month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cape Nelson - 1957–91	1	5	5	4	2	2	2	1	1	3	3	2
Warrnambool - 1957–91	1	3	6	3	3	9	3	2	2	4	2	1
Cape Otway - 1957–91	5	5	6	3	4	1	1	1	2	3	5	4
Lorne - 1969–86	1	1	1	1	2	1	1	0	1	0	1	1
Geelong - 1970–91	0	0	0	1	1	2	1	0	0	0	0	0
Melbourne - 1855–91	2	3	5	7	15	20	17	9	6	3	2	4
Queenscliff - 1957–68	0	2	0	3	3	5	4	3	1	2	2	0
Wilsons Promontory - 1957–91	7	8	10	7	4	2	1	3	4	7	6	6
Lakes Entrance - 1965–91	5	2	4	2	2	1	0	3	1	4	2	4
Gabo Island - 1957–91	6	6	2	2	3	1	1	2	5	3	5	3

Source: Bureau of Meteorology

and ships were lost as a result. These ships have now become part of todays cultural heritage (see Chapter 5).

Persistent spells

A class of synoptic situations termed 'blocking' occurs when the typical west-to-east movement of weather systems stalls and here is an example. In the presence of a blocking High over the Tasman Sea north to north-east winds affect Victoria for periods of up to a week. During summer, they are associated with extended heat-waves and beaches become very crowded as people seek relief from the heat. During winter, they are associated with spells of mild and settled weather.

Another example is the presence of a blocking 'pair' over eastern Australia. In such situations, a Low over Victoria and a High to the south of Tasmania combine to block the progress of other systems from the west. The presence of the Low over Victoria leads to an extended period of unsettled weather.

When Highs block over Tasmania in winter, Victoria experiences a spell of settled weather with cold frosty nights.

Occasionally, Highs block to the south of Western Australia. The frequent passage of fronts moving north-eastward around this High leads to frequent cold and showery outbreaks over Victoria.

The Port Phillip eddy

This interesting local phenomenon affects Port Phillip Bay and the surrounding land and occurs when southern Victoria is in an easterly flow. Under such conditions when an inversion is below 5000 ft, the ranges of South Gippsland have the effect of turning the wind producing an eddy in the flow over Port Phillip Bay. When this happens, low cloud forms very quickly a few hours after sunset and drifts inland. Sometimes, the eddy is associated with drizzle and fog. If it is associated with a blocking High over Tasmania, it may persist for days, and pollution levels steadily rise in the Melbourne area due to the lack of change in the air trapped by the eddy.

El Niño

El Niño is the name given to a global phenomenon that has created much interest in the last few years. The effect is for a warm ocean current to temporarily replace the cold Humbolt current, which usually moves north along the South American Pacific coast.

Typically, the three-dimensional atmospheric circulation that operates across the equatorial plane of the Pacific Basin is best described in terms of a convective cell that has sinking air over the eastern Pacific (where the water is relatively cool) and has rising air over the western Pacific (where the water is relatively warm). This convective cell has the name 'Walker Cell' after its discoverer.

During periods when the El Niño phenomenon operates, the presence of warmer-than-usual water over the eastern Pacific suppresses the Walker Cell. This results in weaker-than-usual upmotion over northern Australia and, with the weaker driving force, can be one factor in reducing rainfall there. This moisture deficiency affects areas beyond the tropical regions and, particularly in spring and summer, is sometimes associated with reduced rainfall in Victoria.

CLIMATE CHANGE

There is increasing interest, because of the socio-economic implications, in predicting what the future climatic trends may be, particularly in relation to the impact of the anthropogenic release of greenhouse-enhancing gasses to the atmosphere. The science of linking the greenhouse effect with climate change is outlined by National Greenhouse Advisory Committee - DASET (1992). Scenarios of possible climatic change due to a specified increase in greenhouse gas concentrations have depended primarily on global circulation models. These models are based on a number of assumptions about the systems they seek to model. They tend to have a spatial resolution of about 600 x 300 km or worse, and that is too coarse for predictions that relate specifically to the Victorian coast, which covers an area of 790 x 190 km. Both terrestrial and marine ecosystems are more likely to be affected by regional changes in circulation patterns that will affect rainfall, run-off, wind, and extreme events. The regional character of climate change may differ markedly from the global trend.

Climate change, be it natural or artificial, has implications for many coastal uses. Sea-level rise may inundate low-lying coastal land. Potential impacts on terrestrial fauna in Victoria generally are outlined in Bennett *et al.* (1991), while DASET Parslow and Jernakoff (1992) outlines issues associated with managing fisheries

The Council of Australian Governments endorsed a national greenhouse response strategy in December 1992 (Australia, Commonwealth 1992). The strategy:

* established a set of guiding principles that underlie the development of all response measures and that should be considered in their application
* sets sectoral goals and strategies for guiding policy implementation

Hole in the ozone layer

The issue of the 'hole in the ozone layer' is sometimes confused with the greenhouse effect; it is not the greenhouse effect, but rather a result of ozone depletion.

The chemical reaction responsible for destroying ozone in the upper atmosphere is reasonably well understood. Furthermore, there is strong evidence that depletion of the ozone layer has already occurred. This ozone layer protects life on earth from the sun's harmful ultraviolet radiation. Notwithstanding that some damaging ultraviolet radiation has always impacted on the earth's surface, people participating in outdoor activities now accept and recognised the implications of ozone reduction and the necessity to 'slip-slop-slap'.

Box 2.1: Global Warming as a Result of the Enhanced Greenhouse Effect

Currently, the best available estimates of global warming are that increasing the carbon dioxide in the atmosphere to double the amount present at the time of the Industrial Revolution will result in average warming of between 1.5 and 4.5^{o}C. The best estimate is 2.5^{o}C.

The rate at which global warming will occur is tied closely to future releases of greenhouse gasses. According to the 'Business-as-Usual' scenario developed by the Intergovernmental Panel on Climate Change (IPCC) in 1990, model simulations suggest a range of warming of 0.2–0.5^{o}C per decade (best estimate 0.3^{o}C). The 1992 IPCC supplement emphasises that this estimate is uncertain because it depends on economic and social factors.

Global warming will also raise average sea levels. Under IPCC's scenario, the best estimate for sea-level rise is 20 $\pm$ 10 cm by 2030, and 65 $\pm$ 35 cm by 2100. Sea level is predicted to rise because the upper layers of the oceans will expand with warming, and because some glaciers and ice in more temperate regions are likely to melt. The best estimates of sea-level rise have not changed substantially since 1985, although their range is now narrower. Current estimates take account of the fact that precipitation is likely to increase over the polar ice-caps, leading to an accumulation of snow and ice. A better understanding of the behaviour of the ice-caps is still required for improved estimates of sea-level rise.

Translating global estimates to predictions of climate change on a regional level is a daunting task, and the focus of much research. The timing, magnitude, and character of regional climate change remain uncertain, but it is clear that there will be marked regional variations from the global average.

Source: National Greenhouse Advisory Committee (1992). 'Grappling with Greenhouse: Understanding the science of climate change.' (DASET: Canberra.)

OCEAN SYSTEMS

Several major physical features of the marine systems affect coastal waters. These are the bathymetry, which describes the three-dimensional shape of the body of water waves, tides, and currents.

BATHYMETRY

Bathymetry is the charting of the sea floor through the measurement of water depth.

Water depth influences the pattern of tides and tidal and other currents, the distribution of intertidal flats, the extent to which the sea floor and overlying water are affected by light, the areas safe for navigation (based on safe water depths or the requirement for channels and port areas), and the areas that may be of interest for recreational diving, for example. Historic background to the collection of bathymetric data in Victoria is given in Box 2.2.

Survey detail

Along the open coast the coarsest resolution for bathymetry is based on sounding transects 2000—4000 m apart. Roughly half of the open coastal near-shore waters are covered in this manner. For approximately one third of the coast, sounding transects are less than 1000 m apart. In general, waters less than 20 m deep have not been surveyed. Also, more-detailed data are available for several smaller areas, including major shipping channels and port approaches, especially those that require dredging; areas surveyed for off-shore cables of pipelines or other structures; and areas forming part of scientific research programs.

In general, the protected waters of bays and inlets are well covered by sounding data. For the larger bays - Port Phillip Bay, Western Port, and Corner Inlet - data have been collected to provide for safe navigation and as part of environmental studies. The rest of the semi-enclosed waters can be cheaply and safely sounded, thanks to their smaller size and more protected nature, and their bathymetry is reasonably well known from research projects.

The bathymetric data used for this report are described the Box 2.3 and the bathymetry shown on the large maps attached to this report.

Box 2.2: Bathymetric Surveys Along the Victorian Coast

To meet the requirement for shipping navigation, bathymetric surveys of Bass Strait commenced in 1801-02 with surveys by HM Brig *Lady Nelson*. Port Phillip Bay was surveyed in 1803-04 by HMS *Calcutta*. Surveys continued for the next 60 years until 1878, when the coast of Victoria was probably better surveyed than any other part of the Australian coast. No further surveys were carried out in Victoria, apart from those by port authorities and the Public Works Department, until 1931, when the northern port areas of Port Phillip Bay were re-surveyed. At the outbreak of World War II, waters to about 15 km off-shore were sprinkled with soundings, all of which had been obtained using manual procedures. Beyond 15 km, where accurate location fixes were almost impossible, only scattered and haphazard soundings were charted, with large areas unsurveyed. This was an unacceptable situation for waters frequented by deep-draft ships.

In 1948, HMAS *Warrego* completed a modern survey of Western Port and its approaches and this was followed in 1949–51 by surveys of Hobsons Bay and Geelong by HMAS *Tallarook*.

The *Warrego* began off-shore work in 1952 and in 1953 HMAS *Barcoo* joined in the work, surveying first from Cape Everard to Cape Howe then Port Phillip to Wilsons Promontory, completing this in 1954. During 1954–55, the *Warrego* surveyed from Port Phillip to Cape Otway, then further west to Moonlight Head. In 1961 HMAS *Bass* surveyed Portland Harbour and the *Barcoo* sounded the approaches to the port. During this time the off-shore surveys had to be controlled by endless lines of moored floating beacons.

The last 100 years has seen a revolution in the collection, storage, and analysis of sounding data. Initially soundings were collected by a weighted line and positions located by visual sightings of land features or astronomic observations. Charts were prepared manually. Today, ship-mounted echo-sounders allow continuous sea-floor profiling, locations are based on very accurate satellite navigation systems, and charting is automated. Over the last 5 years, high-resolution airborne sea-floor depth-measuring systems have been developed that can map waters less than 50 m deep. These have yet to be applied in Victorian waters.

Source: Arnold, V.H. (1966). 'Victorian Year Book - 1966.' (Government Printer: Melbourne.)

Box 2.3: Bathymetric Data Used in this Investigation

The data sources listed below were used to compile the bathymetric base for this study. This base was prepared as a planning tool and should not be used for navigation purposes. Where required, other bathymetric maps were also referred to. Many of these are listed in the Royal Australian Navy Index of Nautical Charts.

For open coast the following National Mapping map sheet series were used:

Port Macdonnell	SJ54-10	Warragul	SJ55-10
Portland	SJ54-11	Sale	SJ55-11
Colac	SJ54-12	Bairnsdale	SJ55-7
Queenscliff	SJ55-9	Mallacoota	SJ55-8
Wilsons Promontory	SJ55-14		

Chart datum on these maps is mean sea level.

For semi-enclosed waters the sources are:

Port Phillip Bay: Aus 143, Datum - Indian Spring Low Water
Westernport: Port of Melbourne Authority Westernport 1:25 000 Map Series September 1974 - August 1984 Chart datum 1.60 m below Australian Height Datum.
Corner Inlet: Aus 181, Datum - Lowest Astronomical Tide

Bathymetry of the open coast

Territorial waters along Victoria's open coast lie on the landward side of the generally low-relief continental shelf (see Figure 2.6). The edge of the shelf is roughly defined by the 200-m water depth. Beyond this edge, the sea floor plunges rapidly to depths of several thousand metres. For example, off east Gippsland, water depths twice the height of Kosciusko (about 2229 m) occur within 100 km of the coast.

Bass Strait is the major feature off the Victorian coast. It has an extensive sea-floor area (known as the Bassian Plain, and roughly 400 km by 200 km in extent) of low relief, with the central and slightly deeper portion about 85 m below sea level. Beyond this plain lies Tasmania. Two low-relief ridges, rising about 30 m above the plain but sometimes coming to the surface to form islands, cross its east and west margins: the western ridge extends across the western entrance of the Strait from King Island to north-west Tasmania; the eastern ridge extends from Wilsons Promontory through a chain of small islands via Flinders Island to north-east Tasmania. The presence of Tasmania and the shallow water depth give Bass Strait a cross sectional area of about 10 sq. km. This has a major effect on tides, waves, and ocean currents, which will be described later. Along the coast either side of the plain, the edge of the continental shelf, at about 200 m water depth, generally lies approximately 30 to 60 km off-shore, except off Cape Howe where the shelf margin comes to within 20 to 30 km of the coast.

Within Victorian territorial waters the greatest depth recorded lies at the territorial limit off Rame Head near Wingan Inlet, where the water is a relatively shallow 110—120 m deep. Even at this depth the Rialto Tower in Melbourne, currently the tallest building in Australia at 60 storeys and 242 m high, would have only its lower half below water.

The proportions of various water depths within Victorian waters are given in Table 2.4, with half of the open coastal territorial waters being less than 40 m deep. The most extensive area of shallow water, less than 30 m deep, lies off the Ninety Mile Beach. It deepens only slowly further off-shore, about 50 m at 50 km off-shore giving the area the name - Gippsland shelf. While Victorian waters are not deep, they contain several areas where depths rapidly increase with distance off-shore. These include the water around the islands near the southern end of Wilsons Promontory, where water depths of 60—70 m occur within 500 m of the shore, and at the entrance to Port Phillip Bay, where depths of just on 100 m occur in a narrow tidally scoured channel between the heads.

Broad-scale bottom topography has been shaped by number of factors. Predominant among these have been the effects of sub-aerial weathering and erosion during periods when

Table 2.4: Water Depths: Open Coast - Territorial Waters Only[1]

Water depth interval (m)[1]	Area covered (sq.km)[2]	Proportion of total area (%)
0—20	3100	44
20—40	2310	33
40—60	1110	16
60—80	450	6
80—100	20	<1
100—120	10	<1
more than 120	not recorded	

Notes:
1. Calculated from the sources cited in Box 2.3 that had been transferred to 1:350 000 scale maps.
2. Rounded to the nearest 10 sq. km.

the sea level was much lower than at present and the subsequent inundation of these areas. Consequently ancestral drainage networks, especially that associated with the Yarra and the Bassian plain, can be identified, along with erosional terraces associated with previous sea levels. Other factors include volcanic activity. For example, lava flows in western Victoria have produced pronounced topographic features. The lobe-shaped area of shallower water extending offshore in Portland Bay (see Map 1) is attributed to the offshore extent of the Tyrendarra lava flow.

Bathymetry of semi-enclosed waters
(see Table 2.5)

Port Phillip Bay is 1950 sq. km in area and roughly basin-shaped. It has a maximum depth of just over 20 m across much of its central zone, while the shallower Corio Bay has maximum depths of about 10—15 m. Hence they require major channel-dredging for port development. The southern end of is also comparatively shallow, with an extensive area of about 240 sq. km (known as the Great Sands) between 5 and 10 m deep. However, among several major channels in this region, the main one reaches more than 30 m.

Western Port has two entrances, one on either side of Phillip Island. The 'western' entrance is significantly larger and deeper (up to 30 m) than the 'eastern' one between San Remo and Newhaven (about 5 m). The Bay is characterised by an extensive tidal channel system, with major arms on the western (north arm) and eastern (eastern arm) sides of French Island. Depths in these major channels exceed 15 m. An intricate network of smaller tidal creeks feeding into the main channels become swift-flowing streams towards low tide as, as the water drains from the exposed intertidal flats.

Extensive, low-relief intertidal flats (270 sq. km) are exposed as the tide recedes. Some may be as much as 1 m above the water level in the channel system at low tide. These flats occur in several localities. In the north-eastern sector of the bay, an extensive area (known as the 'Tidal Divide' or 'Watershed') separates the headwaters of tidal channel systems of the north and east arms. Elsewhere extensive inter-tidal flats have developed where sheltered conditions prevail - for example, Hastings Bight, Blind Bight, and Rhyll Inlet.

Figure 2.6: Generalised Bathymetry

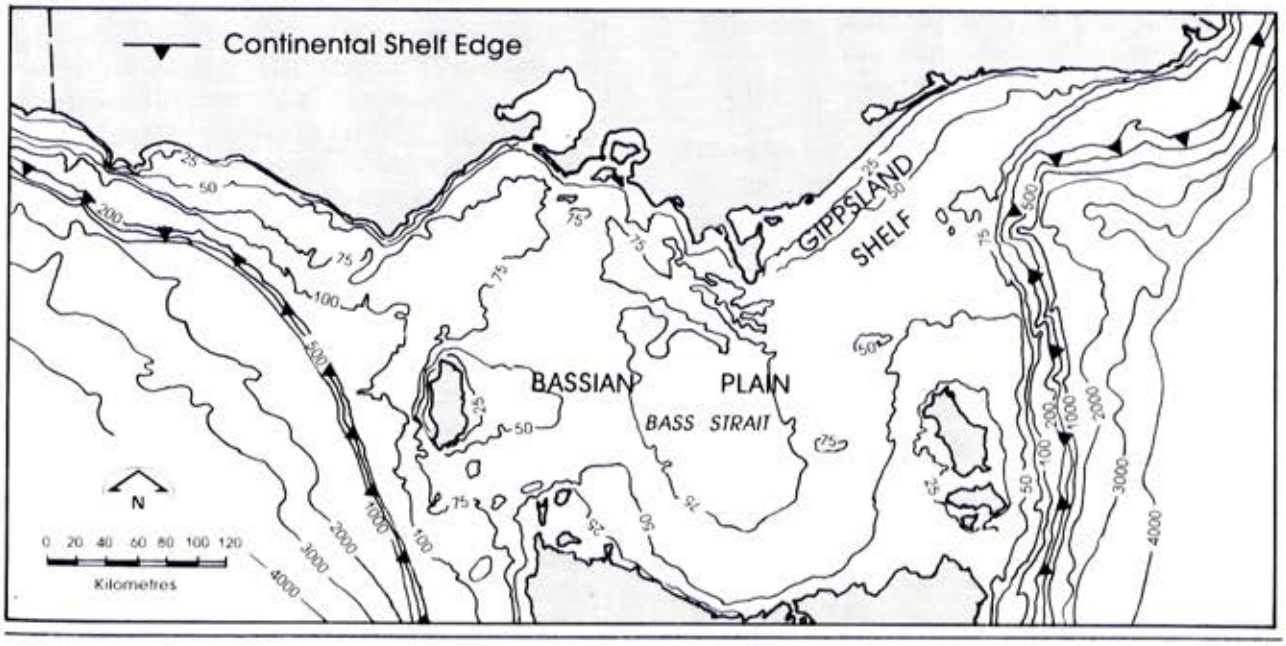


Table 2.5: Water Depths: Semi-enclosed Waters

Intertidal flats	Water depth (m)[1] 0—5	5—10	10—20	20—30	>30
	Area (sq. km) and % of total area[1]				
Port Phillip Bay - 1950 sq. km					
60[3]	370 (19)	400 (21)	620 (33)	510 (27)	<10 (<1)
Western Port - 680 sq. km					
270[3]	420 (61)	160 (23)	90 (13)	20 (3)	<10 (<1)
Corner Inlet/Nooramunga - 510 sq. km					
na	440 (88)	40 (7)	20 (4)	<10 (1)	<10 (<1)
Mallacoota Inlet - 40 sq. km					
<10	30	<10	<10	-	-

Notes:
1. Calculated from the sources cited in Box 2.3 that had been transferred to 1:350 000 scale maps, except for Mallacoota Inlet - see Reinson (1977)
2. Rounded to the nearest 10 sq.km.
3. From Bucher and Saenger (1989).

Corner Inlet also contains extensive intertidal flats separated by a tidal channel system, although the system is less intricate here than at Western Port. The intertidal flats are exposed at low tide as water drains into the large tidal channels, which exceed 20 m in depth. The entrance between the north-eastern extremity of Wilsons Promontory and Snake Island is several kilometres wide.

The Corner Inlet complex is linked to another extensive area of intertidal flats and channels to the east, which has developed behind a chain of barrier islands that extends to Seaspray. This area is linked to Bass Strait by a series of small entrances between the barrier islands, which are shallow (often less than 5 m deep) and difficult to navigate.

Mallacoota Inlet covers about 35 sq. km. It is characterised by three basins, referred to as the Northern Basin, Southern Basin, and Upper Lake. These basins are about 1.5—6 m deep and about 2 sq. km of intertidal flat has been recorded. These basins are inter-connected by narrow passages where water depths exceed 6 m. The deepest areas are in the river channels with 22 m the deepest recorded depth.

WAVES

Wind blowing over the sea surface creates waves, but the exact mechanism leading to their formation is not well understood. Wave characteristics depend mainly on the wind speed and duration, water depth, and the distance for which the wind has blown across the water - known as the fetch length.

By convention, waves still within the generating area of the wind field are known as wind waves, and these typically tend to have a wave period of less than about 6 seconds. 'Wave period' has many definitions, but put simply it is the time between successive occurrences of the upcrossing of the wave profile crossing the mean water level. Waves that have moved out of the generating wind field are known as swell waves, and these are the longer-period waves seen on the open coastline, having wave periods typically between 7 and 18 seconds.

Wave height is defined as the vertical distance between the troughs (minima) and adjacent crests (maxima) of the wave profile, measured across the part of the profile that crosses the mean water level in the upcrossing direction. Again, there are many definitions of wave height. A popular definition is significant wave height, as it can be calculated from measurements, and equates roughly to what an experienced observer would estimate the wave heights to be.

In relation to waves, the water is said to be deep if its depth is about twice the wavelength. In deep water, the waves are not at all influenced by frictional effects of the sea-bed. In shallower water, friction alters the wave height, reduces the wavelength, and modifies the wave profile, generally making it steeper. The wave break in very shallow water is generally one of three breaker types, depending mainly on the seabed slope and wave steepness. Spilling waves are usually found on very flat beaches: they begin breaking at a relatively great distance from shore and break very gradually as they approach still shallow water, with very little reflection back towards the sea. Plunging breakers are much more spectacular: they have a curling top and dissipate much energy in a strongly turbulent break, with little reflection back to sea. Surging breakers occur on steeply shelving shores, such as on a rocky shoreline: they break in a narrow zone, and about half of the energy can be reflected back to sea.

Waves approaching the coastline are generally much modified from the deep-water waves. Where straight shore-parallel contours exist off-shore, and the waves approach normal (at right angles) to the shore, a process called shoaling occurs. This has the effect of initially increasing wave height, and then decreasing it as the wave moves towards shore. If the waves approach an arbitrary coast at any angle, shoaling and refraction occur to alter the wave's height, length, and approach direction. Refraction refers to how the sea-bed bottom contours the direction of the waves. In general, waves approaching a straight coastline will be reduced in height, and the included angle between the wave crests and the shoreline will tend to be reduced. Thus refraction is generally a process by which energy is dispersed. The third major process is diffraction, which occurs when waves pass an impermeable solid partial barrier, such as the tip of a breakwater. It usually results in changes to the wave height, either increases or decreases, and bending of the wave crests into the lee side of the structure.

In practice, the depth generally changes shoreward of a structure such as a breakwater, and then waves are subject to combined shoaling, refraction, and diffraction.

Waves are an important element for coastal land use for a number of reasons. Wave effects shape the coastline and result in the transport of sediments in on-shore—off-shore directions, and parallel to the shore along the beach.

Coastal and marine developments ranging in scale from off-shore oil production platforms to small-scale jetties and sea-walls require adequate wave-climate information for their optimum design and operation. Developments shoreward of the breaker zone typically, and on-shore developments, may significantly alter the in-shore wave climate, which often results in significant coastal impacts and long-term changes.

Knowledge of the wave climate is a key element in many aspects of coastal and marine matters in regard to tourism and recreational pursuits, possible sustainable energy generation, disposal of wastes via outfalls, commercial shipping, recreational boating, foreshore protection, and coastal land management.

Sites suitable for recreational activities such as surfing, rely on having not only large waves, but a range of other favourable elements. These include natural elements such as absence of local wind waves, sea-bed slope to produce certain breaker types, and other social factors (see Chapter 9).

Wave climate

Current knowledge of the wave climate along the outer Victorian coast is limited to short-term studies at selected sites. Prominent among these are the reports of the Coastal Investigation Unit of the Port of Melbourne Authority are those by the authors Thomas (1980s) and Tyshing (late 1980s and 1990s). For Port Phillip Bay, long-term wave statistics are derived from shore-based wind climates. There is scant information for Western Port.

The general lack of good-quality long-term wave information is of concern for development and management of the coast and design of foreshore and marine structures. Under present administrative and funding arrangements, this situation is likely to continue.

Port Phillip Bay

Within Port Phillip Bay, swell waves can not penetrate through the narrow Rip and surrounding Great Sands area. Therefore, the waves within the bay are only 'wind waves'. The Coastal Investigation Unit - PMA, has compared measured wave conditions from wave rider buoys against calculated wave conditions, and established forecast equations. Table 2.6 gives results for a number of sites in terms of the highest significant wave heights possible for actual recorded winds.

On the open coast, the much longer fetches and deeper water lead to considerably higher waveheights and longer period waves.

Table 2.6: Highest Significant Wave Heights - Port Phillip Bay

Site name	Hs (m)	Water depth (m)
Melbourne Port	2.3	12.5
Ricketts Point	2.1	16.0
Frankston	1.5	20.0
South Channel	2.7	15.0
Symmonds Channel	1.7	24.0
West Channel	1.4	20.0
Prince George Bank	1.9	15.0
Point Wilson	1.7	10.0
Werribee	1.8	11.0
Middle of Bay	1.9	23.0

Table 2.7 shows highest values of the wave parameters based generally on a 27-minute sample, collected every hour.

Storm waves on the open coast can result either from ocean swell, or from a combination of swell and superimposed local wind waves.

Table 2.7: Wave Parameters for the Open Coast

Site name	Hs (m)	Hmax (m)	Depth (m)	Data duration (mths)
Mt Gambier	3.0	7.7	20	1
Cape Nelson	6.1	10.5	90	4
Black Rock	3.4	5.8	22	48
Westernport	3.6	5.4	23	18
McGaurins Beach	3.3	na	15	1
Delray Beach	3.1	5.7	20	12

Note: The median values for longer times will be much less: for example, Delray Beach has an annual median Hs of 0.86 m.

Wave energy of the open coast

Wave energy along the coast is described in an unpublished 1992 report to the SECV and the Renewable Energy Authority Victoria and the results are outlined below. Wave energy is principally affected by three key factors: the fetch length for swell generation; depths; and the alignment of the coast. Using these criteria, the coast can be divided into three zones: western, central, and eastern.

Western zone extends from the South Australian border to Cape Otway. It is subject to swell waves that may be generated over thousands of miles of open ocean.

Off-shore, the waters are relatively deep, so little energy is lost to the effects of sea-bed friction or wave refraction. The coast is generally aligned parallel to or at a small angle to the predominant waves, which tend to come from the south-west. Approximately two-thirds of storms approach from the same quarter. Storms from an easterly quadrant are fewer and easterly weather tends to only last for a matter of a week or so.

The wave regime is relatively uniform throughout the year with only minor seasonal variations. Mean off-shore wave power is calculated to be of the order of 46 kW per m of wave front and is considered to be exceptionally high even by world standards.

Results from a wave-ride buoy, deployed in 90 m of water 30 km south-west of Cape Nelson during 1990/91 by Coastal Investigation Unit - PMA, indicated that the median significant wave height was just over 2.8 m and rarely dropped below 1.0 m. The median significant wave period was 10.3 seconds, with periods between 8 and 12 seconds occurring approximately 70% of the recorded time.

Central zone of Bass Strait between Cape Otway and Wilsons Promontory is subject to much lower-energy waves than the western zone, mainly because:

* the fetch is considerably smaller and narrower, being broken by Tasmania and a number of islands in Bass Strait

* the water of Bass Strait is considerably shallower, causing energy losses due to friction.

Based on the alignment of the coast and distribution of headlands, this zone can be divided into two main areas, on either side of Point Lonsdale.

From Cape Otway to Point Lonsdale, the roughly south-west—north-east coastline alignment, is such that the predominant swell from a southerly quadrant is strongly refracted before it reaches the coast, dissipating the bulk of the south and south-westerly component of wave energy. The wave climate is therefore more likely to be affected by locally generated winds.

From Point Lonsdale to Wilsons Promontory, the coast is aligned nearly perpendicular to the predominant swell and is therefore subject to direct exposure to west and south-west swells generated in the Southern Ocean and particularly western Bass Strait. The reduction in refraction losses, compared with the Cape Otway to Point Lonsdale section, results in a higher energy, (see Table 2.8).

Eastern zone gets protection from the land masses of Wilsons Promontory, the Bass Strait Islands, and Tasmania, which effectively shelter it from waves originating in the Southern Ocean. The main waves here, therefore, are 'wind-sea' in origin (generated by predominant west to south-west winds) resulting in a wave energy of the order of 13 kW per m.

Port of Melbourne Authority data for Delray Beach indicate that the median significant wave height for the area was only 0.83 m.

By comparison, data from the Kingfish B oil platform lying about 75 km off-shore indicated that wave height and power were significantly greater there than at Delray Beach. Wave periods were also significantly longer. The differences were attributed to the greater exposure of Kingfish B to prevailing west to south-west winds. Due to the significant differences in wave climate between the two eastern sites, this zone could be further sub-divided into three:

* coastal between Wilsons Promontory and Lakes Entrance - relatively uniform coast with Delray Beach data being representative of the wave climate
* Off-shore (approximately 20 km) - Kingfish B data being representative of general wave climate
* Coastal east of Lakes Entrance - progressively eastward orientated coast is more susceptible to waves generated by south-westerly winds and more exposed to east and south-east swells originating in the Tasman Sea, wave climates expected to change from Delray Beach style in the west to Kingfish B style near Gabo island

Analysis of Kingfish B wave data indicates that conditions are fairly uniformly distributed throughout the year. Small seasonal variations are noticeable - with winter and summer, on average, being slightly more energetic than autumn or spring.

Extreme wave conditions are most likely to result from 'East Coast Lows' - intense small-scale 'cut-off' low-pressure systems that form along the south-east coast of Australia. These pressure systems can produce very strong east to south-east winds, which under the right conditions can generate heights of the order of 10 m. This average equates to individual maximum wave heights of 18—20 m.

Table 2.8: Wave Power - Central Zone

Site	Mean annual wave power (kW per m)
Cape Otway—Point Lonsdale	9
Cape Schanck	12
Cape Paterson	17
Wilsons Promontory	19

TIDES

The periodic rise and fall of the sea on a daily or more frequent basis - tidal movements - essentially result the combination of the earth's rotation and the gravitational effect of both the sun and the moon, with the moon having a significantly greater effect.

At new and full moon, the sun and moon gravitational forces act together to produce the largest tides, known as 'spring tides'. They have nothing to do with the season, and occur at about fortnightly intervals. When the moon is in its first or last quarter, the sun and moon are at right angles in relation to the earth and their gravitational effects are not combined. Tides therefore cover a smaller range and are known as 'neap tides'.

The height of tides at a particular location, along with the times of high and low tides, can be predicted with some accuracy using mathematical formulas. Factors that have to be taken into account include the relative gravitational effects of the sun and the moon, the earth's rotation, obstructions to tidal movement caused by land masses, and friction against the sea floor, especially in shallow seas and embayments. Tidal characteristics are also partially influenced by the size and shape of the ocean basin. Tides are important to coastal geomorphology and marine biota because they lead to regular changes in the level of the sea at or near the coastline and because currents are generated as the tides rise and fall.

Meteorological effects complicate the predictions. For example, on-shore winds can raise tidal levels and bring forward the tidal peak, whereas off-shore winds may have the opposite effect. A fall of 1 millibar in atmospheric pressure is accompanied by a rise in tidal level of about 1 cm. Storm surges are produced when strong onshore winds coincide with high 'spring tides', as has occurred near Seaspray in recent years.

Port of Melbourne Authority staff routinely collect tidal information for a number of stations along the coast, such as Portland, Melbourne, Port Phillip Heads, Geelong, Stony Point, and Welshpool, and publish tables of tidal predictions annually.

The astronomic tidal range along the open coast of Victoria varies between about 0.9 and 2.7 m (see Table 2.9).

Table 2.9: Tidal Characteristics - Open Coast

Site	Rise (m)	
	Springs	Neaps
Portland	0.9	na
Port Fairy	0.9	na
Warrnambool	0.9	na
Port Campbell	1.2	na
Lorne	1.7	na
Flinders	2.7	2.1
Inverloch	2.1	0.4
Corner Inlet	2.4	na
Lakes Entrance	0.9*	na
Gabo Island	1.8	1.52

* The rise for Lakes Entrance is approximate.

Tides along the Victorian Coast are complex, and are influenced by changes in depth in Bass Strait, and propagation of different components of the tide around Tasmania at different rates. The local geometry of the coast also has a significant effect. For example, the narrow entrance to Port Phillip Bay and the Great Sands area throttles the tidal flow, and the relatively flat circular shape results in a uniform tidal range of about 0.9 m throughout the Bay. In Western Port, the constricting nature of the bay with distance inland results in funnelling of the tide, with peak tidal ranges of about 3.1 m at Warneet.

In Port Phillip Bay and Western Port, the tidal cycle is described as semi-diurnal, meaning that, on average, two high waters and two low waters occur in a 24-hour day. Diurnal tides have, on average, one high water and one low water per 24 hour day. Mixed tide character is between these two.

On the open coast, the zones west of Cape Otway and along the Ninety Mile Beach experience mixed tides, while the zone between is mainly semi-diurnal. These variations are illustrated in Figure 2.7, which shows: the variation in tidal rise between springs and neaps; the variation in the timing of high and low tides along the coast; the reduction in tidal rise for Port Phillip Bay (Melbourne) compared with the adjacent open coast (Port Phillip Heads); and the mixed tide character of Portland compared with the semi-diurnal tides of Port Phillip Bay.

Tidal type has great significance in determining variations in the length of the drying period between tides, an important factor in relation to intertidal weathering and biological zonation, and feeding opportunities for wading birds.

Concern over possible greenhouse-induced mean sea-level change has led to the establishment of six high-accuracy self-calibrating tide gauges around the Australian coast. The Victorian one was installed at Portland in 1992, the choice being dictated by the requirement for deep water, stable foundation for the gauge, and minimum shallow-water tidal effects. This station will continue to collect tidal registrations over a long period.

Many areas still have be investigated to fill in knowledge gaps, especially along the open coast such as at Lakes Entrance and the entrance to Port Phillip Bay, which have a high commercial importance. For example, a detailed knowledge of tidal changes could help in timing commercial shipping movements to take advantage of the deeper water depth at high tide, reducing the need for expensive dredging. A better understanding of the tides in Bass Strait requires the establishment of additional stations.

Tidal currents

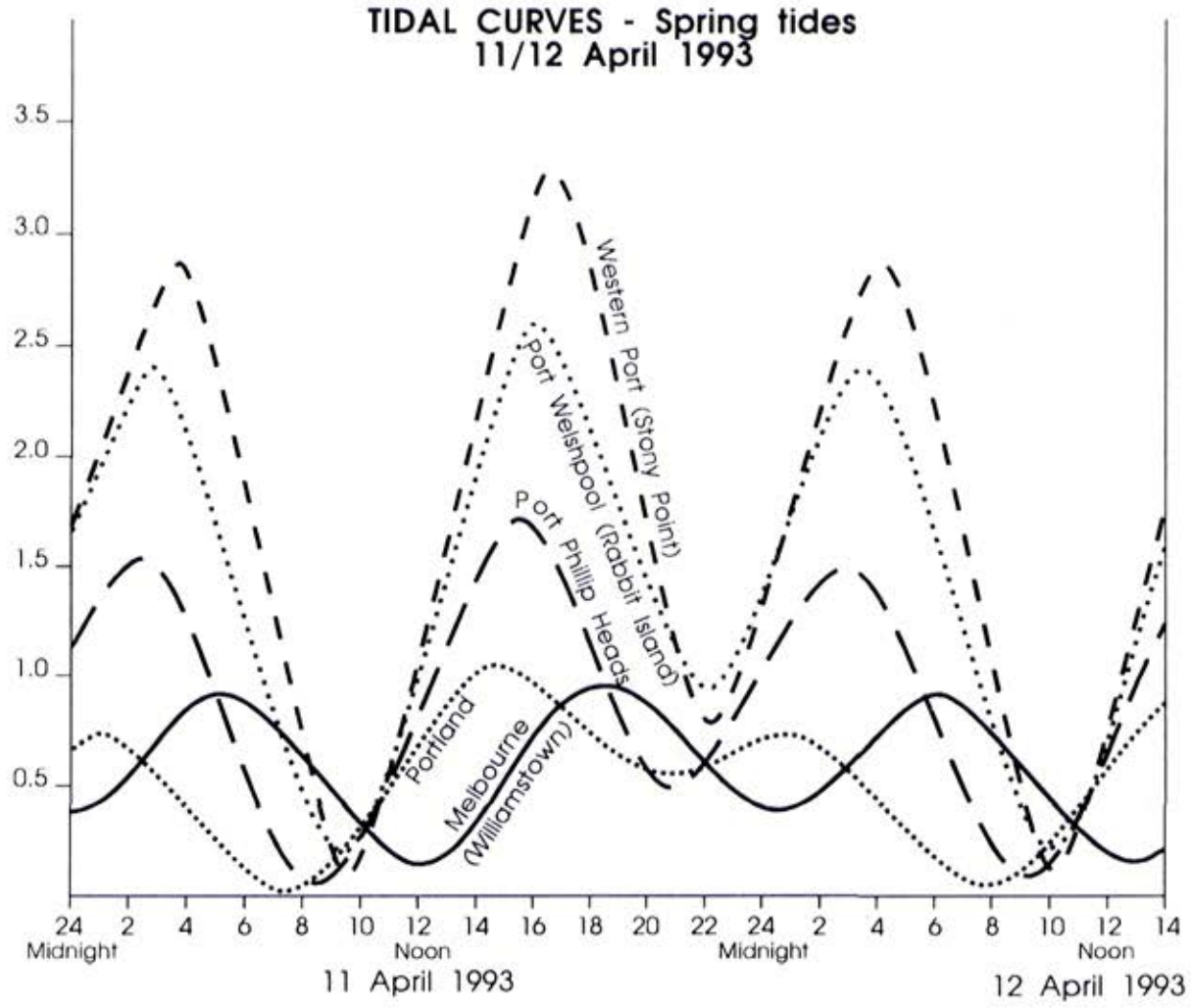
As tides flood and then ebb, tidal currents are generated. These depend on the tidal range and geometry of the water body.

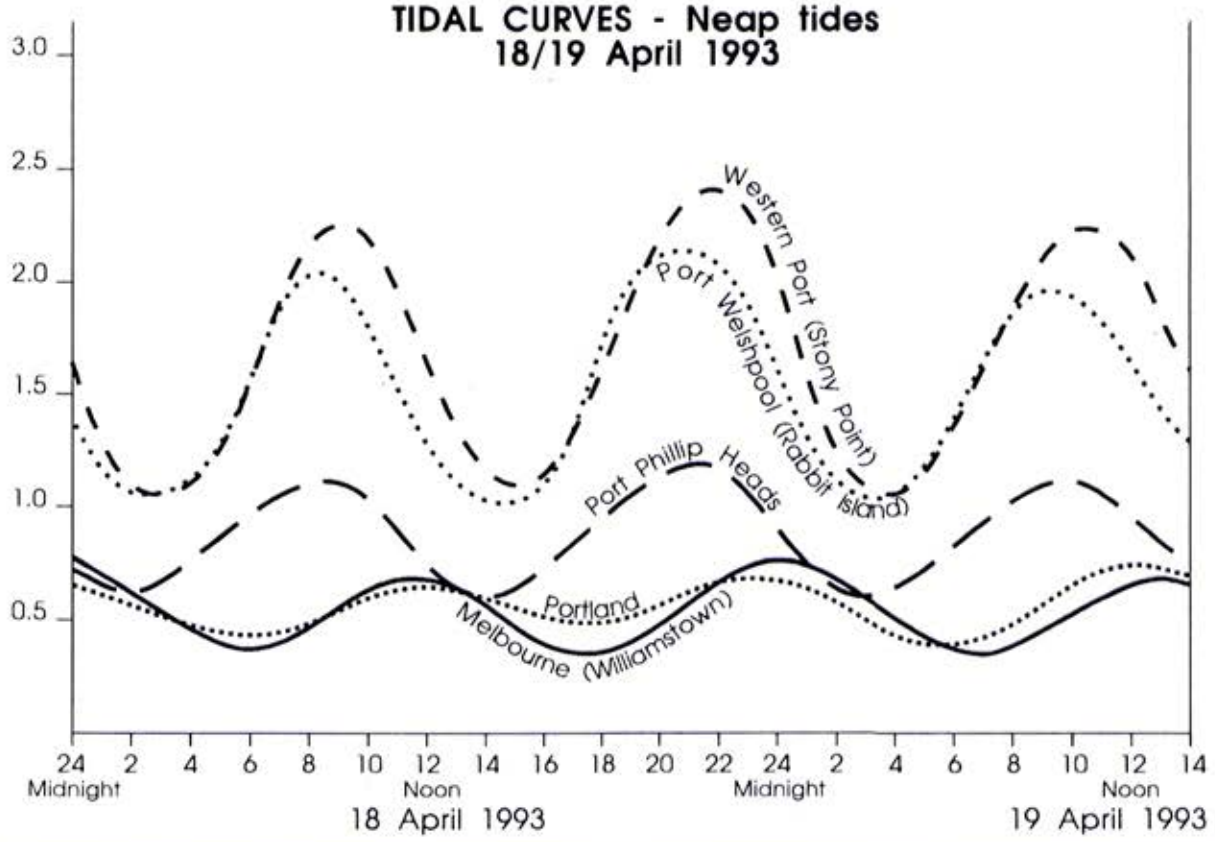
In areas of extreme tide range, such as occurs along the Kimberley coast in north Western Australia, a channelled tidal race may reach a speed of 28 km per hour. Velocities on that scale produce tidal bores (steep-fronted breaking waves that run upstream through an estuary).

For Bass Strait, tides flood into both sides simultaneously and then ebb from both sides simultaneously. Models describing the tidal currents generated in Bass trait and for Port Phillip Bay and Western Port have been described by Black (1992). The higher velocity areas are to the north and south of the major Bass Strait islands and at the entrances to inlets and bays.

In Bass Strait, variations in tidal currents can be matched against the variations in grain size of the sea flood sediments. At the mouths of the major inlets, flood-tide deltas like the Great Sands at Port Phillip Heads and ebb-tide deltas like that at Lakes Entrance may form. Tidal currents have also resulted in the formation of a linear scour channel about 100 m deep on the seaward side of the heads to Port Phillip Bay.

Figure 2.7: Tidal Curves





An understanding of tidal currents is therefore important for determining the impact or success of engineering works and the way in which they may sort sea-floor sediments - potentially affecting their biology. And in recreation divers use tides to 'drift dive', thus covering reasonable bottom distances with little effort, and sailors may need to watch them especially if travelling in the opposite direction to the current.

OCEAN CURRENTS AND WATER CIRCULATION

In addition to those currents produced by tides, waves and local wind patterns, regular and usually large-scale ocean currents occur. In fact, they are the primary means of transporting both water and heat, horizontally and vertically, in the ocean.

Ocean currents move like rivers through the seas. Many are well defined by differences in temperature and velocity compared with the waters through which they are moving. Major ocean currents originate from the regular atmospheric circulation pattern, which produces a pattern of easterly winds near the Equator and westerlies in the high latitudes, both being deflected by the earth's rotation. Ocean currents follow the same pattern of circulation, which is anticlockwise in the Southern Hemisphere. Most of the Australian coast is influenced by these oceanic currents, especially coastline associated with the southern Indian, Southern, and South Pacific Oceans.

The South Australian, Tasmanian, and western Bass Strait coasts are influenced by a cold Circumpolar Current that, while it has a variable direction, is usually driven by the prevailing westerly winds. Its velocity is about 1 kph, although it may be faster in Bass Strait.

By contrast, the East Australian Current - derived from warm equatorial waters - flows down the eastern coast of Australia, generally as far south as the Victoria—New South Wales border area. At its southern extremity, it breaks up into a series of eddies as it meets the colder Southern Ocean waters. In the north, the current is between 30 and 100 km wide and flows at 2—4 kph in summer, but in the south speeds fall to about 1 kph (see Figure 2.8).

Currents are important because they have a marked influence on sea temperature, salinity, nutrients, and marine biota. The major water masses and their complex interactions - with each other and with the physiography of Bass Strait and its coasts - have significant impacts on the ecology and fisheries in the area. For example, when the East Australian Current extends into Bass Strait, subtropical species such as leatherback turtles, manta rays, marlin, and hammerhead sharks may be found as far as western Victoria and Tasmania.

The generally low productivity of most of the waters limits the productivity of exploited marine fish and invertebrates. Localised areas have higher nutrient levels - for example, the continental shelf breaks and slopes at the eastern and western margins of Bass Strait, where upwellings of cold nutrient rich waters promote productive fisheries resources. Off Lakes Entrance, the scallop beds, which occasionally become extremely productive, probably benefit from the nutrients originating from the Gippsland Lakes system.

Ocean currents also play a major part in the recruitment of many marine species. A notable example is the short-fined eel, which occurs in fresh waters throughout Victoria (and elsewhere). Mature eels migrate out of rivers, eastwards through Bass Strait, and up the east coast to their subtropical breeding area. Larval eels use the southward movements of water masses to return to southern Australia to enter coastal rivers and streams. The eastern king prawns that occur and are fished in East Gippsland inlets have a similar movement and recruitment pattern.

Water circulation in Bass Strait

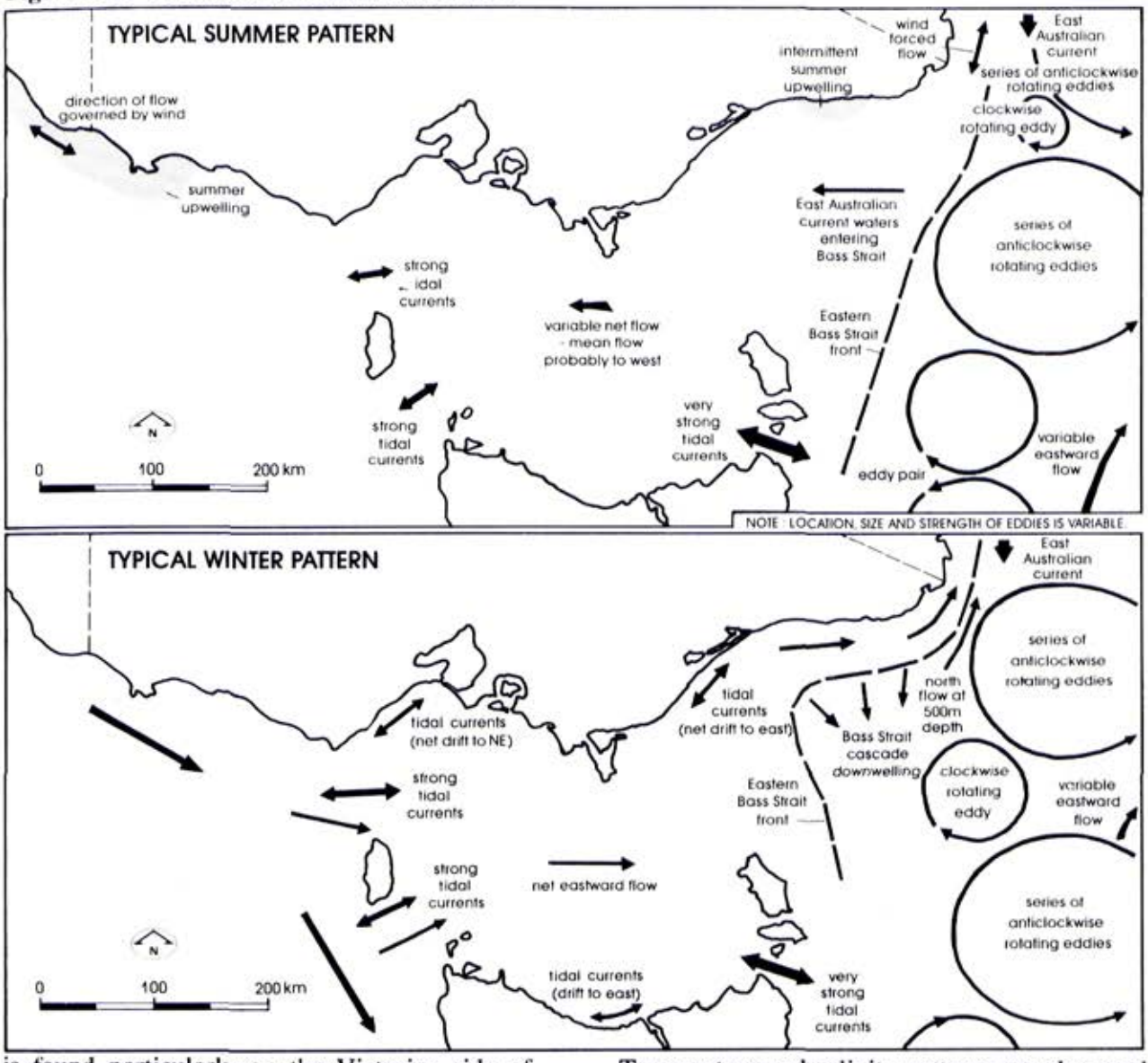
Four 'primary' surface water masses have been identified as contributing to Bass Strait (Newell 1961; Rochford 1957a,b), as outlined below.

East Australian Current water is generally of high temperature and high salinity owing to its origin in the tropics, where high temperatures and evaporation rates prevail. This water is low in nutrients.

Central Tasman water (or Tasman Sea surface water between Australia and New Zealand) is of high salinity and relatively high temperature. Rochford (1957a) defined it as the high-salinity water carried westward and southward into the Tasman sea from the central South Pacific. He suggested that it contributed to the mixture of waters within Bass Strait in summer.

Bass Strait water perhaps more explicitly termed 'north Bass Strait water' (Newell 1961)

Figure 2.8: Generalised Circulation Pattern



is found particularly on the Victorian side of Bass Strait in winter. It has relatively low temperature and high salinity, and is relatively low in nutrients. One theory for its high salinity is evaporation in the relatively shallow areas of Spencer and St Vincent Gulfs followed by its passage along the Victorian coastline.

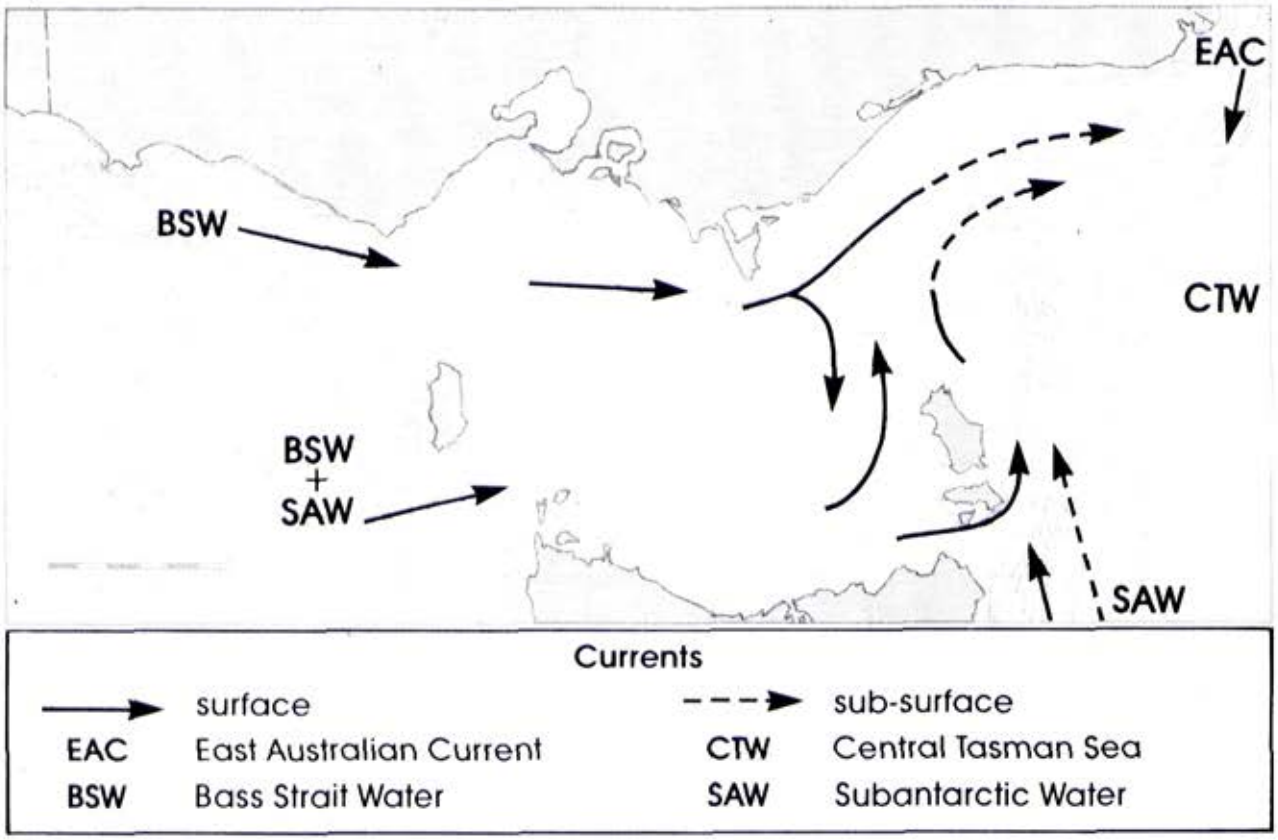
Subantarctic water, cold and with low salinity, originates in high (southerly) latitudes. It is relatively rich in nutrients and therefore supports high biological productivity. It reaches the areas off the east and west extremities of Bass Strait, mainly subsurface but also at the surface.

Deep waters over the continental slopes to the east and west of Bass Strait are cold, of low salinity, and very rich in nutrients. These are characteristics of very deep ocean waters in general. Water movement has been inferred from both drift bottle experiments and measurements of temperature and salinity. Temperature and salinity patterns are also used to predict water movement. A summary of water movements in winter and contributing water masses (based on Gibbs *et al.* 1991 and Tomczak 1985) is presented in Figure 2.9.

In summer the position is less clear. However, it is believed that East Australian Current and Central Tasman waters may contribute more and subantarctic water contribute less to Bass Strait.

The timing of the winter—summer alternation of surface movement is apparently variable. Newell (1961) suggests this alteration is due to the north—south migration of the Australian (atmospheric) high-pressure zone. In winter this anticyclone moves north, bringing subantarctic water to lower latitudes. In summer, the anticyclone and subtropical convergence move south, and the East Australian Current penetrates further south, perhaps into Bass Strait

Figure 2.9: Water Masses - Bass Strait



ISSUE

Information is required on the physical and chemical oceanography of the near-shore areas.

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3. GEOLOGY AND GEOMORPHOLOGY

COASTAL GEOLOGY

Geologically, Victoria's coastline provides a broad representation of the whole State, encompassing most rock types and ages, from Cambrian greenstone to Recent beach sands and lagoonal sediments. Detailed geology is presented in the geological maps published by the Department of Energy and Minerals, but Table 3.1 and Figure 3.1 give a summary.

The coastline of Victoria has been considerably influenced by Tertiary tectonic activity and earth movements as well as Quaternary sea-level changes. Quaternary depositional environments were determined during the Tertiary by the uplift of structural highs such as the Otway Ranges, the Mornington Peninsula, and the South Gippsland Ranges. The subsidence of the Western District, the Port Phillip and Westernport sunklands, the Corner Inlet depression, and the Gippsland Basin created areas suitable for sediment deposition.

Major coastal embayments are either partly enclosed and irregular or open and broadly curved in plan. The form of the partly enclosed embayments, such as Port Phillip Bay and Western Port, is directly related to the marginal tectonic lineaments. The broadly curved embayments, such as the Ninety Mile Beach, are in depressions with a gentle fall to seaward. The curved form is due to the formation of virtually continuous sandy beach barriers, usually terminated along shore by headlands.

The oldest rocks exposed on the coast are the Cambrian greenstones that outcrop east of Cape Liptrap. The greenstone forms a fault-bounded horst consisting of metabasalt and metagabbros and is a possible southern extension of the Mount Easton Belt. The intermittent but persistent positive topographic nature of this axis is indicated by the overlying shallow-water Lower Ordovician to Lower Devonian limestones.

During the Ordovician, a very thick sequence of marine sediments was deposited in several sedimentary basins across Victoria, constituting a fundamental component of the Palaeozoic Lachlan Fold Belt. The sediments are generally siltstone, silty shale, and felspathic sandstone of turbidite origin. Outcrop of these rocks along the coast is restricted to East Gippsland. Here sediments of the Mallacoota Beds have been folded and faulted with a resultant dominant north—south tectonic grain. The outcrops reflect a relatively low grade of metamorphism, altering the original rocks to low-grade phyllites and quartzites. Much of the outcrop east of Cann River is masked by a thin veneer of Tertiary sediments, except where faulting has exposed large blocks. Silurian-age rocks only outcrop as limited occurrences of Melbourne Trough marine siltstones and sandstones at Sandstone Island and Golden Point, Western Port.

The presence of Devonian-age rocks along the coast is restricted to the relatively shallow marine turbidite sequence of the Liptrap Formation and associated limestones in the Cape Liptrap area. The sediments have been subject to complex folding and faulting.

Many granitic intrusions occurred during the Devonian, formed in the waning stages of orogenic activity of the Lachlan Fold Belt in south-eastern Australia. These outcrop east of Melbourne at such localities as Cape Woolamai, Wilsons Promontory, Cape Conran, and Gabo Island.

Extensive Cretaceous sediments outcrop along the coast. These were deposited in three major basins formed by mid Mesozoic rifting - the Otway, Bass, and Gippsland - extending along the southern margin of the State. The King Island—Mornington Peninsula Ridge separates the Otway and Gippsland Basins, with the Bass Basin present offshore within Tasmanian waters.

In the Otway Basin, Lower Cretaceous sediments of the Otway Group consist of felspathic sandstone and minor siltstone and conglomerate. These sediments outcrop continuously along the Otway coast from Moonlight Head to Eastern View. The structure of the Otway Ranges is domal with major faults and anticlinal folds running north-east.

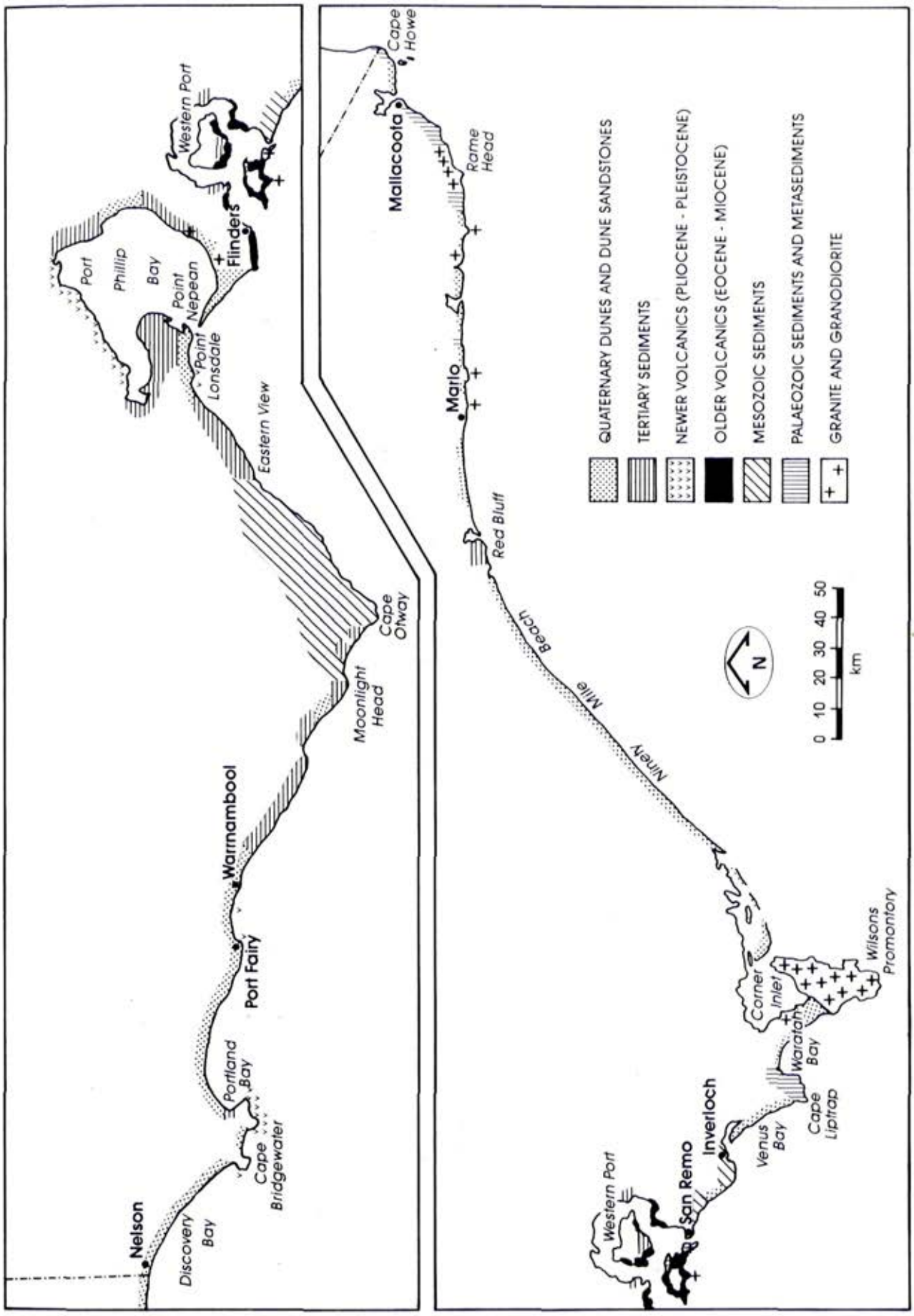
Similar sediments occur in the Strzelecki Group of the Gippsland Basin, with minor coal measures in the Wonthaggi area. The Group is

Table 3.1: Summary - Coastal Geology of Victoria

Era	Period	Age (m.yr)	Epoch	Coastal geology
CAINOZOIC	Quaternary	0.01	Holocene	Modern beaches, dunes, saltmarshes Swamp peats, especially Westernport Tower Hill tuff Tyrendarra lava flow
			Pleistocene	Dune calcarenites mainly west of Wilsons Promontory Quartzose sands of Gippsland coast Quartzose sands of Port Phillip Bay and Western Port Silty clays of the Bellarine Peninsula Older alluvium in bays and inlets Newer Basalt of Portland area and the Western District, extending south of Geelong and to the west coast of Port Phillip Bay
		1.8		
	Tertiary		Pliocene	Ferruginous sands and sandstones (e.g., Baxter Sandstone) around Port Phillip Bay and Western Port, and in East Gippsland Maretimo clays and early Newer Basalts in the Portland district
		5		
			Miocene	Balcombe Clay on the Mornington Peninsula Fyansford Clay and Curlewis Limestone on the Bellarine Peninsula Clays and sandy limestones at Torquay Clays near Princetown overlain by the Port Campbell Limestone, extending west to the Warrnambool district Portland Limestone Final flows of the Older Basalt
		24		
			Oligocene	Point Addis Formation, passing laterally from limestone to clay near Torquay, and resting on the Angahook Formation, which shows lateral transition from sand and clay at Anglesea through volcanic rocks at Aireys Inlet to limestones near Torquay Some Older Basalt
		37		
			Eocene	Anglesea Sand, with organic sandy beds at Demons Bluff Major Older Basalt flows of south-east Mornington Peninsula and Phillip Island
		58		
			Palaeocene	Eastern View Coal Measures at and west of Anglesea Grits, sandstone, and clays between Moonlight Head and the mouth of the Gellibrand River
		66		
	Cretaceous			Sandstones (arkoses) and mudstones of Otways and South Gippsland (San Remo; Kilcunda; Cape Paterson—Andersons Inlet), with minor outcrops in Port Phillip Bay and Western Port
		133		
MESOZOIC	Jurassic			Not represented
		204		
	Triassic			
		250		
PALAEOZOIC	Permian			Not represented
		295		
	Carboniferous			Not represented
		354		
	Devonian			Intruded granites of Wilsons Promontory, Cape Woolamai, East Gippsland, and granodiorites of the Mornington Peninsula Liptrap Formation and Cape Liptrap, and Bell Point and Waratah Limestone at Walkerville
		410		
	Silurian			Sandstone Island and Golden Point, Western Port
		434		
	Ordovician			Limestones and shales near Walkerville Shales and sandstones of the East Gippsland capes
		500		
	Cambrian			Greenstones near Cape Liptrap
		580		
PRE-CAMBRIAN				Not represented

Source: Modified from Bird (1981)

Figure 3.1: Simplified Coastal Geology



particularly well exposed along the coast from Inverloch to San Remo. Its major structural features trend north-east, paralleling trends in the Otway Group.

Tertiary stratigraphy indicates the change from marine to terrestrial/coastal depositional environments, reflecting changes in relative sea level over time. An angular unconformity separates the Otway Group from the Tertiary limestone and marl of the Heytesbury Group. These sediments, exposed on the coast west of Moonlight Head, record the sequence of marine transgressions and regressions occurring from the Middle Palaeocene to the Late Miocene. Similar sediments were deposited in the Torquay Basin on the eastern flank of the Otway Group. Tertiary sediments outcrop on structural highs around Port Phillip and Westernport Basins. Sediment type again reflects marine transgressions and regressions, resulting in marls, clays, and sandstones. Basalt, agglomerate, and tuff of the Older Volcanics represent volcanic activity during the Eocene to Miocene, outcropping over the southern Mornington Peninsula, Phillip Island, and French Island.

While significant sediment accumulation and subsidence resulted in a thick terrestrial—marine sequence in the Gippsland Basin, little Tertiary outcrops along the coast.

Quaternary dune formations are mainly calcareous west of Wilsons Promontory, including the extensive calcarenites of the Nepean Peninsula and Warrnambool—Portland coast. East of Wilsons Promontory, quartzose dunes predominate, including the multiple barrier formations of Corner Inlet and the Gippsland Lakes. Newer Volcanics of Plio—Pleistocene age border the western shore of Port Phillip Bay and outcrop on the coast at Portland and Port Fairy. Holocene sand and mud deposits are extensive within Western Port and Corner Inlet. Swamp deposits form in back barrier depressions all along the coast.

GEOMORPHOLOGY OF THE VICTORIAN COASTLINE

The landforms include a variety of geomorphological features that evolved as a result of interactions between geological factors and coastal processes such as ocean swell, storm waves, wind, current, and tidal activity.

In the west, from Nelson to Cape Otway, Victoria has a relatively high-energy coast, subject to consistent south-west wind and swell wave activity generated in the long fetch of the Southern Ocean. Local south-east wind seas are of minor importance. This produces a significant west to east littoral drift.

The centre, from Cape Otway to Wilsons Promontory, has a more variable wave-energy climate. The effects of south-west swell waves are reduced by refraction and the sheltering effect of Cape Otway and King Island. The coast from Cape Otway to Point Lonsdale is aligned south-west to north-east, so refraction reduces incoming swell waves. The coast between Point Lonsdale and Wilsons Promontory, being aligned roughly parallel to incoming swell waves, has relatively higher energy. Within Port Phillip Bay and to a lesser extent Western Port, local wind waves predominate.

Wilsons Promontory and the Bass Strait islands largely protect the coast east of the Promontory from south-west swell waves. Consequently, local west to south-west wind waves combine with the less frequent, but larger east to south-east swell waves generated by Tasman Sea low pressure systems. Littoral drift moves large volumes of sand in either direction.

Apart from wave generation, wind influences coastal geomorphology through the development of extensive dune systems on barrier coasts such as the East Gippsland barrier, and their subsequent modification by blowouts. Other variations in coastal morphology relate to contrasts in tide range. A large tidal range implies a broad intertidal zone. Waves expend energy in traversing such a broad shore zone and those reaching the backshore at high tide are much diminished by friction in the shallows. Where tide range is small, wave energy is concentrated at a more consistent level, facilitating cliff erosion.

The coast can be divided into several geomorphic units, listed below from west to east. Localities are shown on Figure 3.1

Discovery Bay

This 50 km, gently curved, sandy bay is broken in several places by headlands of outcropping Pleistocene calcarenite, with shore platforms forming at the base. These headlands, such as Nobles Rocks, have calcarenite overlain by unconsolidated sands with a well-formed soil horizon capping the sequence.



Quaternary dunes, Discovery Bay.

Dating of Aboriginal middens from this soil horizon gives an age of approximately 8000 years before present.

Immediately behind the coast lies an extensive dune system with local calcarenite outcrop. Dunes in the western section of Discovery Bay are mostly vegetated while the central and eastern sections contain large areas of naturally occurring, bare, mobile dunes. These extend more than 1 km inland and to 40 m high, with a swamp or lake present at their inland edge.

At several locations along Discovery Bay, 5000- to 6000-year-old peat outcrops on the beach. It would have formed in a back barrier swamp or lake, similar to the present-day Bridgewater Lakes—Long Swamp situation, which implies that the sea must have been at some distance during the peats' formation. Hence, the peat or back barrier depression/swamp was separated from the sea by at least one dune ridge that has since been eroded. Present-day erosion has formed 15 m high cliffs in the Descartes Bay area.

Bridgewater Promontory

The promontory consists of several ancient volcanic systems. Volcanoes are coincident with Cape Bridgewater and the remnant caldera with Nelson Bay. Basalt and tuff capped by calcarenite and unconsolidated dune sands form the high, vertical cliffs of the promontory. Only minor, narrow shore platforms have formed at the base. The cliff-top dunes developed through wind and wave action transporting sand until it formed a ramp against the cliffs. Wind action then carried the sand up and over, creating an elevated dune-field, now left stranded by erosion of the sand ramp. Lawrence Rocks, offshore of Point Danger, are eroded basalt remnants of previous volcanic eruption centres.

The curved Bridgewater Bay has formed between the two main volcanic centres. Its western end is partly sheltered from the prevailing south-west swell, but increased wave and wind energy toward the east result in a large blowout dune system at its eastern end. Along most of the beach, a high-erosion scarp has formed at the seaward face of the primary dune, indicating long-term erosion. Within this framework, shorter cycles of stability or accumulation may occur. Local outcrops of calcarenite form cliffs and small headlands with associated well-developed shore platforms.

Portland Bay

As at Bridgewater Bay, wave energy increases to the east along Portland Bay as the coast is increasingly exposed to the predominant south-west swell. Portland Harbour has developed in the sheltered lee of the Bridgewater Promontory, and its long main breakwater has trapped large volumes of sand along the outer edge. Large sections of the coast downdrift of the Harbour have suffered extensive erosion.

The dune system increases in height and width progressively toward the east, reflecting the increase in wind and wave energy and sediment supply. Unlike the coast to the west, a near-continuous vegetation cover stabilises the dune systems, limiting the extent of blowout dunes to the Cape Reamur area.

Like Discovery Bay, Portland Bay is 'anchored' at its eastern end by basalt of the lava flow that filled the ancestral Moyne River. Extensive unconsolidated dune sheets and Pleistocene calcarenite have accumulated on the western side of this basalt promontory as a result of the predominant west to east littoral drift. Cliffs and shore platforms have formed in the calcarenite. Lady Julia Percy Island is an eroded basalt remnant of a former volcanic eruption centre.

Port Fairy—Warrnambool

Port Fairy Bay is partly sheltered from the predominant south-west swell by Griffiths Island, allowing port development. The Moyne River training walls and channel-dredging have restricted west to east sediment movement. A loss of sand along Eastern Beach, Port Fairy, accompanies accumulation of sand adjacent to the training walls.

Killarney beach is protected by a natural offshore basalt reef, allowing for low inshore

wave energy and subsequent beach accumulation. Further east toward Warrnambool, the beach is exposed to higher wave energy, forming a wide dune barrier system with many ancient and active blowout dunes. Extensive outcrops of Pleistocene calcarenite, forming spectacular cliffs and shore platforms, 'anchor' the beach at its eastern end near Warrnambool. This calcarenite has a similar geomorphic role to the basalt at Port Fairy.

Warrnambool—Moonlight Head

Lady Bay, Warrnambool, is partly sheltered from the prevailing south-west swell by Thunder Point. This natural shelter has been improved by the construction of Warrnambool Harbour breakwater. Sand accumulation within the breakwater's wave-shadow area has created 11 ha of land, and water depths have significantly decreased.

East of Warrnambool, the coast changes from wide beaches with high, grassed dunes to 30—60 m high vertical cliffs and associated narrow shore platforms cut in Pleistocene calcarenite or Miocene limestone. Cliff profile varies with rock type: unlike the vertical profiles above, limestone overlaid by softer



Tertiary sediments, Loch Ard Gorge.

Pliocene sandy clays forms a bevelled cliff-top. These cliffs are actively eroding, as indicated by regular block slumping as a result of wave undercutting and the collapse of London Bridge in 1990.

High wave energy along this coast is related to the orientation of the coast to the south-west swell and the narrow, steeply shelving offshore profile. Vertical jointing controls erosion of the relatively soft sedimentary rock. Solution along the joints produces numerous caves, sink holes, offshore stacks, and reefs.

Coastal sediment accumulation is restricted to the heads of small coves or areas sheltered by offshore reefs, such as at Peterborough.

Moonlight Head—Eastern View

The predominantly cliffed coast from Moonlight Head to Eastern View has a rugged hinterland of Lower Cretaceous Otway Group sandstones. Many youthful streams emerge at the coast and those with deeper valleys, such as the Aire and Erskine Rivers, are infilled with estuarine lagoonal and alluvial deposits. Vertical cliffs are developed at Castle Cove and around Cape Otway. Steep, rugged, vegetated cliffs form the rest of the coastline. Extensive shore platform development occurs throughout the Otway region. The general straightness of the coast from Cape Otway to Lorne is due to the major offshore Torquay Fault.

Large deposits of calcarenite have accumulated on the updrift (western) side of Cape Otway. Along the eastern side, Holocene dunes are found at a few restricted locations such as Apollo Bay and Lorne. Here, structural movements within the bedrock have formed depressions enabling the deposition and preservation of sediments. Local beach accumulation has occurred downdrift of the Apollo Bay harbour. Natural infill of the harbour entrance due to the net northerly littoral drift requires regular dredging. Dredge spoil disposed on the outside of the lee breakwater over the years has resulted in the extensive accumulation of the beach and the creation of 8 ha of land.

Eastern View—Point Lonsdale

Analogous to the Warrnambool—Moonlight Head stretch, the coastline from Eastern View to Torquay has high vertical cliffs cut in Tertiary marine limestone and marl dominating. This has lower wave energy than the coast west of Cape Otway, which allows

for beach and dune accumulation at the base of cliffs in such areas as Eastern View and Fairhaven. Protruding headlands such as Point Addis and Urquharts Bluff are subject to active wave undercutting and consequent block slumping. At Split Point, Aireys Inlet, a shore platform has developed in Older Volcanics basalt with the overlying Point Addis Limestone forming vertical cliffs.

Land elevation decreases east of Torquay, allowing beach and dune barrier systems to form sub-parallel to the prevailing south-west swell. These broadly curved beaches are 'anchored' by the resistant calcarenite headlands of Barwon Heads and Point Lonsdale. Shore platforms front the headlands.

Low bluffs and shore platforms have formed in the Newer Volcanic basalt at Breamlea. The Barwon River entrance has formed in the sheltered lee of Barwon Heads. The Barwon River estuary, including the relatively low-lying Lake Connewarre, is the largest estuary in western Victoria, extending 10 km upstream.

Port Phillip Bay

The geomorphology of the eastern Port Phillip coastline differs from the western, due to the configuration of the bay and unequal distribution of local wind-generated waves. Broad, well-sorted, sandy beaches, shore platforms, nearshore bars, steep cliffs and a predominance of erosion characterise the eastern, Nepean Peninsula. By contrast, narrow, poorly sorted, shelly, sandy beaches, low cliffs, and sediment accumulation characterise the west coast.

Along its southern section, the Nepean Peninsula has sandy beaches interrupted by cliffs, headlands and shore platforms of calcarenite, with a complex system of nearshore bars between Blairgowrie and McCrae. Steep cliffs and narrow shore platforms have formed in the Mount Martha Granodiorite. North from Mount Martha to Frankston, small sandy embayments occur between rocky headlands and cliffs of Miocene, iron-cemented Baxter Sandstone. Carrum Swamp, in the depression from Frankston to Mentone is bordered along the coast by a 600 m wide dune barrier system with a broad continuous beach and complex nearshore bar system. Local erosion occurs adjacent to drainage outlets such as Mordialloc Creek due to the interruption of the natural littoral drift by training walls or by dredging activities.

From Mentone to Brighton, non-continuous beaches alternate between Pliocene Brighton Group sandstone cliffs. The iron-cemented Black Rock Sandstone forms the cliff base, shore platforms, and nearshore reefs, and underlies poorly consolidated, easily eroded Red Bluff Sands. Towards Port Melbourne, the coast is relatively low-lying, with wide sandy dune barrier systems present. Large accumulations of sand have formed in the lee of Sandringham, Brighton and St Kilda breakwaters, resulting in erosion of adjacent beaches.

Port Melbourne marks the change of character. Narrow sandy beaches stretch continuously in the north from Williamstown to Corio Bay, forming a veneer over the Newer Volcanic basalt. Basalt nearshore reefs lie off Point Cook, for example. Low cliffs cut in alluvial silts adjoin Werribee River. Along the Bellarine Peninsula from Geelong to Portarlington, narrow beaches front cliffs and shore platforms of Tertiary sands, basalt, and minor calcareous clay. South of Portarlington, the beaches are wider and better sorted, due to increased exposure to waves. Local low headlands, cliffs and nearshore reefs of Pliocene sandstone occur at Indented Head and St Leonards.

Extensive mud flats have formed in the lee of the calcarenite sandy barrier of Queenscliff—Swan Island. Sand has accumulated naturally south of the Queenscliff Creek training walls, while dredge-spoil disposal north of the creek has created the 21-ha Sand Island. Erosion along the eastern coast of Swan Island has been a long-standing problem.

Point Nepean—Flinders

From Point Nepean to Rye ocean beach, the coast is dominated by Pleistocene calcarenite and overlying Recent unconsolidated sand dunes with intercalated soil horizons. The calcarenite forms extensive cliffs, headlands, wide shore platforms, and nearshore reefs. Weaknesses within it have been excavated by wave action, and the resultant embayments contain sandy beaches. Beyond Rye ocean beach, calcarenite forms only local cliffs and shore platforms, and a wide sand-dune system predominates.

Immediately north-west of Cape Schanck at Rowley Cove lies the Selwyn Fault. Movement along the fault has resulted in the relative uplift to the east. Consequently,

calcarenite and unconsolidated sands overly the Eocene Older Volcanic basalts from Cape Schanck to Bushrangers Bay. Extensive high cliffs, stacks, and shore platforms of basalt occur along the Cape Schanck—Flinders coast.

Westernport

The south-western entrance to the bay has relatively high wave energy and consists of basalt cliffs and rocky shores with sectors of sandy beaches. From Somers to Sandy Point, a predominant easterly littoral drift has led to the accumulation of sediment forming the parallel dune ridges of the Sandy Point promontory. In recent years, the Somers—Sandy Point coast has changed from this generally accumulating coast to one that suffers net erosion.

Mangrove-fringed saltmarsh occupies the northern and western lower-wave-energy environments of the bay. At their seaward end, the mudflats descend steeply into deep tidal channels, scoured out by strong tidal currents. Tidal currents as well as wave-induced currents exert a major influence on sediment transport patterns. In the north-east, the tidal watershed has a large area of seagrass covered by recently deposited sands and mud. These sediments have eroded from incised streams as a result of swamp reclamation.

Considerable erosion of the Western Port coastline has followed dieback and clearing of the mangrove fringe. The low earth cliffs fronting Koo-Wee-Rup Swamp have eroded. The poorly consolidated Pliocene sands at Red Bluff have also eroded due to wave attack and surface gullying of the cliff face.

The southern, high-wave-energy ocean coast of Phillip Island consists of cliffs and well-developed shore platforms cut into the Older Volcanic basalt with intervening sandy embayments. Cobble beaches may occur locally. Cliffs cut in Cape Woolamai granite show the formation of jagged rock stacks through erosion along joints. A sandy isthmus joins Cape Woolamai with the main Phillip Island.

In contrast to the open ocean coast, the low-wave-energy north-east Phillip Island coast from Rhyll to Newhaven is accumulating, with widespread mangrove swamps and mudflats. Observation Point, an eastward-migrating sandy spit, receives sand from the coast and offshore area west of Cowes. The coast east of Cowes consists of narrow beaches with intervening headlands and shore platforms of Older Volcanic basalt and associated sediments. The Nobbies and Seal Rocks are eroded outliers of basalt.

At the eastern entrance of Western Port, an active blowout dune delivers sand from the Cape Woolamai isthmus to an accumulating shoreline on the shores of Cleeland Bight. A combination of wave action and inflowing tidal currents has transported this sand around the Bight.

Although the southern coast of French Island has higher energy than the northern, it is still largely sheltered from ocean swell. It comprises cliffs and shore platforms cut into basalt, local Lower Cretaceous sandstone, and overlying Pliocene sands, while saltmarsh and mangroves dominate the north coast.

San Remo—Inverloch

High vertical cliffs, stacks, and associated shore platforms of Lower Cretaceous Strzelecki Group sandstone outcrop along the coast from San Remo to Kilcunda and from Coal Point to Petrel Point. A long continuous stretch of beach backed by dunes occurs between Kilcunda and Coal Point, with bare, mobile dunes present toward Coal Point. The Powlett River forms an estuary in the back barrier depression east of Kilcunda.

From Petrel Point to Andersons Inlet, the coast consists of a sandy beach backed by vegetated low dunes with a sandstone shore platform present in the intertidal zone. At Andersons Inlet, a shallow tidal estuary, tidal scour maintains the entrance, although this and the delta sand bars are mobile and may undergo significant lateral variations. The inlet is bordered by low-lying sandy beaches, saltmarsh, mangroves, and intertidal mudflats.

Venus Bay

The broadly curved Venus Bay is a relatively high-energy coast, forming sub-parallel to the predominant south-west swell. Regularly spaced rip currents occur along the beach. A wide dune system, with several modern active and ancient vegetated blowout dunes extending inland, backs the sandy beach, which is 'anchored' at its southern end by the hard rock Cape Liptrap.

Cape Liptrap

Extensive shore platforms and high cliffs cut into thinly bedded sandstones and siltstones of



Folded Palaeozoic sediments, Cape Liptrap.

the Liptrap Formation mark the west and south coasts of Cape Liptrap. Its east coast has a more varied geology, with low cliffs, shore platforms, and small islands of Cambrian greenstone and Ordovician to Devonian limestone.

Waratah Bay

As Cape Liptrap's shelter from the predominant south-west swell decreases, wave and wind energy, and coincidentally, dune barrier height and width increase to the south-east along Waratah Bay.

The entrance to Shallow Inlet is permanently open to the sea, but alters its position cyclically under the influence of the west to east littoral drift. This causes periodic high rates of erosion on the eastern side. Shallow Inlet has a wide swamp and mudflat shoreline.

Wilsons Promontory

The large Upper Devonian granitic massif of Wilsons Promontory is joined to the mainland by the Yanakie Isthmus. The isthmus consists of Pleistocene to Recent sand dunes on the surface, but with Palaeozoic bedrock intermittently below that sand.

Along the west coast north of Darby River, an erosion scarp borders the seaward edge of the dune and underlying calcarenite. Peat also outcrops along the beach, indicating long-term erosion along this coast, as at Discovery Bay.

Wilsons Promontory and surrounding islands exhibit steep rocky coasts plunging into deep water. Large boulders may occur along the cliff base, but few shore platforms have developed. The promontory forms a natural barrier to nearshore sediment movement between western and eastern Bass Strait. It is the major divide between quartzose sediments to the east and calcareous sediments to the west. Protruding granitic headlands confine pocket beaches at the head of embayments and preclude much sediment transport between them. Wide dune sheets with blowout dunes on the west coast, such as at Oberon Bay, contrast with large swamp deposits behind the narrow beach barriers on the east coast, such as at Sealers Cove and Five Mile Beach.

Corner Inlet

This large tidal inlet is protected from the ocean by a dissected dune barrier; it has five permanently open entrances with associated large sandy tidal deltas. The outer barrier is generally low-lying and narrow with the eastern section suffering long-term erosion, as indicated by the formation and maintenance of a new entrance when storm waves breached the barrier near McLoughlans Beach in recent years.

Islands in the inlet, such as Snake and Sunday Island, are generally eroding on the west, being exposed to local westerly wind waves, and accumulating via mangroves and saltmarsh on their eastern shores.

Similar to Western Port, Corner Inlet has mangrove-fringed saltmarsh in the lower-wave-energy environments. At their seaward end, the mudflats descend steeply into deep tidal channels, scoured out by tidal currents. Prevailing south-west winds deliver sand to the inlet's western shore, via the active blowout dunes on the Yanakie Isthmus, which is dispersed by tidal currents and wave action to form intertidal shoals.

Ninety Mile Beach

A NE—SW orientated beach extends from Corner Inlet to Red Bluff, broken only by the artificial entrance at Lakes Entrance. The Ninety Mile Beach fronts the Gippsland Lakes, a 400 sq.km system of coastal lakes. During the Quaternary, at least three major barrier systems were built, the present outer barrier representing the most recent system.

Its southern end, near McLoughlans Beach, is suffering long-term erosion with an erosion scarp cut into the wide dune ridge system. The dune ridges are not parallel to the coast and this, combined with the extensive erosion, indicates long-term natural coastline realignment.

Only a narrow, single dune barrier runs from Jack Smith Lake to Seaspray. The dune ridge fronts a wide, flat, low-lying coastal plain with an ancient shoreline, marked by a bluff cut in Pleistocene sediments, up to several kilometres inland.

The barrier widens as the number of dune ridges increases eastward toward Delray Beach. West of Ocean Grange, numerous recurved spits and flood-tide deltas mark previous lake entrances. Bunga Arm is the result of eastward spit growth leaving a narrow, abandoned Holocene barrier abutting Boole Poole Peninsula. These Holocene features - together with modern measurements of waves, nearshore currents, and the eastward offset of the Lakes Entrance ebb-tidal delta - indicate a net littoral drift from west to east. Significant periods of reversal would also occur.

The continuous beach is broken only by Lakes Entrance and Red Bluff at its eastern end. The artificial entrance there, constructed in 1889, has formed a large ebb-tidal delta and extends over 500 m offshore. Dredging is required to maintain a navigable entrance through the bar as well as clear sand deposited inside as a flood-tidal delta. Red Bluff is an abandoned coastal cliff of Lower Pliocene calcareous silty sand, marl and shell beds of the Jemmys Point Formation.

A well-formed, shore-parallel longshore bar and trough occur in the nearshore zone along the beach. Depending on incident wave conditions, rhythmic features such as beach cusps, rips, and crescentic bars may form.

Red Bluff—Marlo

The narrow outer barrier of the Ninety Mile Beach continues eastward of Red Bluff to Marlo, at the mouth of the Snowy River. Immediately east of Red Bluff lies Lake Tyers, an estuary formed by the flooding of former river valleys. Like other East Gippsland estuaries, it is not continuously open to the sea: the stability of its entrance depends on river flow and longshore sediment supply. The orientation of the coast changes to an east—west alignment near Marlo. The wide back dune depression/swamp of Ewings Morass occurs behind the high, single dune barrier. Narrow dune blowouts orientated north-east dissect the barrier, causing sand encroachment over the swamp.

The mouth of the Snowy River varies over a distance of 3 km. Due to the influence of the predominant west to east littoral drift, the entrance migrates eastward. When the river gradient becomes too low to maintain a natural entrance, a new entrance is cut during flood events, west of the old one.

As on the Ninety Mile Beach, the nearshore bar system varies from a longshore bar and trough to a more rhythmic bar, rip, and cusp, depending on incident wave conditions.

Marlo—Rame Head

While the east—west coastal orientation continues, the width of dune ridges increases significantly east of Marlo. Ancient vegetated, as well as modern, natural, bare, mobile blowout dunes extend up to 1 km inland. The blowout dunes are orientated north-east. Sediment is passed around Point Hicks via one of these large blowout dunes, which feeds sand blown from the west into the lower reaches of the Thurra River. This overloads the river with sediment, changing it into a braided stream. During high river flows, the sand is then transported to the coast east of Point Hicks.

Hard Lower Devonian granite and Ordovician quartzite and phyllite form protruding headlands and associated narrow shore platforms, as at Cape Conran, Point Hicks, and Rame Head. The large Bemm and Cann River systems have large estuaries in back barrier depressions, such as Sydenham and Tamboon Inlets. The entrances to these estuaries migrate to the eastern end of their embayment and are often closed. Floods may break through again, west of the previous entrance.

As on the coast to the west, the nearshore bar system varies from a longshore bar and trough to a more rhythmic bar, rip, and cusp, depending on incident wave conditions.

Rame Head—Cape Howe

From Rame Head to Mallacoota, the coast changes orientation abruptly, trending north-east. This results in a relatively low-wave-energy and sediment-deficient rocky coastline. Hard Devonian granite and Ordovician quartzite and phyllite dominate the coastal geology, with only minor development of bare or vegetated dune systems.

Wingan Inlet is unique, occupying a sheltered embayment in the lee of Rame Head to the west and The Skerries islands to the east.

Mallacoota Inlet - a large estuary formed by the flooding of the former Genoa River valley - has a sandy barrier and dune system at its permanently open mouth. The inlet entrance is a highly variable and dynamic system, with its location varying across 1 km east of Bastion Point. Large dune systems east of Mallacoota include cuspate spits in the lee of granitic Tullaberga and Gabo Islands. Extensive back dune swamps and lakes are also present.

Between Gabo Island and Cape Howe, large mobile transverse dunes occur, with crests at 40—60^{0} to the coast. The dunes are migrating inland as well as supplying sediment to the New South Wales coast.

MARINE GEOLOGY

Much of the coastline and the immediate hinterland can be reached by car and can be inspected on foot and as such is relatively well known. By comparison, mapping the geology of the sea floor requires boat transport, and the depth that divers can readily inspect is limited to less than 40 m. It is possible to collect information using other techniques, such as devices that retrieve samples from the sea floor, remote-sensing equipment like video cameras, and various ship-borne or air-borne meters that record the properties of the rocks lying below the sea. As the major bays and inlets are shallow and easily accessible, they are cheaper to survey, and the need for dredging or effluent disposal makes it an economic and environmental necessity to record the sea-floor geology.

Knowledge of the geology of the sea-floor surface is important for a variety of reasons. The nature of the surface layer influences the biological communities present. Muddy sediments, for example, have different spaces between the grains and are, in most instances, less abrasive than sandy sediment; hard rock reefs have different surface characteristics according to their geology, and can vary from relatively smooth to those containing numerous cracks or crevices that may provide suitable habitat for animals such as the rock lobster. The presence of rock outcrops will determine: the suitability of an area for different commercial fishing techniques; the nature of load bearing foundations required for structures; or the ease with which areas can be dredged.

Subsurface geology of sea-floor off the open coast is generally only known as a result of oil exploration and production.

Sea-floor surface geology - open coast

The surface of the sea floor varies from rock to unconsolidated surficial sediments, which may overlay a consolidated substrate.

In general terms, the geology of the rocky sea floor near the coastline will reflect the geology of the coastline itself. For example, the reefs off the southern end of Wilsons Promontory are likely to consist of granite (the rock presence on the promontory shoreline and the adjacent islands), whereas those in Portland Bay are likely to consist of basalt or limestones. While reef distribution within about 1 km of the coast is reasonably well known - from mapping reefs of interest for commercial abalone harvesting - we know little about the distribution of rocky sea floor for Victorian territorial waters as a whole. Figure 3.2 (see over) shows the nature of the sea floor for major regions of Bass Strait and along the State's western coastal margin. It must be emphasised that this is a very generalised description, and that other rocky sea-floor areas (such as the Gippsland coast) are also known, but the detail of the rocky outcrops of these areas have yet to be systematically mapped.

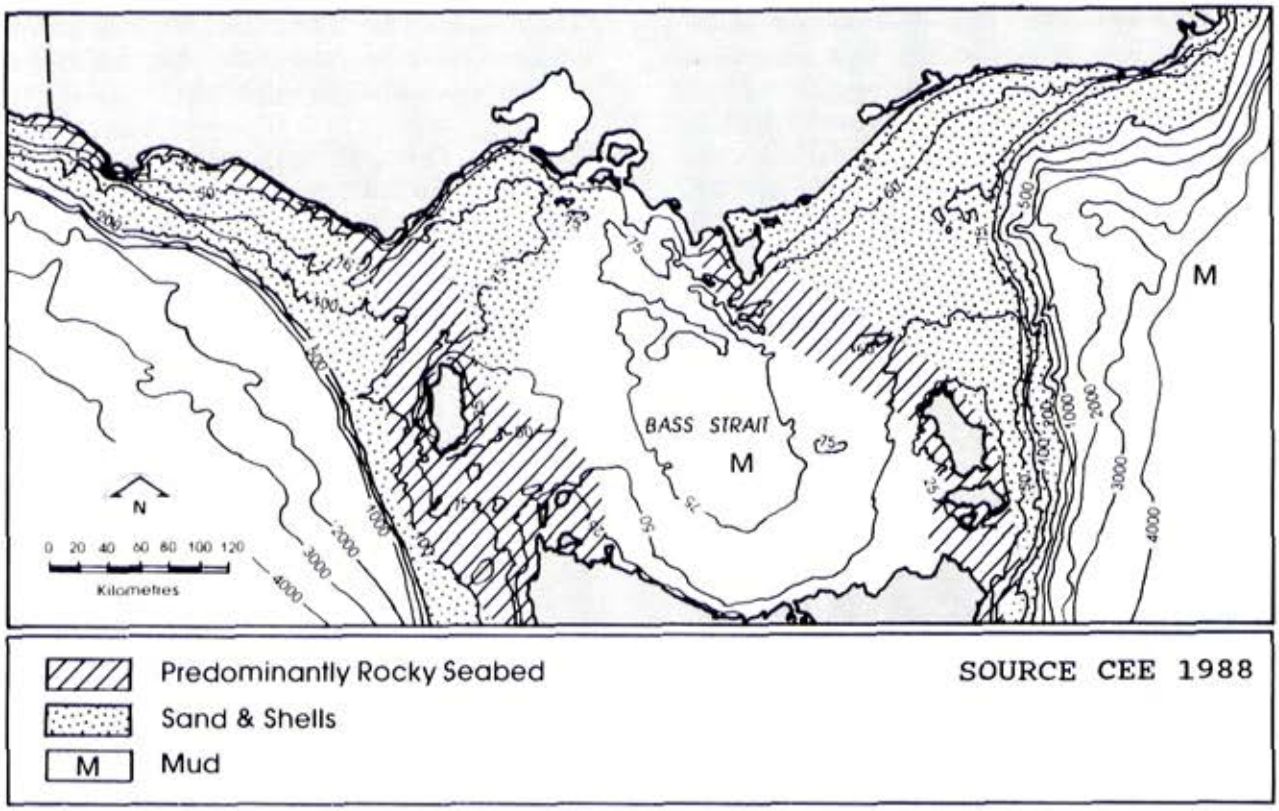
Very broad-scale surveys have shown the general nature of surficial sediments in Bass Strait. These sediments are derived from various sources, including biological detritus consisting of shelly debris. One of the best areas sampled for its surface sediment is off east Gippsland, where 52 samples were collected from an area of 83 km (along-shore) by 30 km (off-shore), giving a sample density for the area of 1 for about every 50 sq. km.

Black (1992) summaries the sediment particle-size distribution for much of Bass Strait. The data indicate high gravel contents in areas of rocky sea floor around King Island, north-west of Tasmania, and in a band that extends to the north-west of Flinders Island. Central Bass Strait has fine and muddy bed sediments, whereas fine to medium sand occurs along the Gippsland shelf and near the coast between Cape Otway and Port Phillip Bay.

Surface geology of the major bays

The surface geology here is dominated by a diverse range of sediment size types and these have been described by Bowler (1966) for Port Phillip Bay, Marsden and Mallett (1975) for Western Port, and in a 1989 report to the DCE Yarram region, Rosengren, for Corner Inlet/Noorumunga.

Figure 3.2: Generalised Sea-floor Surface Geology



COASTAL STABILITY

From a geological and geomorphological perspective, two aspects of coastal stability have a range of implications for coastal planning: the susceptibility of the coast to mass movement and to inundation.

Susceptibility to mass movement

The coastline is a dynamic environment, with cliffed coastlines as well as sandy beaches having the potential to change over time. Of these, steep coastal slopes, or sea cliffs, are the most prone to mass movement and therefore may constitute a hazard to human safety and have implication for a range of uses involving the use of cliff-tops or the areas beneath them.

Steep slopes are widely distributed along the Victorian coast, mainly from Wilsons Promontory to the west. Steep rock slopes are restricted in east Gippsland, apart from a major occurrence between Mallacoota and Sand Patch Point. Temporary steep slopes in eroded or active costal dunes and sand barriers occur on the Ninety Mile Beach and other areas of Croajingolong, but - because of their low height, slope generally below 40^{0}, and the absence of hard rock material - are deemed a minor hazard and are not further considered here.

Mass movements tend to occur on steep, unstable slopes or cliffs, and more readily in poorly consolidated, uncemented (i.e., incompetent) rock masses. The Tertiary marine and non-marine sediments are among the most susceptible. Potential geological hazards exist along the coast where Tertiary sediments form cliffs in Port Phillip Bay (Beaumaris, Sandringham, and Olivers Hill at Frankston) and Western Port (West Head, Flinders, San Remo, Red Bluff, and Lang Lang). The Tertiary sequences along the coast from Torquay to Eastern View, from Warrnambool to Moonlight Head, and at Portland are also potentially hazardous. In addition, mass movement occurs along the cliffed coastline of Cretaceous Otway Group



Slumped cliff, Childers Cove.

sediments as well as the Cretaceous sandstone cliffs from San Remo to Inverloch. Cliffs cut into more competent rock masses, such as the granite at Wilsons Promontory, are more stable and provide a lesser geological hazard, although individual rock blocks may become detached.

Mass movements vary from small local phenomena to much larger events, with some slumps more than 50 ha in area. Some of these movements, such as rock topple or rock fall, are sudden and catastrophic compared with slumping and creep, which are generally slow, developing over a long period of time.

High rainfall combined with coastal storms are common triggering mechanisms. The rainfall helps to lubricate the planes of weakness along which the rock mass will fail. The coastal storms increase local sea levels due to storm surge and this, combined with higher wave energy, increases the undercutting of cliffs at their base, forming a wave-cut notch: eventually the overhanging cliff face fails and the rock mass catastrophically falls to the cliff base. This is common along the vertical limestone and marl cliffs in the Port Campbell to Peterborough and Anglesea areas. Wave action also tends to remove debris from the cliff base, allowing formation of another wave-cut notch and the cycle repeats itself.

Susceptibility of coastal land to inundation

Coastal areas are susceptible to inundation as a result of the natural flooding processes that effect estuaries and as a result of a possible sea-level rise.

Estuaries

Low-lying land adjacent to estuaries is susceptible to flooding by two processes. The first through the storms within the estuary catchment which lead to rises and falls in water levels that are relatively rapid being usually less than a week of inundation. The second occurs when through the accumulation of sand moving along the coast, the estuary mouth closes. When this occurs water backs up in the estuary and covers adjacent low-lying areas. This is a natural process and the flora and fauna respond as the salinity of the estuary waters is reduced through the addition of freshwater from the rivers that drain to it. High-water levels may persist for months. In some estuaries, such as Lakes Entrance, the entrances are artificially maintained by dredging.

Sea-level rise

Sea levels relative to land at a global scale have changed considerably over the last 100 000 years and will undoubtedly continue to do so into the future. Localised changes may also result from natural geological processes such as uplift of the land or subsidence. Subsidence can also result from cultural processes such as groundwater pumping and collapse of the underlying strata. This process has caused the sinking of Venice.

As explained in Chapter 2, sea level may also change as a result of culturally induced climatic changes. Irrespective of the cause, either a rise or fall and the rate of change have implications for coastal planning, which range from the location of utilities such as ports to the use of foreshore areas and conservation of particular habitat, which may change in size or location. The emphasis to date has been on identifying the potential impacts of a sea-level rise. The effect of such a change will vary along the coast, influenced by factors such as coastal topography, geology, and wave climate.

Areas of potential impact of a sea level rise along the coast have been identified (PMA Coastal Investigations Unit 1992), and the following is summarised from that report. The

Box 3.1 - Common Forms and Examples of Mass Wasting

* Hillside creep, a slow movement of soil material downslope.
* Debris flow, a saturated flow of weathered rock debris - for example, Clarkes Slip, Eastern View.
* Rock block slide, movement of blocks of rock along lubricated planes of weakness - for example, Windy Point, south-east of Lorne; Soapy Rocks, Demons Bluff, and Point Addis, Anglesea.
* Rock topple, blocks of jointed rock fall to the base of the near-vertical cliff - for example, Cumberland River, Lorne; Port Campbell and Anglesea coastlines.
* Slump, with break-up and debris flow of the toe - for example, Wild Dog Creek, Apollo Bay.
* Rock fall, debris fall, rocks, or saturated bodies of rock debris fall down the near vertical cliff - for example, south-west of Cinema Point, near Lorne.

Unit identified areas of high potential impact using existing data which were in quantifiable form and were limited to projected sea-level rises based on current regional-scale prediction models of climate changes.

Modelling of a sea-level rise on various beaches indicated that those west of Cape Otway have the largest recession rates, due to the relatively fine beach sand and the more severe Southern Ocean wave conditions. Shoreline recession rates will also be significant in parts of Port Phillip Bay and Gippsland Lakes, which have a generally narrower beach zone than the open ocean beaches.

Delineated by topographic type, the following locations (not listed in priority order) were identified as areas with potential significant impact.

* Sandy beaches - Middle Park, Brighton, McCrae, Somers, St Leonards, Swan Island, narrow sections of the beach from Aspendale to Carrum, Henty Bay area Portland, Bridgewater Bay, Port Fairy, Lorne, Grantville, and the majority of beaches in the Gippsland Lakes.

* Sandy Barriers - Melbourne Water Corporation Metropolitan Sewerage Farm at Werribee, Cheetham Salt Works at Werribee, Avalon and Point Henry, Ninety Mile Beach fronting Bunga Arm and Jack Smith Lake, Ewings Morass, and low-lying sections of the barrier fronting Corner Inlet.

* Estuaries - Lake Connewarre; Lower Barwon River; Snowy River, Andersons, Shallow, and Sydenham Inlets, and Belfast Lough; Port Fairy.

* Mudflats - Swan Bay, north-east Corner Inlet and low-gradient mudflats in north, west, and eastern sections of Western Port.

* Swamplands - Carrum Swamp and low-lying sections adjacent to the Gippsland Lakes, especially Lake Wellington and the Mitchell River silt jetties.

* Cliffs - Tertiary sedimentary cliffs at Sandringham, Beaumaris, Torquay to Fairhaven, and Pebble Point to Warrnambool; and the calcarenite cliffs Portsea to Sorrento, and Warrnambool. In general, impacts will be slower on cliffs than on the more dynamic, variable landforms listed above.

The study also identified other smaller sites with potentially local impacts.

SITES OF GEOLOGICAL AND GEOMORPHOLOGICAL SIGNIFICANCE

Features of special scientific or educational value form the essential basis of geological education, research, and reference. They are often of particular interest to the public and some, like the Twelve Apostles, may identify sections of the coast for tourists.

As part of its ongoing Victoria-wide review, the joint Geological Society of Australia/Geological Survey of Victoria committee compiled a list of sites of significance along the Victorian coast. The committee consisted of the Geological Heritage Subcommittee of the Society's Victorian Division, and personnel from the Geological Survey of Victoria, Department of Energy and Minerals. This committee reached consensus on sites only after consultation with the wider geological community.

Features were collated from published reports and the files of the Survey. Most of these earlier reports dealt with sections of the coast and did not have the advantage of a complete listing of coastal sites to assist in assigning significance ratings. The joint committee has



Tamboon Inlet, site of State geological and geomorphological significance.

reviewed the significance of each site and, in many cases, has downgraded it from the rating previously published. The sites are listed in Appendix I and shown on Map 1.

As the compilation is based on existing records which generally only cover the intertidal zone and above, no systematic assessment of subtidal features along the open coast was possible.

Significance is ascribed at several levels:

International significance pertains to landforms, structures, and rock formations that are rare in the world, or that, by the nature of their scale, state of preservation, or display, are comparable with other internationally known sites.

National significance indicates a feature unique or unusual in Australia that has been so little disturbed as to clearly display the site properties. These relatively pristine features can contribute to research into the Australian earth sciences.

State significance describes features important in the context of developing the geological and geomorphological understanding of Victoria.

Regional/Local significance indicates landforms or rock types important in understanding geology and geomorphology on a regional/local scale and applies to clear examples of common features. Some of the literature reviewed differentiated between regional and local significance, but, due to difficulties in defining uniform regional/local boundaries, the two categories have been combined as in Joyce and King (1980).

Significance rating is a dynamic concept reflecting the level of representation of geological or geomorphological aspects of the particular site. The rating levels must be reassessed from time to time as our understanding of geology and geomorphology changes, as new geological concepts develop, as the needs of the community change, and as sites undergo changes in value due to natural and human activities. It should be noted that the features indicating possible variations in ancient sea levels are now being reassessed due to recent advances in research and new theories regarding variations in sea level over time.

Many larger sites are clusters of smaller sites; that is, several small sites may occur within a larger identified area. For example, Wilsons Promontory National Park as a whole is an identified site of national importance as well as containing many smaller sites of regional/local and State significance. Generally the smaller, individual sites have a significance rating less than the clustered site as a whole. That is, the total geological/geomorphological system, represented by the clustered sites, has greater significance than the sum of the individual ones.

In total, 448 features of geological and geomorphological significance were identified along the Victorian coast. They are rated as follows:

International significance	3
National significance	21
State significance	74
Regional/Local significance	350

These include 18 clustered sites.

ISSUES

* Further information is required on the composition of the seabed and the distribution of sediment types and reefs.

* The protection of significant geological and geomorphological values.

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4. BIOLOGY

This chapter describes the biology of the Victorian coast. It is divided into the following sections:

* Terrestrial habitats and associated flora and fauna
* Marine habitats and associated flora and fauna
* Marine habitats and communities - case studies
* Oceanic birds
* Marine mammals

TERRESTRIAL HABITATS AND ASSOCIATED FLORA AND FAUNA

After identifying and describing broad terrestrial habitat types on the Victorian coast and their associated flora and vertebrate fauna, this section describes available information on sites of biological significance. It is based on a 1993 report by J. Yugovic and others, which - together with all other relevant references - is listed in full in a bibliography available from the Land Conservation Council.

Taxonomy

Plant taxonomy follows the 'Census of the Vascular Plants of Victoria' by Ross, 1990, and subsequent updates by Entwisle. Common names follow the Flora Information System of the CNR.

Faunal taxonomy follows Menkhorst for mammals, Emison and others for birds, and the 'Atlas of Victorian Wildlife' for reptiles and amphibians.

BROAD HABITAT TYPES[1]

Coastal habitats in Victoria are particularly diverse, and include cliffs, dunes, beaches, estuaries, lagoons, and swamps. These reflect wide variations in geology, geomorphology, climate, exposure to wind and salt spray, and tidal regime.

Well over 50 vegetation communities occur along the Victorian coast, but no comprehensive floristic classification of coastal vegetation is available. In many areas, these communities form patterns that are highly intricate compared with hinterland vegetation. Regional studies have often referred to coastal vegetation as 'coastal complex' for simplicity.

A distinction may be drawn between vegetation communities that are intrinsically coastal (comprising species that are highly salt-tolerant and predominantly coastal in distribution), and those that are extrinsically so (comprising plants that are not particularly salt-tolerant or coastal in distribution and that occur on the coast only due to sea-level rise). The latter communities are essentially protected from salt spray. They may occur above high cliffs, such as the heathlands at Anglesea; these heathlands are floristically very similar or identical to those several kilometres or more inland. Similarly, the community referred to as 'coastal heathland' in East Gippsland extends up to 30 km inland, with most occurrences well beyond 1 km from the coast. Very sheltered situations may hold other examples, such as at Sealers Cove at Wilsons Promontory, where forest vegetation reaches the beach. Vegetation not dominated by highly salt-tolerant, predominantly coastal species is referred to as hinterland vegetation in this study, although the communities may have a near-coastal distribution.

While hinterland vegetation may reach the coastline in certain situations, a broad zone of distinctive, intrinsically coastal vegetation generally extends along the entire Victorian coast. Its width is determined by environmental factors such as geology, exposure, and tidal regime, and may vary from a few metres to several kilometres where large estuaries or dunefields occur, but is frequently of the order of 100—200 metres.

The large range of intrinsically coastal vegetation communities in Victoria may be conveniently grouped into several broad habitat types:

1 cliffs/slopes (calcarenite)
2 cliffs/slopes (non-calcarenite)
3 dunes (active, sparsely vegetated)
4 dunes (stable, well-vegetated)
5 mangroves
6 marshes (saline)
7 marshes (brackish/fresh-water)

[1] In this section '*' denotes introduced species.

Box 4.1: Habitat Map

The distribution of the broad habitat types identified in this study is largely based on 'The Coast of Victoria: a Physiographic Atlas' (Edgell *et al.* 1975) but has been modified in the light of the experience of Biosis staff and discussions with CNR regional staff.

Map 2 indicates the broad habitats within the area of intrinsically coastal vegetation which has a seaward limit of beach or mudflat. However, the inland limit may vary considerably with habitat type; it can be the rear of dune scrub, the inland margin of a blowout, or the inland (brackish) limit of an estuary. Hinterland vegetation is extremely varied and includes native vegetation (heathland, woodland, scrub, dry forest, damp forest, wet forest, and rainforest) and exotic vegetation (plantations, cleared agricultural land, and urban areas).

The map shows linear (schematic) representations of habitats. Where more than one habitat is present (for example, dune scrub situated behind a blowout) two parallel lines are drawn. Areas lacking native vegetation (urban areas, pastures, etc.) are left uncoloured.

As previously stated, no comprehensive floristic classification of coastal vegetation in Victoria is available, hence it is not possible to identify and characterise the numerous vegetation communities that comprise each broad habitat type. These communities are described in general terms here and their distribution is shown on Map 2 (and see Box 4.1). Vegetation that is predominantly exotic is not considered here.

Most fauna are not restricted to particular habitat types; this is particularly true for highly mobile species such as birds and bats. The latter species generally need a range of habitats in order to meet all their feeding, roosting, and breeding requirements. Less mobile species such as small mammals, reptiles, and amphibians - which depend on microclimatic conditions and are more susceptible to predation - generally restrict their movements to more densely vegetated habitats. For fauna, habitat preference is often determined by vegetation structure rather than by floristics or geology; hence, the faunal assemblages of cliff-top vegetation (habitat types 1 and 2) are similar to those of stable vegetated dunes (habitat type 4). Furthermore, other than sea-bird and migratory waders, few fauna species are restricted to the coast; most range widely in Victoria.

Despite a severe lack of detailed data on the invertebrate fauna, some information is available on butterflies (Lepidoptera) and jewel beetles (Coleoptera) in coastal habitats. In addition, coastal survey work has been carried out at Anglesea and is currently being undertaken at Point Cook.

The flora and fauna associated with each habitat type are discussed below. Appendix II lists native vascular plant species characteristic of each habitat while Appendix III lists major environmental weeds associated with 'dry' (habitat types 1—4) and 'wet' (habitat types 5—7) coastal vegetation. Fauna utilising the broad habitat types are given in Appendix IV.

Cliffs/slopes (calcarenite)

Cliffs and slopes composed of calcarenite (cemented dune limestone) occur along the coast westwards from Wilsons Promontory. They generally face south-west, indicating recent (Quaternary) origins under prevailing wind directions. Calcarenite typically forms high jagged cliffs and extensive shore platforms and frequently occurs as a capping over other geological formations such as basalt or sandstone. It usually partially underlies unconsolidated sands and thus shares plant species also found in association with sand dunes. Soils developed on calcarenite are strongly alkaline.

Flora

Most plant species typical of sand dunes and non-calcarenite cliffs and slopes occur here.



Calcarenite cliffs, Sorrento.

These include sea box (*Alyxia buxifolia*), white correa (*Correa alba*), coast beard-heath (*Leucopogon parviflorus*), coast tea-tree (*Leptospermum laevigatum*), cushion bush (*Leucophyta brownii*), coast everlasting (*Ozothamnus turbinatus*), and prickly spear-grass (*Stipa teretifolia*). However, in addition a number of shrub species show a marked preference for calcarenite: pale turpentine bush (*Beyeria lechenaultii*), sticky daisy-bush (*Olearia glutinosa*), and thyme rice-flower (*Pimelea serpyllifolia*). Wirilda (*Acacia retinodes* var. *uncifolia*) and moonah (*Melaleuca lanceolata*) are also characteristic of most calcarenite coasts.

Calcarenite cliffs are generally unstable. Apart from cushion bush, few plants grow on the cliff face. The cliff edge is commonly almost unvegetated, due to wind erosion having removed overlying sand to expose a hard calcrete layer. On the cliff-top, low shrubs such as those listed above, in open shrubland formation, grade into a closed scrub. Such closed scrubs largely occur on sand surmounting the calcarenite, and are thus similar to stable dune communities. The scrub dominants vary regionally. In the Portland area, moonah occurs with coast gum (*Eucalyptus diversifolia*), while in the Otways coast wattle (*Acacia sophorae*) and coast beard-heath are co-dominant. From Barwon Heads to Cape Schanck, moonah and coast tea-tree occur in a complex mosaic. Moonah does not occur east of Corinella along the Victorian coast.

Fauna

No fauna species are restricted to this habitat type. Its characteristic unvegetated, unstable cliff faces, and dense cliff-top shrubland form a relatively small proportion of the Victorian coastline; it is utilised by those species with specific roosting/breeding habitat requirements such as bats, raptors, and swallows and martins and by coastal dune scrub species in general.

Calcarenite cliffs provide roosting and breeding sites for the common bent-wing bat, which has only two known maternity caves in Victoria; one of these is situated on the coast near Warrnambool. Mammalian species typical of the cliff-top scrubland include white-footed dunnart, brown antechinus, swamp rat, house mouse*, black rat*, and swamp wallaby. The eastern pygmy possum and common ringtail possum may forage in the canopy layer.

Coastal cliffs provide important breeding sites for the peregrine falcon, and many (although not all) of these are known. Peregrines nest on ledges formed on calcarenite cliffs. The species is not considered to be rare in the State; nevertheless, its nesting site locations are not disclosed by the CNR. A number of bird species may be found in the open scrubland habitats found on calcarenite slopes. These include species preferring scrubby habitats, such as white-browed scrubwren, grey fantail, superb fairy-wren, brown thornbill, silvereyes, beautiful firetail, and the introduced greenfinch*. A range of honeyeater species, in particular the New Holland honeyeater and the singing honeyeater forage in flowering shrubs. Scrub vegetation in general (including calcarenite) is the preferred habitat for the rufous bristlebird.

Among reptile species, the four-toed skink, White's skink, and three-lined skink may utilise calcarenite cliffs and slopes and the blotched blue-tongued lizard and common blue-tongued lizard may visit.

No amphibian species are typical of this habitat type.

Cliffs/slopes (non-calcarenite)

Cliffs and slopes (other than calcarenite) are extensive along several parts of the Victorian coast, including Portland (basalt), Port Campbell coast (limestone), the Otway Ranges (sandstones, mudstones, etc.), eastern Port Phillip with Black Rock (sandstone) and Mount Martha (granodiorite), Phillip Island (basalt), Cape Liptrap (sandstones and mudstones), Wilsons Promontory (granite), and parts of East Gippsland such as Point Hicks (granite), Ram Head (granite), Kilcunda—Cape Paterson (sandstones and mudstones), and Mallacoota (sandstones). These represent a wide range of geological parent materials.

Flora

The vegetation on cliffs and slopes varies considerably in response to factors such as geology, exposure to salt spray and prevailing winds, and cliff morphology. Vegetation patterns are largely determined by the nature of the cliff profile, which is strongly influenced by structural characteristics of the parent rock material (particularly the patterns of jointing) and degree of exposure to wave action. On plunging cliffs such as those at Wilsons Promontory, vegetation is restricted to cliff tops and crevices, but on more gently sloping ones it may be well developed down to the shore platform. Cliffs cut in poorly



Non-calcarenite cliffs, east of Cape Schanck.

consolidated materials frequently have terraced profiles due to slumping.

At the base of cliffs, in or near the splash zone, salt-tolerant herbs may be common. These include rounded noon-flower (*Disphyma crassifolium*), creeping brookweed (*Samolus repens*), and beaded samphire (*Sarcocornia quinqueflora*). Exposed slopes and cliff-tops, such as headlands at Cape Woolamai on Phillip Island, frequently support tussock grassland dominated by blue tussock-grass (*Poa poiformis*) or prickly spear-grass. Cushion bush and bower spinach (*Tetragonia implexicoma*) may be abundant in this community. Cliff-tops often support shrublands dominated by a range of species including sea box, white correa, coast beard-heath, coast daisy-bush (*Olearia axillaris*), and coast everlasting (*Ozothamnus turbinatus*), or scrubs or woodlands dominated by drooping she-oak (*Allocasuarina verticillata*) or coast tea-tree.

Windswept granite islands off Wilsons Promontory support tussock grasslands with blue tussock-grass dominant, and develop low scrub usually dominated by coast tea-tree on less-exposed sites. On Rabbit Island, shrubs such as white correa, coast tea-tree, and coast beard-heath have re-established since the control of rabbits in 1965.

Hinterland vegetation communities, particularly heathlands, may occur within this habitat, in situations largely protected from the effects of salt spray. Heathlands on tertiary sediments are widespread in southern Victoria and in several places reach sea-cliff edges. Limestone cliff-tops of the Port Campbell coast support heaths dominated by prickly tea-tree (*Leptospermum continentale*) and scrub she-oak (*Allocasuarina paludosa*), behind a narrow zone of tussock grassland on the cliff edge with blue tussock-grass and cushion bush dominant.

Heathlands on the Anglesea coast are dominated by species such as heath tea-tree (*Leptospermum myrsinoides*), scrub she-oak (*Allocasuarina paludosa*), silky banksia (*Banksia marginata*), and thatch saw-sedge (*Gahnia radula*). Groves of stunted messmate stringybark (*Eucalyptus obliqua*) are common. Differences in heath floristics in the Anglesea district reflect variations in drainage, soils, and topography rather than proximity to the coast.

Heathlands in the south-eastern suburbs of Melbourne formerly reached the coast above high cliffs in several places, such as Red Bluff at Black Rock, but are no longer present. At Cape Liptrap, wet heaths dominated by scented paperbark (*Melaleuca squarrosa*) and prickly tea-tree occur on perched water tables immediately behind coast tea-tree scrub. In eastern Victoria, heaths occur between the Benedore River and Mallacoota on exposed and seasonally waterlogged coastal plateaus. Some sites carry a fringe of coast tea-tree or giant honey-myrtle (*Melaleuca armillaris*) scrub. This community, sometimes referred to as 'coastal heathland', extends to more than 30 km inland, although one subcommunity is restricted to the coast.

Fauna

As faunal habitat, non-calcarenite cliffs and slopes tend to be stable and are characterised by unvegetated rocky areas, open tussock grasslands, and dense shrubland with little or no understorey. The habitat type has particular importance for fauna species with specific feeding, roosting, or breeding requirements such as seals, sea-bird, raptors, and bats. It occurs both on the mainland and on islands and can be natural or artificially constructed (e.g., breakwaters).

Few mammal species utilise open rocky areas: Australian fur seals haul out onto some rocky islands off the Victorian coast to rest or to breed. In addition, the common bent-wing bat may have roosting or overwintering caves located here, but distribution of these caves is very restricted in Victoria. Mammal species in non-calcarenite scrubland are similar to those of calcarenite cliff tops; they include short-beaked echidna, white-footed dunnart, brown antechinus, swamp rat, bush rat, house mouse*, black rat* and swamp wallaby. Rabbits* may graze in *Poa* grasslands typical of some cliff tops. The swamp antechinus, a rare species with a disjunct coastal distribution, may also utilise this habitat type. Eastern

pygmy possums and common ringtail possums forage in the canopy layer.

Rocky areas provide breeding sites for black-faced shags, Australasian gannets, silver gulls, crested terns, and kelp gulls. Little penguins may nest in crevices on rocky shores or on constructed breakwaters. Some species, such as sooty oystercatchers, prefer foraging on rocky shorelines and some migratory waders, such as the ruddy turnstone, may also be found foraging or roosting there. Cormorants, gulls, and terns roost in rocky areas. Species nesting in burrows excavated in *Poa* grassland habitat include: white-faced storm-petrel, short-tailed shearwater, fairy prion and common diving-petrel. Other common coastal species occupying the grassland habitat are silver gull, pacific gull, and little penguin. A species which may utilise open cliff faces for its nesting requirements is the peregrine falcon.

The numerous bird species found on non-calcarenite vegetated slopes and cliff tops include coastal species that prefer open or sparsely vegetated areas, such as white-fronted chat, calamanthus, and red-browed firetail. Others prefer dense vegetation or flowering shrubs - such as white-browed scrubwrens, superb fairy-wren, grey fantail, brown thornbill, silvereye, greenfinch*, and a range of honeyeater species including spiny-cheeked, New Holland, and singing honeyeaters. The presence of banksias attracts rainbow lorikeets and little wattlebirds. The rufous bristlebird, a rare species in Victoria, prefers coastal dune scrub.

One reptile species that can be found on rocky cliffs and islands is the eastern water skink. White's skink, three-lined skink, metallic skink, and (rarely) the common and blotched blue tongue lizards also utilise this habitat type.

Heathlands provide a relatively stable habitat with dense vegetative cover. Compared with the intrinsic coastal habitat types, heathland is a relatively complex environment, comprising a constant supply of flowering plants and a mosaic of post-fire regenerative phases. Hence, it supports a wider range of mammalian and avian species. Along some parts of the coastline (e.g., Anglesea and the Parker River), the diversity of small ground mammals is particularly high.

Most of the species typical of intrinsic coastal vegetation also utilise heathland, together with the long-nosed potoroo, southern brown bandicoot, and New Holland mouse. The last species has a patchy coastal distribution, associated with heathland in the early to middle stages of regeneration after fire. Bandicoot distribution is also related to heath age. The dusky antechinus is found in heathland but is not restricted to this habitat type or to coastal areas in particular.

Distribution of the ground parrot is restricted to coastal heathlands dominated by *Xanthorrhoea* and *Casuarina* spp. and to sedgelands. The bird does not occur in very young and very old heaths, preferring those 3—20 years old. The southern emu-wren also has a coastal distribution and is largely (but not exclusively) restricted to coastal heathlands. Heaths provide a wide range of flowering shrubs for honeyeaters such as the white-plumed, white-naped, and crescent honeyeaters, and eastern spinebill. The tawny-crowned honeyeater is restricted to this habitat type (although it occurs in semi-arid heaths as well).

Reptile species inhabiting intrinsic coastal habitats are also typical here; the white-lipped snake occupies heathland habitats while the swamp skink is associated with this habitat in particular. Amphibian species are associated with wet heaths and include southern toadlet and Haswell's froglet.

Dunes (active, sparsely vegetated)

Active (sparsely vegetated) sand dunes occur on many sectors of the Victorian coast, intermittently with stable (well-vegetated) dunes. These sectors include Discovery Bay, Wilsons Promontory, Ninety Mile Beach, and parts of the East Gippsland coast such as Point Hicks and Cape Howe. The habitat includes expansive sandy beaches and sparsely vegetated or eroding foredunes.



Active dune in Croajingolong National Park.

Flora

Plants associated with this open habitat include coast saltbush (*Atriplex cinerea*) and hairy spinifex (*Spinifex sericeus*), and the introduced species marram grass* (*Ammophila arenaria*), beach rocket* (*Cakile maritima*), and sea wheat-grass* (*Thinopyrum junceum*). The ongoing processes of erosion and deposition generally prevent these species from attaining high levels of cover.

The vegetation developed on sand dunes usually shows a gradual progression from pioneer colonising species on foredunes, through shrub species, to a dense dune scrub further inland. In some areas however, the vegetation may become destabilised, leading to aeolian (wind-blown) mass movement of sand inland to form blowouts. Once initiated, such active dunefields may become extensive and, as mobile dunes, can smother all vegetation types in their way, including woodlands and swamps, before eventual vegetation recovery. The more extensive dunefields, such as at Point Hicks, pre-date the arrival of Europeans and were recorded by early surveyors.

Fauna

The sandy environment with little vegetation cover is relatively inhospitable to fauna, especially small ground-dwelling species. Most species are birds with specific foraging, roosting, and breeding requirements.

Beach and unstable dune habitats are utilised by breeding terns and oystercatchers; both of these species lay their eggs within shallow depressions in sand, shell debris, shingle, or gravel. The distribution of colonial breeding sites for Caspian and crested terns is restricted to this habitat type. Two rare species, the little tern and the fairy tern, exhibit poor breeding success due to a lack of suitable nesting sites, high predation rates on eggs and young, and inclement weather. Beaches provide roost sites for cormorants, pelicans, gulls, and plovers, and feeding and roosting sites for a diversity of migratory waders such as double-banded plover, eastern curlew, curlew sandpiper, terek sandpiper, red-necked stint, ruddy turnstone, red knot, great knot, and sanderling. Sandy beaches are preferred by two resident waders - red-capped plover, and hooded plover. Another coastal species, the forest raven, often forages along beaches.

Reptile species typical of unstable dunes include White's, four-toed, grass, metallic, and three-lined skinks, blotched and common blue-tongued lizards, and lowland copperhead.

There are no amphibian species typical of this habitat type.

Dunes (stable, well-vegetated)

Stable, well-vegetated sand dunes are common behind sandy beaches along the Victorian coast, such as along the Ninety Mile Beach. Stable dunes also frequently occur to the rear of unstable dunes or blowouts. Dunes east of Wilsons Promontory predominantly consist of quartzose sand while those to the west are predominantly calcareous. Beaches and low dunes composed of shell fragments are common along the north-west coast of Port Phillip Bay.

Flora

The vegetation on sand dunes shows a gradual succession from pioneer colonising species on foredunes, through shrub species, to a dense dune scrub. This primary succession of vegetation communities with distance inland is related to reduced exposure to wind and salt spray and changes in soil chemistry (including lowering of salinity and calcium levels and a build-up of organic matter), and eventually results in replacement of coastal vegetation by hinterland communities such as heathlands and woodlands. Destabilisation of older parallel coastal dune systems in heathland and woodland may result in secondary succession, with parabolic dunes supporting younger soils and dune scrub vegetation, such as at Sperm Whale Head.

Succession on coastal dunes commences with strand plants on the beach such as beach rocket and coast saltbush. Foredunes support herbaceous species (mainly grasses) such as hairy spinifex, marram grass*, and sea wheat-grass*. Shrubs subsequently replacing these species include coast wattle, white correa, coast everlasting, coast beard-heath, common boobialla (*Myoporum insulare*), coast daisy-bush, seaberry saltbush (*Rhagodia candolleana*), and the sedges knobby club-sedge (*Isolepis nodosa*) and coast sword-sedge (*Lepidosperma gladiatum*).

The introduced marram grass* has been widely used in coastal Victoria to stabilise sand dunes. While effective for this purpose, the species has become naturalised and is now spreading on sandy coastlines throughout the State, including remote places such as Five Mile

Beach at Wilsons Promontory. Marram grass alters dune morphology by characteristically building taller dunes than hairy spinifex and can act as a sand filter, reducing the sand supply to dunefields further inland. It has also largely replaced coast fescue (*Austrofestuca littoralis*), a grass once characteristic of sandy coasts but now increasingly rare. Marram grass is now regarded as a weed of coastal dunes.

Dune scrub develops further inland. On the eastern and central Victorian coasts, it is dominated by coast tea-tree with emergent coast banksia (*Banksia integrifolia*), while in western Victoria it is dominated by moonah, coast beard-heath, and coast wattle. The natural western range limit of coast tea-tree is not known with certainty but is considered to fall between Torquay and Cape Otway; occurrences further west have probably escaped from gardens and hedges. These dune scrubs have a dense canopy but are usually sparsely vegetated at ground level, providing habitat for small shade-tolerant herbs, particularly orchids of the genera *Corybas* and *Pterostylis*. Gap-colonising species, adapted to grow in breaks in the scrub canopy, include coast bitter-bush (*Adriana klotzchii*) and climbing lignum (*Muehlenbeckia adpressa*). Dune scrub is highly susceptible to weed invasion, and intact examples are now rare near settled areas.

Fauna

The foredune habitat provides a sandy environment grading from exposed sparsely vegetated areas near the coast to dense shrubland further inland. Dune scrub is similar in vegetation structure to the scrubland found on calcarenite and non-calcarenite cliff-tops; fauna assemblages in all these habitats are therefore similar. Stable vegetated dunes provide breeding sites for some species of sea-bird.

Foredune areas may be utilised by white-footed dunnart and swamp antechinus. Mammal species may be found in dune scrub areas: bush rat, brown antechinus, swamp rat, black rat*, house mouse*, and swamp wallaby. Eastern pygmy possum and common ringtail possum may forage in the canopy layer. The rare smoky mouse occurs in stable dune vegetation in East Gippsland; however, this species is not coastal in its distribution and is not confined to this habitat type.

Breeding colonies of white-faced storm-petrels, short-tailed shearwaters, Australian pelican, and little penguin may be located on stable dune vegetation. Little penguins and silver gulls also utilise this habitat type for nesting. Fore-dune areas may be visited by calamanthus. Species that utilise dune scrub include brown thornbill, white-browed scrubwren, superb fairy-wren, silvereye, beautiful firetail, and the New Holland, singing, white-eared, and yellow-faced honeyeaters. The pink robin may overwinter there. The rufous bristlebird prefers coastal dune vegetation.

The following reptile species may utilise stable dune habitat: White's, four-toed, garden, grass, metallic, three-lined skinks, and common, and blotched blue-tongued lizards, and lowland copperhead. A rare species, the striped worm-lizard, is found in this habitat type, and also, occasionally, the garden skink.

There are no amphibian species typical of this habitat type.



Stable dunes, Discovery Bay.

Mangroves

These shrubs or small trees 1—4 m high are found in tidal areas on sheltered (low-wave-energy) coastlines in Victoria. They form a distinctive vegetation type seaward of the saltmarsh zone, and are generally flooded by tides twice daily. Northern Australia contains many species of mangrove; however, species diversity declines with increasing latitude (due to lower temperatures) until in Victoria only one species remains - white mangrove (*Avicennia marina*).

In Victoria, white mangrove has a discontinuous distribution from Barwon Heads in the west to McLoughlins Beach in the east. They grow along sheltered coasts of Port Phillip Bay near Williamstown and Geelong, and seedlings were observed at Mud Islands in 1991 in southern Port Phillip Bay. Mangrove

shrublands are well developed in northern Western Port, Anderson Inlet, Corner Inlet, and the adjacent Nooramunga area. The southernmost occurrence in the world is near Millers Landing in Corner Inlet.

Flora

In most areas, white mangrove occurs in relatively tall open scrub formation. A sparse ground layer, comprising common saltmarsh species such as beaded samphire (*Sarcocornia quinqueflora*) and streaked arrow-grass (*Triglochin striata*), occurs in relatively well-drained areas. Much bare ground remains, often covered with thick mats of brown algae. Vertical breathing roots (pneumatophores) up to 40 cm high, a distinctive feature of white mangrove, protrude from the ground in abundance. On slightly higher sites, particularly within estuaries, mangroves may occur with a well-developed herbaceous stratum in which sea rush (*Juncus kraussii*) is typically abundant. Both forms of mangrove vegetation are present in the Barwon estuary.

Mangroves reach their maximum development in the sheltered north-west corner of Western Port where they may be 4 m high. They usually occur on muddy (silt/clay) substrates but may be found on sand or even rock indicating that physical substrate conditions are not critical factors. Mangroves grow on a rocky (basalt) substrate rather than a muddy substrate at Williamstown (Jawbone Flora and Fauna Reserve), at the rear of a basalt boulder platform that protects them from wave action. This occurrence on basalt is unique in Victoria.

White mangrove is a primary coloniser of bare substrates, establishing at or just below mid-tide level and extending to about mean spring-high-tide level. It extends inland through saltmarsh wherever tidal creeks are well developed. Mangroves accumulate fine sediment, a process assisted by the extensive development of pneumatophores, and thus have a major influence in shaping intertidal topography. For the areas in which they occur, they are particularly important as a protective barrier for coasts during severe storms. Once the depositional level of the marsh has been built up to a suitable level, saltmarsh vegetation replaces mangrove vegetation.



Mangroves near Churchill Island.

Despite its salt-requiring metabolism, white mangrove cannot tolerate hypersalinity and is consequently restricted to the zone of frequent tidal wash where the effects of evaporation and evapotranspiration are minimised. Its extension upstream into estuaries is limited by prolonged periods without sea water, frost damage, and competition with swamp paperbark. The removal of seedlings, by strong currents and wave action, limit its seaward extension.

Fauna

Mangroves comprise a quiet muddy habitat for a wide diversity of invertebrate fauna and their fish predators. These are described in the following section. Roosting water birds utilise the trees, and foraging waders use their muddy substrates. Mammals, reptiles, and amphibians are not typical of this habitat type.

The trees provide roosting habitat for cormorants, ibis, spoonbills, egrets, herons, and sooty oystercatchers. Grey-tailed tattlers and terek sandpipers also roost there, and common sandpipers and greenshank forage in the muddy substrate. Azure kingfishers utilise mangroves, as do little grassbirds. Metallic lizards may be found in areas fringing mangroves, but amphibian species are highly intolerant of saline conditions.

Marshes (saline)

Saltmarsh is a distinctive vegetation type developed on land that is subject to periodic flooding by the sea or (occasionally) beside lakes with residual salinity related to high sea levels in the past. It is a characteristic feature of all sheltered coastlines in Victoria, and has a scattered distribution, from the Glenelg River to Mallacoota Inlet. It is particularly extensive in the Barwon estuary, Western Port and Corner Inlet, and has become more extensive in the Gippsland Lakes following the creation of the artificial entrance.

Flora

Saltmarshes are subject to high soil salinities, waterlogging, and tidal scour, with the intensity of these influences varying over a wide range. The vegetation is characterised by a range of halophytic (salt-tolerant), usually succulent, herbs and shrubs. Members of the family Chenopodiaceae dominate this habitat, particularly the leafless succulents - beaded samphire and shrubby samphire (*Sclerostegia arbuscula*). Other frequent species include marsh saltbush (*Atriplex paludosa*), trailing hemichroa (*Hemichroa pentandra*), creeping brookweed, thick-head samphire (*Sarcocornia blackiana*), prickly spear-grass (on elevated sites such as stranded sand ridges), austral seablite (*Suaeda australis*), and streaked arrow-grass. Introduced species are largely confined to upper marsh levels and include saltbush* (*Atriplex prostrata*) and sea barley-grass* (*Critesion marinum*). Cord-grass* (*Spartina townsendii*) is a serious weed capable of invading and transforming lower-level marshes, with major infestations at Andersons Inlet and Corner Inlet (see Box 4.2).

Box 4.2: Cord Grass (*Spartina townsendii*)

Because of its vigorous rhizome spread, cord-grass was imported from England to stabilise farmland properties abutting estuarine areas.

Unfortunately, the plant will spread to areas great distances away from the original point of intended use. It has now become a major environmental weed in South Gippsland. As the plant colonises estuarine areas it excludes invertebrate life from the surface soil strata, thus depleting bird feeding habitats. This is of particular concern in regard to the transitory waders that seasonally inhabit estuarine areas of South Gippsland.

Cord-grass is also rapidly changing the profile of intertidal-zone vegetation. It is displacing plants such as white mangrove and beaded samphire on a wide scale. Mangrove sand flats and mangrove mud flats are very important in marine food chains, and they act as nurseries in the reproductive cycle of various marine life.

A characteristic feature of saltmarsh vegetation in general is zonation, which is largely a function of elevation and tidal inundation. Very minor changes in relief (a few centimetres or less) can affect vegetation patterns through changes in salinity and water regimes. The widths of the zones depend on local groundslopes, which are ultimately determined by patterns of sedimentation and erosion. Zonation in estuaries can be unusually complex due to the presence of geomorphic features such as lagoons, levees, abandoned river channels, and an abundance of tidal creeks (related to strong ebb-tide currents). By disrupting microtopographic gradients, these landforms result in the development of complex vegetation mosaics rather than the relatively simple zonation evident in non-estuarine saltmarshes. The estuary of the Barwon River, including Lake Connewarre, provides an example.

The zonation is related to the presence of a considerable number of vegetation associations (or communities), each of which occupies a zone. Detailed surveys of saltmarsh vegetation have revealed considerable complexity in floristic composition and vegetation patterns. One study identified three communities and 16 subcommunities of saltmarsh in the Western Port catchment. Another produced a floristic classification of coastal saltmarshes in southern Australia recognising a total of 22 floristic associations, of which 17 occur in Victoria. Additional associations are probably present in Victoria, but no comprehensive survey has yet been undertaken. The complexity of saltmarsh vegetation is illustrated by the vegetation map of Mud Islands (see Map 5).

Floristic and structural diversity is highest along the central coast of Victoria between Barwon Heads and Melbourne. This is due to the relatively dry climate (see Chapter 2) which produces intensely hypersaline conditions and habitats not found elsewhere.

These climatically drier areas support distinctive vegetation communities dominated by grey samphire (*Halosarcia halocnemoides*) and black-seeded samphire (*H. pergranulata*). The distinctive samphire shrub dominated saltmarshes of the Port Phillip region have been referred to as 'dry' saltmarsh. As well as the relatively dry climate, the situation of these communities towards the landward edge of the marsh, where tidal inundation is infrequent, makes the term appropriate. 'Wet' saltmarsh,

typified by shrubby samphire, is the only form in higher rainfall areas (such as Westernport), but also extends into drier areas, where it forms a broad band fringing dry saltmarsh on sites receiving regular tidal inundation. Localities where wet and dry elements coincide, such as Point Wilson, support the most diverse saltmarshes in Victoria.

Fauna

Coastal salt water marshes contain low dense vegetation subject to periodic inundation, providing abundant cover and invertebrate food for a variety of water birds and waders and some species of reptiles. For migratory-wader habitat, saltmarsh cannot be considered on its own as it forms an integral part of the saltmarsh/sandy beach/intertidal mudflat complex. Although beach habitat forms part of habitat type 3, intertidal mudflats are best considered part of the saline marsh habitat



Saltmarsh, Swan Island.

type. Mudflats are characterised by open expanses of mud covered by a green meadow of seagrasses, the roots of which stabilise the mud. These provide detritus, which in turn supports invertebrate and fish populations. Migratory waders feed in both saltmarsh and mudflat habitats and roost on saltmarshes, sandy beaches, mangroves, and rocky promontories. It should be noted than many of the water birds and waders utilising saline marshes are also found in brackish/fresh-water wetlands.

No mammal species are typical of this habitat type. However, it may be utilised by water rats.

Coastal saline marshes are utilised by foraging rails, crakes, plovers, stilts, avocets, ibis, egrets, and ducks and by roosting swans, cormorants, and pelicans. Among migratory waders, this habitat type provides over-wintering requirements for the eastern curlew, common sandpiper, red-necked stint, greenshank, marsh sandpiper, lesser golden plover, double-banded plover, sharp-tailed sandpiper and Latham's snipe. Blue-winged parrot and the endangered orange-bellied parrot also occupy coastal saltmarsh. The latter species is dependent on Victorian saltmarsh communities, especially those in Port Phillip Bay, for its overwintering habitat. Passerines that utilise coastal saltmarshes include the white-fronted chat, calamanthus, little grassbird, Horsfield's bronze-cuckoo, brown thornbill, goldfinch* and house sparrow*. Typical coastal raptor species include marsh harrier, white-bellied sea-eagle and peregrine falcon.

Amongst the reptile species here, the swamp skink has an apparently disjunct coastal distribution that may result from its habitat preference or from the lack of suitable survey techniques. Metallic skink often occurs in association with it, and the glossy grass skink also occupies this habitat type. No amphibian species are found in coastal saline habitats.

Marshes (brackish/fresh-water)

Marshes (other than saltmarshes) are frequently developed in coastal vegetation. They vary considerably in response to factors such as salinity, water depth, and duration of inundation.

Flora

As tidal influence decreases with distance up estuaries, saltmarsh vegetation gradually gives way to brackish and eventually fresh-water communities. Residual salinity in flood-prone areas beyond tidal influence leads to the development of brackish (subsaline) marsh. Plant species typical of such marshes include bare twig-sedge (*Baumea juncea*), Australian salt-grass (*Distichlis distichophylla*), sea club-sedge (*Bolboschoenus caldwellii*), chaffy saw-sedge (*Gahnia filum*), sea rush, shiny swamp-mat (*Selliera radicans*) and silky wilsonia (*Wilsonia humilis*).

Subsaline marsh is widespread in coastal Victoria, particularly in association with estuaries. It is particularly well developed in the Barwon estuary at Lake Connewarre, with extensive unusual communities such as silky wilsonia herbland, chaffy saw-sedge sedgeland, and Australian salt-grassland with emergent shrubby tangled lignum (*Muehlenbeckia florulenta*).

In Western Port, saltmarshes are usually fringed by a closed scrub on brackish soils dominated by swamp paperbark (*Melaleuca ericifolia*). The understorey is carpeted by mosses and includes salt-tolerant vascular species such as rounded noon-flower, creeping brookweed, and shiny swamp-mat. Similar brackish vegetation dominated by swamp paperbark occurs elsewhere in eastern Victoria, such as in the estuary of Balcombe Creek (Port Phillip Bay) and in the Gippsland Lakes.

Fresh-water marshes are frequent in coastal vegetation, often as dune-blocked swamps. A wide range of vegetation communities, intergrading with brackish communities, occur but these are not well documented. The communities, being widespread in Victoria, could be considered hinterland vegetation types. Common plant species in this broad habitat include red azolla (*Azolla filiculoides*), soft twig-sedge (*Baumea rubiginosa*), leafy twig-rush (*Cladium procerum*), common spike-rush (*Eleocharis acuta*), tall spike-sedge (*Eleocharis sphacelata*), and eel weed (*Vallisneria spiralis*). Extensive beds of common reed (*Phragmites australis*) and cumbungi (*Typha orientalis*) may occur, in either fresh or brackish conditions. On slightly higher ground woolly tea-tree (*Leptospermum lanigerum*) and swamp paperbark east from Melbourne, form closed scrubs. Moonah, normally a species of well-drained sites, has an unusual occurrence on a swampy site near the mouth of the Anglesea River.

Fauna

In terms of faunal habitat, coastal marshes may be permanent or semi-permanent and may contain open water, dense shrub or herb strata, muddy areas, and/or emergent trees. This habitat type is of particular importance for water-bird and amphibian species.

Two mammals, the platypus and the water rat, are typically found in coastal wetlands. Both of these species are adapted to an aquatic lifestyle - feeding on aquatic invertebrates, with the water rat also feeding on fish, and nesting in burrows situated at the water's edge. Other coastal species may utilise sedgeland habitats, including swamp rat and black rat*. Many insectivorous bats hunt over coastal wetland areas, but these species use a wide range of coastal and inland habitats.

Coastal fresh-water and brackish marshes are particularly important for water-birds, including resident and migratory waders. Open waters are utilised by grebes, coots, moorhens, swamphens, cormorants, pelicans, swans, ducks, terns, and azure kingfishers. Shallow waters and muddy shorelines carry water-bird species such as plovers, dotterels, spoonbills, stilts, ibis, egrets, and herons. Migratory waders utilising this habitat type during summer include marsh, curlew and sharp-tailed sandpipers, and greenshank and red-necked stints. The densely vegetated reedy margins provide habitat for the more secretive rail, crake, and bittern species and for Latham's snipe. They also provide cover for coots, moorhens, swamphens, and ducks. Fresh-water wetlands along the Victorian coast provide restricted colonial breeding sites for the pied cormorant, Australian pelican and the royal spoonbill.

A range of raptor species utilise the coastal environment, but three species, the marsh harrier, white-bellied sea-eagle, and peregrine falcon, typically hunt in coastal wetlands.



Fresh-water marsh, Western Port.

White-bellied sea-eagles may utilise any tall, emergent trees as nesting sites. Ground parrots use dense coastal sedgelands, but are most commonly found in wet heathlands dominated by *Xanthorrhoea* or *Casuarina* spp. Passerine species associated with fringing wetland vegetation include calamanthus, little grassbird, clamorous reed-warbler and golden-headed cisticola. The rare eastern bristlebird utilises wetland edge habitats.

Coastal wetlands provide feeding habitat for some reptile species. Whereas the common long-necked tortoise is largely aquatic in its habits, other reptiles are confined to wetland edges. The swamp skink occupies habitats characterised by the presence of reeds, sedges, paperbark, tea-tree, or tussock grasses. It has a disjunct distribution through coastal Victoria. Another rare species, the glossy grass skink, prefers the humid micro-environment provided

by dense ground vegetation in saltmarshes and swamps. Snakes such as the copperhead and tiger snake utilise wetlands for hunting frogs.

Amphibian species typical of coastal habitats in East Gippsland include: Haswell's froglet, common froglet, southern bullfrog, striped marsh frog, southern brown tree frog, Verreaux's tree frog, green and golden bell frog, growling grass frog, Tyler's toadlet, Martin's toadlet, and southern toadlet. In the Westernport area, another typical species is the spotted marsh frog.

SITES OF TERRESTRIAL BIOLOGICAL SIGNIFICANCE

Sites of biological significance are important in land use planning and environmental management, and 76 sites of regional or higher significance are identified along the coast. These are delineated using information from flora and fauna surveys, published reports, and communications with biologists and land managers. Appendix V gives details of each site, which are summarised in Table 4.1 and are shown on Map 2.

To assess the biological significance of a site, the following factors were considered:

* diversity (number of indigenous flora and fauna species and vegetation communities)
* naturalness (degree of disturbance)
* reservation status (representation in biological reserves)
* rarity of vegetation communities
* number and ranking of significant species of flora and fauna
* critical feeding, breeding, and roosting sites for significant fauna species
* species or habitats identified by international agreements (JAMBA, CAMBA, Ramsar)
* scientific values

Pre-existing (delineated) sites of significance in coastal Victoria relate to either flora or fauna (but not both). In order to delineate sites of biological significance (that is, combining flora and fauna) it has been necessary to amalgamate overlapping pre-existing flora and fauna sites into composites. The derivation of such composite sites is explained for each one.

Many of the sites presented here have not been previously identified or mapped, particularly those in western Victoria. It should be noted that there is considerable potential to refine the boundaries of most, using aerial photography, on-ground inspection, and detailed survey.

Some sites are considered integral components of larger ones that extend inland well beyond 1 km. For example, the Otways site between Point Franklin and Shelly Beach is part of a large site of significance based on the Otway National Park. Most sites comprise both intrinsic coastal and hinterland vegetation.

Not all flora and fauna in coastal Victoria have been surveyed or documented. It is likely therefore that occurrences of some individual species or vegetation communities of significance are not documented here, particularly in the case of rare plant species.

Significance levels

Levels have been assigned using the above criteria in a geographic or biogeographic context. For example, a site has State significance when it is considered to make a substantial contribution to nature conservation in Victoria; it has regional significance if it makes a substantial contribution to nature conservation in a given region. Therefore a record of a species of State significance does not necessarily confer State significance on the site, as its size, condition, viability and importance need to be considered. For example, a single sighting of an orange-bellied parrot over, say, a 10 year period does not mean that the location has national significance for conservation.

Flora and fauna significance have been separately assessed for each site on the basis of available information. The significance of the site is the higher of these two ratings; however, this can result in a distinct faunal bias due to disparities in the existing systems of rating flora and fauna significance. International agreements on the conservation of migratory fauna have led to 'international' ratings in several fauna studies, whereas 'national' is the highest significance rating usually applied in flora studies (it is assumed that 'national' is equivalent to 'international' due to the uniqueness or high endemism of the Australian flora).

Several international agreements are relevant to the protection of migratory waders and their habitat along the Victorian coastline. These are the CAMBA and JAMBA agreements and the Ramsar convention and are discussed in Chapter 18.

Table 4.1: Summary of Sites of Biological Significance

Site no	Site name	Site area (ha)	Flora significance	Fauna significance	Biological significance
1	Mouth of Glenelg River	230	State	Regional	State
2	Long Swamp	2 140	State	State	State
3	Discovery Bay	4 750	Regional	State	State
4	Bridgewater Lakes	470	State	Regional	State
5	Cape Bridgewater	<1	Not documented	State#	State#
6	Cape Nelson	540	State	Regional	State
7	Point Danger	80	State	Regional	State
8	Lawrence Rocks	c. 20	Not documented	National	National
8A	Lady Julia Percy Island	140	Regional	State	Regional
9	Cape Reamur	***	Regional	Not documented	Regional
10	Port Fairy Shore and Griffith Island	80	Regional	State	State
11	Killarney Reef	***	Nil	State	State
11A	Rutledges Cutting	90	Nil	State	State
12	Armstrong Bay	90	Regional	Regional	Regional
13	Warrnambool Shore, Thunder Point	***	Not documented	Regional	Regional
14	Middle and Merri Islands, Warrnambool	1-2	Not documented	Regional	Regional
15	Lake Gillear Cave	<1	Not documented	State	State
16	Point Mepunga	c. 10	Regional	Not documented	Regional
17	Armstrongs Creek to Flaxmans Hill	***	Regional	Not documented	Regional
18	Port Campbell Cliffs and Hinterland	1 780	State	State	State
19	Moonlight Head (The Gable)	760	State	Regional	State
20	Cape Volney	<1	Not documented	Regional#	Regional
21	Cape Volney to Johanna Beach	420	Regional	Regional	Regional
22	Rotten Point to Point Franklin	890	State	State	State
23	Point Franklin to Shelly Beach	880	State	National	National
24	Cape Patton to Lorne	1 930	State	State	State
25	Lorne to Aireys Inlet	290	Regional	Regional	Regional
26	Mouth of Painkalac Creek	60	Regional/State	Regional	Regional/State
27	Urquhart Bluff Coastline	590	National	National	National
28	Anglesea River	40	Regional	Local	Regional
29	Anglesea to Bells Beach	440	State	Regional	State
30	Breamlea	280	Regional	Regional	Regional
31	Lake Connewarre and Barwon River	3 300	National	International	International
32	Lonsdale Lakes	260	Regional	State	State
33	Swan Bay	3 520	State	International	International
33A	Pope's Eye	<0.5	Nil	State	State
33B	Wedge Light	<0.5	Nil	State	State
34	Mud Islands	86	State	National	National
35	South Channel Island	<1	Nil	State	State
36	St Leonards	90	Regional	Local	Regional
37	Geelong Saltworks	950	Local	National	National
38	Limeburners Bay	160	Regional	National	National
39	Metro. Farm Werribee to Avalon Saltworks	3 300	National	International	International
40	Point Cook and Laverton Saltworks	970	State	International	International
41	Altona to Williamstown	60	State	National	National
42	Sandringham Foreshore	c. 100	Regional	Local	Regional
43	Seaford Foreshore (and Kananook Creek)	c. 50	Regional	Local	Regional
44	Mornington Foreshore	c. 150	Regional	Local	Regional
45	Balcombe Creek estuary	c. 100	Regional	Regional	Regional
46	Point Nepean coastline	2 040	State	State	State
47	Western Port	52 300	No terr. veg.	International	International
48	Coolart	130	Local	State	State
49	Sandy Point	1 040	State	? Regional	State
50	Crib Point to Hastings	670	Regional/state	Regional	Regional/State
51	Northern Shores of Western Port	1 890	State	State	State
52	Quail and Chinaman Islands	540	State	Regional	State
53	French Island (including off-shore islands)	5 390	National/State	State	National/State
54	Bass River mouth	410	Regional	Regional	Regional
55	Conservation Hill	640	Regional	State	State
56	Seal Rocks	c. 2	Nil	National	National
57	Phillip Island (South and West Coasts)	1 540	State	State	State
58	Bunurong coastline	1 710	State	Regional	State
59	Andersons Inlet	2 740	Regional	State	State
60	Cape Liptrap to Walkerville	***	State	State	State
61	Shallow Inlet	2 500	Regional	National	National
62	Wilsons Promontory Coast	16980	National	State	National
63	Wilsons Promontory Islands	***	State	State	State
64	Corner Inlet	110 000	State	International	International
65	Jack Smith Lake	c. 3 700	Regional	State	State
66	Lake Dennison	640	Regional	Regional	Regional
67	Gippsland Lakes	18 400	State	National	National
68	Lake Tyers	170	Regional	State	State
69	Ewing Marsh to Point Ricardo	4 820	State	Regional/State	State
70	First and Second Islands	1.5	Regional	Not documented	Regional
71	Point Ricardo to Wingan Inlet	9 650	National	National	National
72	The Skerries	1-2	Nil	State	State
73	Wingan Inlet to Mallacoota	3 170	National	National	National
74	Goodwin Sands	120	Nil	State	State
75	Gabo and Tullaberga Islands	154	State	State	State
76	Mallacoota to Cape Howe	2 590	National	National	National

Note:

1. *** The area for these sites could not be calculated due to indeterminate site boundaries.

2. # Probable significance.

VEGETATION PATTERNS - CASE STUDIES

To illustrate the typical complexity of coastal vegetation, discussed at the beginning of this section, two case studies are briefly discussed below.

Mud Islands Wildlife Reserve

Mud Islands - near the entrance to Port Phillip Bay, 55 km south-west of Melbourne - comprise an irregular ring of shrubby sand ridges enclosing saltmarshes and a shallow lagoon, and cover 86 ha (land area 51 ha; lagoon 35 ha). The sand ridges rise to 4 m elevation at the southern end. Nine vegetation communities (one marine, three saltmarsh, and five sand dune) occur within the reserve.

Their configuration has changed repeatedly since they were first surveyed in 1836, although the most stable area, Boatswain Island (in the south-west), has remained similar in size and outline since last century. Vegetation patterns are remarkably dynamic as a consequence of this constant physiographic change, and are described in Map 5.

Saltmarsh is extensively developed in the interior of Mud Islands, where wave energies are relatively low. These marshes form a mosaic with sand dune vegetation communities, particularly on Eastern Island. Most of the central lagoon is vegetated by seagrass (*Zostera muelleri*).

The vegetation patterns developed in saltmarsh on Boatswain Island are particularly complex. Prickly spear-grass grassland is confined to relict recurved sand spits, which reflect stages in the longitudinal growth of the island. Elsewhere on Boatswain Island the saltmarsh consists of beaded samphire herbland and shrubby samphire shrubland, both developed on peaty clay substrates. The latter communities form alternating longitudinal bands that become concentrically curved towards the inner edge of the island, anticipating the present lagoon shoreline. This pattern is related to minor topographic undulation and may reflect lateral growth of the island. Interrupting the zonation, small, tightly meandering tidal creeks enter the lagoon. A series of small pools, formed by unknown but presumably natural processes, occur in the herbland.

Sand dune vegetation is extensively developed in areas above high water level. Five vegetation communities are associated with the dunes. The entire perimeter of the island system supports this vegetation type except for the northern extremity, where erosion has exposed *Sclerostegia* shrubland. Considerable change in the dune vegetation has occurred this century, particularly the removal by marine erosion of an area of coast beard-heath scrub growing at North Cape until the early 1970s. Several indigenous plant species have become locally extinct on the Islands as a result.

Coast saltbush shrubland has become extensive only in recent decades. This *Atriplex* species was rare on the Islands in the 1930s, while later aerial photographs show that in 1951 the sandy areas on Mud Islands were 'bare, or sparsely vegetated' and that by 1969 'scrub vegetation, mainly *Atriplex*' had spread over about half of Eastern Island. In 1972 coast saltbush was still localised, with most of the sandy areas occupied by exotic annuals. During the late '70s it began a major expansion and, by 1980 had become extremely dense and widespread on nearly all the high ground. This expansion is almost certainly related to a simultaneous population explosion in silver gulls - from about 1000 pairs in 1970 to an estimated 40—50 000 pairs in 1986. Silver gulls utilise coast saltbush as nesting habitat; their abundant faeces increase soil fertility, which is thought to stimulate the plant.

Australian hollyhock (*Lavatera plebeia* var. *tomentosa*) dominates an unusual shrubland community on Eastern Island. This strictly coastal plant has a scattered distribution in Victoria, with records coming from the Portland area, Port Phillip Bay (Altona and Port Melbourne), and islands off Wilsons Promontory. Although generally a short-lived fugitive species, it dominates an area here mined for guano early this century and formerly known as the 'airstrip' due to its former sparse cover of exotic annual herbs. The population of several thousand plants is the largest known in Victoria. This vegetation community is also the main colony site for white-faced storm-petrels on Mud Islands.

Lake Connewarre Game Reserve

The Lake Connewarre Game Reserve on the Bellarine Peninsula, 65 km south-west of Melbourne, covers 3300 ha. The reserve contains an extensive wetland ecosystem showing a gradual progression from saline to fresh-water conditions with distance from the sea. It supports large areas of diverse native terrestrial vegetation interspersed with bodies

of open water. It lies outside the study area, however, and is described for context purposes only.

The reserve includes the estuary of the Barwon River - one of Victoria's largest estuaries. The vegetation remains largely undisturbed in many areas, and several of the communities, while extensive within the reserve, are rare elsewhere in Victoria. The pronounced changes in vegetation as tidal influence decreases along the estuary are of considerable scientific interest.

In 1985, Yugovic identified more than 20 vegetation communities within the reserve, grouping them into 15 vegetation units for mapping purposes.

Belts of white mangrove, extending up to 4 km upstream, are frequent in areas receiving daily tidal inundation. Shrubby samphire shrubland is common in the lower estuary, on moderately elevated sites. Samphire herbland, usually dominated by beaded samphire, occurs on flats and along drainage lines where pools and sheets of water are left by high tides. Sea rush rushland is extensive in areas subject to regular flooding by brackish tidal water.

Australian salt-grass forms a well-developed grassland along the levees of the Barwon River and its tidal creeks, upstream from the mangrove zone. These levees impede the drainage of backswamps supporting samphire herbland. Chaffy saw-sedge is abundant on elevated sites, particularly at the rear of marshes. Moonah scrub occurs along the southern bank of the Barwon River at The Sheepwash.

Salt Swamp, a large, unusually broad saltmarsh lies south of Lake Connewarre. It supports diverse and unusual vegetation, including the extensive (*c.* 65 ha) silky wilsonia herbland. The expanse of this low glaucous vegetation is the largest occurrence of this community in Victoria. It has developed on land subject to major seasonal fluctuations in water levels, from prolonged inundation following major floods of the Barwon in winter or spring to prolonged exposure in summer and autumn. Shell-grit extraction has left scars in parts of the herbland. Blue tussock-grass grassland occurs behind extensive belts of chaffy saw-sedge sedgeland, and is the climax vegetation community for the area.

Lake Connewarre is a large (860 ha) irregularly shaped, shallow estuarine lagoon. The tidal delta at the outlet of the Barwon is significant as it is one of the largest active tidal deltas supporting terrestrial vegetation in Victoria. It comprises numerous islands separated by an intricate network of shifting shoals and distributaries. The islands support a mosaic of samphire herbland and Australian salt-grass grassland and are critical habitat for the endangered orange-bellied parrot. The tidal delta is actively extending into the lake.

Fresh-water marsh vegetation is extensively developed in areas beyond tidal influence. At the inland end of the reserve are two large swamps: Reedy Lake is the largest predominantly fresh-water lake along the central Victorian coastline (other than artificial impoundments); Hospital Swamp supports a mosaic of fresh-water, subsaline, and saline vegetation communities. Both swamps have undergone considerable vegetation change due to drainage modifications for waterfowl management.

The vegetation of Reedy Lake is characterised by concentric zones of wetland vegetation surrounding deeper, often open areas of water. The patterns result from an interaction of basin configuration, water and salinity regimes, plant species composition, and disturbance history. The west, north, and east shores of the lake are fringed by saltmarsh and sea club-rush sedgeland. Large beds of common reed across the surface of the lake form a mosaic with cumbungi sedgeland. Numerous submergent aquatic species are abundant throughout the lake. A broad zone of common spike-rush sedgeland occurs along the lake's southern shoreline. Between Reedy Lake and the Barwon River is an area of tangled lignum shrubland.

MARINE HABITATS AND ASSOCIATED FLORA AND FAUNA

The coastal and marine environment of Victoria contains a number of habitat types supporting a diverse biota. This section identifies the following eight habitat types - intertidal rocky shores, subtidal rocky reefs, seagrass beds, sheltered intertidal flats, mangroves, sandy beaches, subtidal soft substrates, and pelagic environments - and describes the visually dominant or characteristic species of associated flora and fauna. Habitat types are categorised according to three major determinants of species

distributions and community composition: tidal level, substrate type, and wave energy or exposure. Vegetation, a secondary determinant, is also used where applicable. It should be kept in mind that the more open nature of marine systems makes marine habitats and communities much more difficult to delineate in space than their terrestrial counterparts. Estuaries are not considered as a separate category in this review. Bucher and Saenger (1992), in a recent inventory of Australian estuaries and enclosed marine waters, reported on their distribution and ecological status.

CURRENT STATE OF KNOWLEDGE

Knowledge of Victoria's marine communities is poor in comparison with terrestrial vegetation communities. Detailed descriptions have only been produced for a few major habitat types and no State-wide survey has been carried out. Few quantitative data have been collected. Particular regions or specific groups of flora and fauna have received detailed attention, but many information gaps remain. Several factors account for this poor state of knowledge.

Taxonomic impediments Of the 33 recognised animal phyla, 32 are invertebrates and 13 - e.g., echinoderms, brachiopods - are exclusively marine. Many invertebrate phyla, such as sponges, bryozoans, and nematodes are poorly known world wide; they have a large percentage of undescribed species and taxonomists give them limited attention.

Richardson (1983) estimates that less than half the fauna species thought to live in Australia have been described so far. In 1983, information was available on almost all families of vertebrates and insects, but more than 40% of the remaining faunal groups lacked any data.

No estimate can be made of the total number of marine species in Victoria. Some of the inadequately understood groups may also be very species-diverse, increasing the task of describing them. Most sampling programs of benthic organisms in Victoria will yield undescribed species. Other groups - e.g., cnidarians - although relatively well known on a world scale (with some exceptions) have not been described in Victoria because of limited local taxonomic expertise. Even when taxonomic expertise is available, many species are small and so require careful and time-consuming examination for identification.

Restricted biological sampling Only a few regions have been examined in detail (see Figure 4.1). The detailed environmental studies programs of the 1970s and early to mid 1980s included comprehensive studies of soft-bottom marine environments in Port Phillip Bay, Western Port, and the Gippsland Lakes, but with few exceptions (discussed below) nearshore marine areas of Bass Strait have never been surveyed systematically. Results of studies there by environmental consultants or post-graduate research students are often unpublished.

Selective nature of available information The available data is fragmented not only systematically and geographically, but also by the nature of information collected. More is known about morphology and taxonomy of Victorian marine biota, for example than about functional ecology.

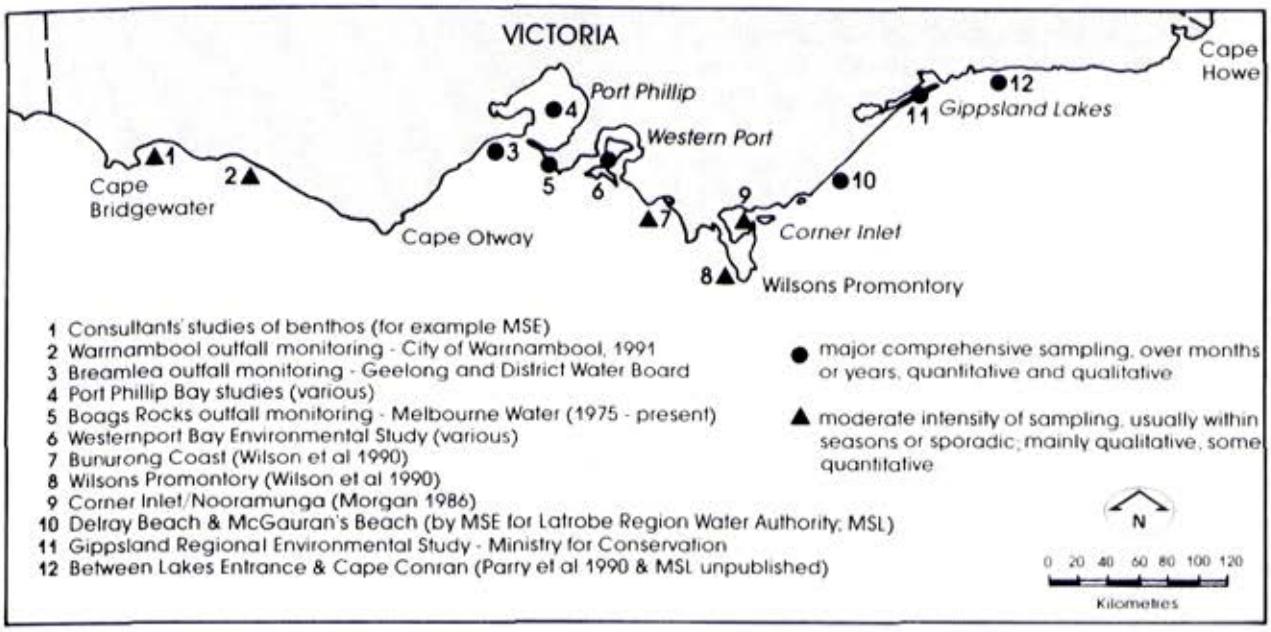
Inaccessibility of many marine environments The exposure of much of the Victorian coastline to high wave action and onshore winds makes it necessary to use large and expensive vessels for safety. Divers cannot safely survey areas deeper than 30 m, and diver bottom-time is severely limited at depths greater than about 15 m. Remote-controlled underwater video is a potential tool for surveying otherwise-inaccessible habitats, but such equipment is expensive and provides qualitative rather than quantitative information.

High cost of scientific survey One of the greatest impediments to comprehensive surveys of Victoria's marine environment is the high cost of ship time, equipment, diving and technical assistance, and subsequent laboratory analysis. For example, to sort and identify (where possible) a 0.10 sq. m sediment sample takes approximately three person days.

MARINE SURVEYS IN VICTORIA

Investigation and description of Victoria's marine biota began with the English and French explorers in the 18th and early 19th Centuries. Ducker (1981) has described the era of the sailors and naturalists and their contributions to our knowledge of the marine algae, and subsequent periods in the history of Australian marine phycology. The first collections of invertebrates from Victoria were made in the 1820s, in Western Port, by the French exploration vessel *Astrolabe*. Early expeditions tended to collect the larger and more obvious marine fauna and those with hard skeletons or shells, as these were easier to take

Figure 4.1: Main Marine Biological Surveys



back to Europe. Many Victorian species were originally collected, and described, from other areas, and subsequently recorded as Victorian by later naturalists, particularly in the 1880s and 1890s. The first dredging seems to have been done by the British research vessel HMS *Challenger* in 1874, with a station at 33 fathoms (60 m) 'off entrance to Port Phillip'. The owners of the Godefroy shipping line in Hamburg encouraged their ships' captains to make collections for their museum during the 1860s and 1870s. In this way some Victorian material made its way back to Europe for description.

In the second half of the 19th Century, Victorian naturalists began to explore the flora and fauna, collecting in the intertidal zone in easily accessible areas and often working on little-known groups such as corals, hydroids, forams, bryozoa, and small crustaceans. John Bracebridge Wilson (1828—95) pioneered marine biology in Victoria, collecting from the seashore and by regular dredgings near Port Phillip Heads. The Microscopical Society of Victoria was founded by naturalists with interests in lesser-known groups, among whom T.S. Ralph worked on hydroids, and Charles Macgillivray, Charles Mapleston, and J.R. Goldstein worked on bryozoa.

In 1888 the Royal Society of Victoria organised the first Port Phillip Survey, led by Bracebridge Wilson. Detailed accounts of progress in the work published between 1890 and 1895 included descriptions of sponges, algae, and cnidarians. Other teacher-naturalists and biologists, working alone or through scientific societies, continued to add to our knowledge of marine flora and fauna through the first half of this century. Between 1957 and 1963, the National Museum and the Fisheries and Wildlife Division jointly undertook a second Port Phillip Survey to record the macro flora and fauna and plot their distribution, as the Museum reported in its Memoirs in 1966 and 1971. This survey marked the beginning of a new era of detailed regional studies of Victoria's marine environments.

In 1965 the Fisheries and Wildlife Division carried out a detailed survey of the benthos around Crib Point in Western Port. Further quantitative investigations of the fauna of soft-bottom environments of Port Phillip Bay were undertaken between 1969 and 1973 (Poore *et al.* 1975, Poore and Rainer 1979) and subsequently major surveys have been carried out on Western Port (Shapiro 1975, Coleman *et al.* 1978, Ministry for Conservation 1980b, King and Kay 1980, Watson *et al.* 1984, Robertson 1977) and the Gippsland Lakes (Poore 1982, Rigby 1982, Ramm 1986). Less comprehensive surveys of Corner Inlet (Morgan 1986) and East Gippsland (Parry *et al.* 1990), and smaller studies at Wilsons Promontory and the Bunurong coast near Inverloch (Wilson *et al.* 1990) have been undertaken more recently.

The first attempt at systematic survey of Bass Strait was probably in 1973 when Museum scientists and associates participated in a collection expedition on HMAS *Kimbla*. This work led to the later major Bass Strait study,

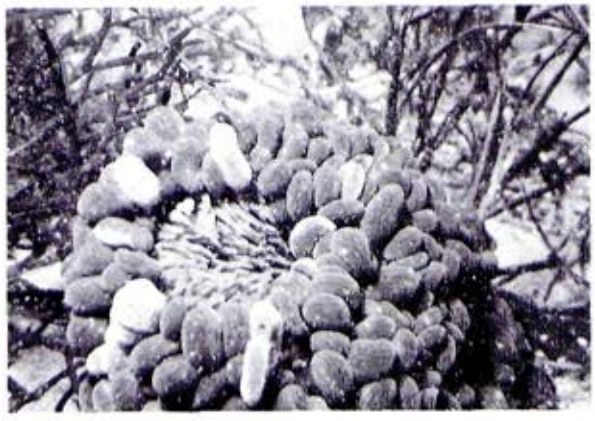
carried out from 1978 to about 1982 and co-ordinated by the Victorian Institute of Marine Sciences. Although most of the sampling stations were outside the territorial Victorian waters (Wilson and Poore 1987), some of the data from this survey program may be relevant to descriptions of inshore waters. A limited amount of quantitative information will become available for the region offshore from Orbost as a result of benthic studies currently under way.

Surprisingly, no quantitative survey has been undertaken of Victorian intertidal or subtidal rocky reefs, although descriptive data are relatively abundant. Intertidal zonation on rocky shores in Victoria was investigated and described by Bennett and Pope (1953, 1960). Naturalist groups, notably the Marine Research Group, are still very prominent in investigating and recording the marine flora and fauna of Victoria. Between 1980 and 1984 they surveyed the distribution of common intertidal invertebrates along the Victorian coast (Phillips *et al.* 1984).

Museum and herbarium collections and reports prepared by consultant marine biologists (Carey and Watson 1992) provide further major sources of biological data. Investigations and publications dealing with fisheries resource assessment also contain data relevant to Victorian waters. Additional information about the natural features of the Victoria's coast is scattered in papers, unpublished theses, and undocumented biological collections. Documented ecological and taxonomic studies of marine habitats in southern New South Wales, Tasmania, South Australia, and southern Western Australia form a further scientific resource with application to Victoria, because the various biota have many common elements.

Among the few studies that have examined the whole coastline, Brown and Bedford (1978) described in summary form important biological communities as an input to guidelines for the control of oil spills, Bird (1973) described Victorian sites of special scientific significance, and McShane *et al.* (1986) prepared an atlas of reefs supporting commercial abalone populations. The Ministry for Conservation (1980a) mapped the coastal communities. A number of field guides and reference texts have been produced dealing specifically with Victoria's marine biota.

The information presented below has been compiled from all of the above sources.



Wandering anemone.

THE NATURE OF MARINE SYSTEMS

In addition to the diurnal and seasonal cycles that affect all animals and plants, tides and depth have a marked influence on species composition in marine communities.

In the case of tides, intertidal organisms are subject to conditions that rarely affect subtidal biota, such as exposure to desiccation, extremes of temperature and salinity, and specific predators. As a consequence, these flora and fauna tend to be distinct from those of adjacent subtidal habitats of the same substrate type. Hence, most substrate types discussed below are divided into intertidal and subtidal habitat types.

As a result of depth changes, less light penetrates to deeper water and algae gradually disappear. For example, on rocky reefs algae are usually replaced by sessile invertebrates. This change occurs around 20—30 m, reaching 50 m in clearer waters (Womersley 1981). Beyond these depths, invertebrate filter feeders such as sponges, sea whips, hydroids, and bryozoans predominate.

Intertidal faunal assemblage during low-tide periods may differ from that present or active while the habitats are submerged. A similar shift in the composition or activity of fauna may mark different times of day. The macro-fauna active and evident during the day are often different from those that emerge at night.

Seasonal changes in the presence and abundance of particular flora and fauna also occur. Mobile fauna such as pelagic fishes and whales may have seasonal migrations into or through Victorian coastal waters. Many algae too, such as *Splachnidium rugosum* and *Porphyra columbina*, settle and reproduce at

particular times of the year, but are not evident otherwise. Other animals gather in coastal waters at different times forming aggregations; for example, the large spider crabs (*Leptomithrax gaimardii*) appear in Port Phillip Bay in spring in certain years.

BIOGEOGRAPHIC SETTING OF VICTORIA'S COASTLINE

As described in the first section of this chapter, the coastline of Victoria contains a wide range of physical environments from exposed sandy beaches and rocky shores, to sheltered bays, inlets, and estuaries.

In the surrounding cold temperate waters of Bass Strait, surface temperatures typically range between 13°C and 17°C. In shallow sheltered bays and inlets, the annual range is greater. For example, Port Phillip Bay has been recorded with a range of 10—21°C. The whole the southern Australian coast from Western Australia to the New South Wales border, is considered to be 'cold temperate', defined by the biogeographic unit 'Southern Australian Region' (Wilson and Allen 1987).

The Southern Australian Region contains a rich flora and fauna with a high level of endemicity. Its waters contain one of the highest diversities of marine algae in the world (more than 1000 species), of which approximately 70% are endemic to the region. Many of its faunal groups, including molluscs, crustaceans, and fishes, also display high levels of endemicity, sometimes as high as 95%. The distinctness of the southern Australian biota contrasts with Australia's tropical marine biota, which is part of a generally widely distributed Indo—West Pacific flora and fauna. However, for some groups, apparently high levels of endemism should be treated cautiously. Bergquist and Skinner (1982) warn that for southern Australian sponges the high level of regional endemism evident from the literature is a false impression resulting from meagre knowledge, and that future collections will show that many species have a wider distribution.

At the eastern limit of Victorian waters and along the Ninety Mile Beach there is a transition to the warm temperate waters of New South Wales. Water temperatures increase and the biota typical of Victoria's coast are replaced by a warm temperate flora and fauna. The Eastern Australian Current travels south along the east coast of Australia carrying warmer waters from further north. Occasional eddies of this current may carry pockets of warm water into Bass Strait and Victorian coastal waters perhaps being responsible for the occasional incursions of tropical biota such as turtles, manta rays, and sea snakes. A periodic upwelling between Lakes Entrance and Gabo Island (Parry *et al.* 1990) results in coastal waters being about 5°C colder than adjacent surface waters and may contribute to the possibly distinct fauna off East Gippsland. These currents may also account for the local established populations of a number of biota more typically found in New South Wales waters - for example, the 'permanent' reef biota off the Ninety Mile Beach.

All biogeographic treatments place the whole Victorian coast in one zone. Any east—west distributional trends will be subtle and are difficult to confirm with the limited geographical data available for Victoria. Some information, however, is available on distributional differences. For example, the littorinid snail *Littorina praetermissa* is recorded more commonly in central and western Victoria. The intertidal mollusc *Notoacmea mayi* is common in western Victoria, less common in central Victoria, and absent east of Wilsons Promontory. Another intertidal mollusc, *Austrocochlea odontis* is common at and below mid-tide level in western and central Victoria, but also absent east of Wilsons Promontory. Cunjevoi (*Pyura stolonifera*) is not recorded west of Port Campbell. King, in his 1972 unpublished PhD thesis, found a major floristic discontinuity at Wilsons Promontory, with a loss of species to the New South Wales border, especially the siphonous green algae such as *Caulerpa* spp. and the brown algae - order Fucales, including the genus *Cystophera*.

Wilsons Promontory is also the distributional boundary for a number of marine invertebrate species, but without detailed records of species distributions and abundance, and more knowledge of the biology of individual species, it is not possible to do more than speculate on the biogeography and origins of the Victorian marine biota. However, Wilson and Allen (1987) briefly discuss the evolutionary results of the dramatic sea-level fluctuations in the Pleistocene that, at times of low sea level, kept Bass Strait dry. In some cases, eastern and western daughter species that evolved during periods of isolation have remained isolated - e.g., the bivalve molluscs *Neotrigonia margaritacea* and *N. bednalli*. In other bivalves, the daughter species have re-established zones of overlap in Bass Strait after it was re-flooded.

SIGNIFICANT MARINE COMMUNITIES

Measures of biological significance such as rarity, threatened status, and diversity commonly used for the terrestrial environment are less successfully applied to marine ecosystems. This is partly due to the level of available information on marine flora and fauna, but is also related to distinct attributes of marine systems. For example, it is sometimes stated that extinctions are less likely to occur in marine than in terrestrial systems, presumably because the wide dispersal of pelagic larvae makes it difficult to fragment or isolate marine habitats. Another hypothesis states that many open-sea systems respond to rapid changes in their general environment and so are more adaptable, in an ecological sense, than terrestrial ecosystems (Steele 1991).

There are two available sources of information on threatened Victorian plants and animals:

* consolidated lists of threatened flora and fauna prepared as guides to the conservation status of the Victorian biota

* listed taxa under the *Flora and Fauna Guarantee Act* 1988

The list of threatened fauna in Victoria (prepared as a DCE procedural document in 1991), includes extinct, endangered, vulnerable, rare, and insufficiently known taxa. It contains three marine species - southern right whale, blue whale, and humpback whale. The list of rare or threatened plants in Victoria (Gullan *et al.* 1990) considers vascular plants only, thus excluding almost all of the marine flora, the algae. Two seagrasses, *Halophila decipiens* and *Posidonia australis*, are categorised as rare.



San Remo marine community.

A species, subspecies, or community is eligible to be listed as threatened under the *Flora and Fauna Guarantee Act* 1988 if it is in a demonstrable state of decline or if it is significantly prone to future threats. As well as the southern right whale, one marine community located in Western Port near San Remo, is listed as threatened under the Act. This intertidal and subtidal community is extremely species-rich, characterised by an unusually large number of opisthobranch molluscs and bryozoans, many of which are considered rare. Two opisthobranch taxa from the community, *Platydoris galbana* and genus *Rhodope*, are also listed as threatened taxa. Eight other opisthobranchs, yet to be described, are known only at the San Remo site.

An examination of the criteria for determining listing of taxa as threatened, either in lists or under the Act, shows that the concept has little utility for Victorian marine biota at present. We know too little about the distribution and composition of marine flora and fauna to confidently assign taxa to categories. For example, a taxon is presumed extinct if it has not been definitely located in the wild during the last 50 years. Many marine species in Victoria are known only from the site of original collection, frequently more than 50 years ago, and have not been collected since. Few biologists would claim that taxon to be extinct.

Rabinowitz *et al.* (1986) examined the concept of rarity by looking at three traits: geographic range, habitat specificity, and local population size. Species with a narrow geographic distribution, very specific habitat requirements, and low numbers (i.e., rare in each of the three dimensions) are the classic rare species that excite biologists and conservationists. Those with a wide geographic range, broad habitat requirements, and large populations are common in the accepted general sense. Describing a species as rare is sometimes taken to mean that it is declining in abundance or range, when of course it may not be threatened at all. The present state of knowledge makes it impossible to say what proportion of Victorian marine species are naturally rare. Depending on the form of rarity, species may be more or less vulnerable to a particular endangering process. Moreover, the nature of endangering processes in marine systems may differ from

that in terrestrial systems; for example, pollution events may be more difficult to contain and may have more widespread impacts in the sea.

Marine areas may also be significant because they provide critical habitat for threatened or economically important species, or those of international significance. Many such sites in Victoria, most notably in the sheltered inlets and embayments, provide feeding grounds for migratory and resident shorebirds, and nursery areas for sought-after fish species. A significant calving ground for the southern right whale occurs offshore near Warrnambool in western Victoria.

Areas are also considered to be significant if they have high species diversity - as does, for example, the San Remo marine community. Again, so little is known of the composition and distribution of the Victorian marine biota that it is difficult to compare areas in terms of their biodiversity. Impacted sites may have higher diversity than unimpacted ones. In a discussion of the topic, Ray (1988) persuasively argues against what he refers to as 'species accounting' - that is, comparisons of total numbers of species as a measure of the value of a habitat - in favour of the concept of 'characteristic diversity'. Areas of naturally low species diversity may be or may not be highly productive, but are in any case no less in need of protection than those of naturally high diversity.

Apart from the few significant marine species and one community mentioned above, some marine areas have scientific significance. Some, like the Point Lonsdale rock platform have been studied over long periods and are the type locality for many marine species. Others have been inaccessible to people for various reasons and are of scientific importance as research sites as they allow comparison with impacted sites to determine the extent of changes. Point Nepean rock platforms and the Jawbone site at Williamstown are examples.

MAJOR HABITAT TYPES IN VICTORIAN COASTAL WATERS

This discussion outlines major habitat types, primarily defined by tidal level, substrate type, exposure, and dominant flora. These are divided into eight categories in a subjective classification presented for descriptive purposes only. As mentioned above, only a few regions have been examined in detail, and the information for description of habitats, particularly for open coastline, often had to be inferred or extrapolated from the very few and general studies. It is indicative of our state of knowledge that most surveys of even very limited duration will yield hitherto-undescribed taxa, even in such relatively well-known groups as the fishes. Clearly as more information becomes available about the composition of the Victorian marine biota and about ecological processes in temperate waters, categories may be refined or completely redefined. For example, work currently in progress on the benthic fauna of the east Gippsland coast suggests considerable differences in species composition between areas only 80 to 100 km apart on similar bottom type. Such areas could not of course be discriminated in the coarse classification of habitats used here.

In general, only visually or structurally dominant or characteristic macroflora and macrofauna are discussed. The species mentioned are listed in Appendix VI. The marine ecosystems also support a rich microflora and microfauna, often making up a large proportion of the biomass. Microflora, such as diatoms and other single-celled algae, form the basis of food webs in many systems, providing the diet of many herbivores. Often, rich fauna of small invertebrates can form a large proportion of the biomass, playing vital roles in food webs and nutrient cycling. Taxa include micromolluscs, polychaetes, nematodes, and microcrustacea such as copepods, ostracods, amphipods, isopods, and cumaceans. These components of each habitat type are seldom treated below.

Habitat types are not always well defined. One habitat may grade into another, especially at the lower end of the intertidal and the upper subtidal zones. Different substrate types may also be patchily distributed in an area, each with its characteristic biota.

Intertidal rocky shores

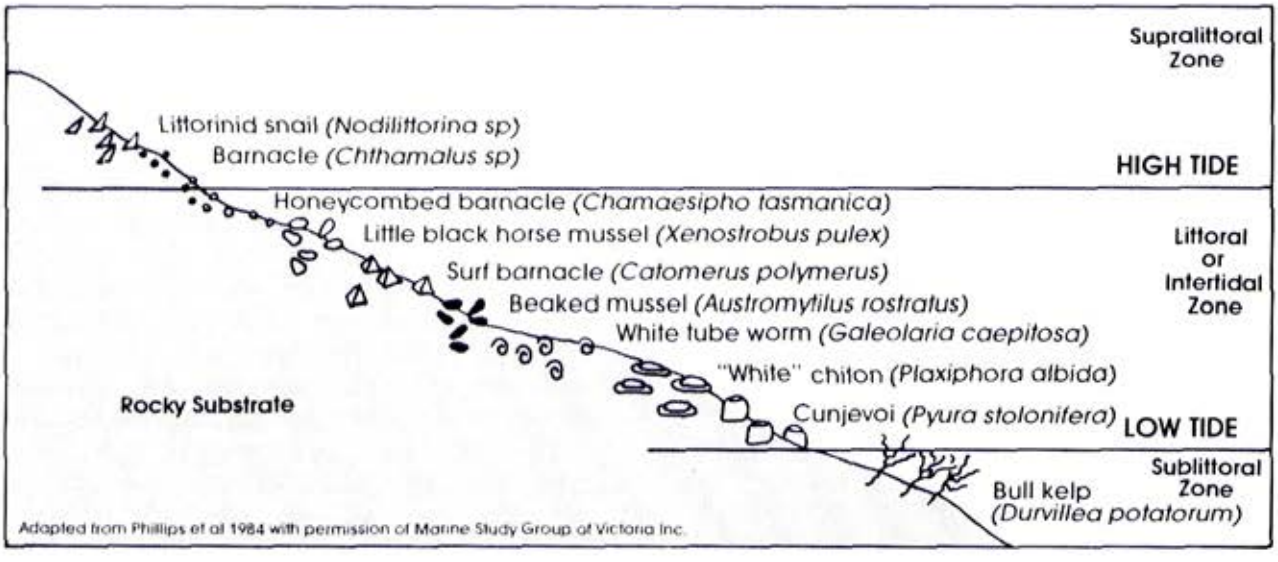
The intertidal zone of Victoria's rocky shores is well studied at a purely descriptive level in comparison with other marine habitats. Some of the fauna, such as molluscs, have been collected and described by naturalists since last century. However, geographic cover is patchy, with most of the information available coming from accessible sites between Cape Otway and Wilsons Promontory. However, the Marine Research Group surveyed the whole Victorian coastline for the common larger invertebrates from 1980 to 1984. Paradoxically, almost no

quantitative data are available comparing species abundances on different intertidal rocky reefs.

This habitat occurs along the exposed coasts of Victoria, particularly between Wilsons Promontory and Portland. Rocky headlands with intertidal platforms are also present within embayments such as Port Phillip Bay. Many rocky-shore invertebrate species are widely distributed in Victoria wherever suitable substrate is found, while others are restricted to rock or hard substrates in sheltered waters. A few species are adapted to life in very high-wave-energy environments.

A characteristic feature of these intertidal rocky shores is a distinct vertical zonation of organisms (see Figure 4.2). Specific flora and fauna are often confined to a particular zone. The upper zone contains the most desiccation-resistant fauna, primarily littorinid snails, which graze algae off rock surfaces in the highest splash zone. The lower part of this upper zone often has patches of the small black branched lichen - *Lichina confinis*. The mid intertidal zone is typically dominated by various grazing snails or mussels and barnacles, although King noted that the importance of barnacles falls, both in abundance and diversity, west of Cape Otway. Lower zones are often algae-dominated, but also characteristically contain chitons, other molluscs, and numerous crustaceans. These patterns of zonation are described in Bennett and Pope (1953, 1960). Womersley (1981) discusses intertidal zonation on Australian temperate rocky coasts with an emphasis on the algae.

Figure 4.2: Zonation on Intertidal Rocky Shores



Several macro-algae are typically found on Victoria's intertidal rocky shores. The brown alga Neptune's necklace (*Hormosira banksii*) often forms large beds on rock platforms in the lower intertidal zone. The green alga - sea lettuce (*Ulva lactuca*) also occurs at high densities, particularly in winter. Many micro-algal species form a fine layer over intertidal rock surfaces, providing the diet for grazing gastropod molluscs, while species such as the brown alga (*Gelidium pusillum*) and arborescent coralline red algae form turf-like beds. Rock pools isolated during low tides also contain a range of algae more commonly found on subtidal reefs, particularly species of the brown algae genera *Cystophora* and *Sargassum* and the green algae genera *Caulerpa* and *Codium*. The large and fleshy bull kelp (*Durvillaea potatorum*) frequently grows on the lower intertidal fringe of more exposed rocky shores.

Most of the animal species found on intertidal rocky shores are herbivores, grazing algae off rock surfaces. The dominant molluscs here: littorinid snails at and above the high tide-mark (*Littorina unifasciata* throughout Victoria and *L. praetermissa* recorded more commonly from central and western Victoria); limpets (*Cellana tramoserica* abundant throughout the intertidal zone, *Patelloida alticostata* at low tide or, in Port Phillip Bay, below it, *P. latistrigata* at mid to high tide, and *Notoacmea* spp. and the pulmonate snail *Siphonaria diemenensis* across much of the tidal range); top shells (*Austrocochlea constricta* and *A. odontis*); warrener (*Turbo undulatus*) common at and

below mid-tide level; black nerite (*Nerita atramentosa*) abundant at mid- to high-tide level; striped-mouth conniwink (*Bembicium nanum*); and chitons (*Plaxiphora albida, Ischnochiton (Ischnoradsia) australis*, and *I. elongatus*). Abundance of some of the common intertidal molluscs, as mentioned earlier, varies geographically across the State; for example, *Notoacmea mayi* is common in western Victoria, less common in the centre, and absent east of Wilsons Promontory. *Austrocochlea odontis* is common at and below mid-tide level in western and central Victoria but also absent east of Wilsons Promontory.

Filter-feeding organisms abound. The polychaete worm (*Galeolaria caespitosa*) and the sea squirt (or ascidian) known as 'cunjevoi' (*Pyura stolonifera*) both occur in the lower intertidal zone, often forming large beds on some shores. Cunjevoi are not recorded in Victoria west of Port Campbell. Mussel species include the beaked mussel (*Austromytilus rostratus*) and the little black horse mussel (*Xenostrobus pulex*). Barnacle species include the rough barnacle (*Chthamalus antennatus*) abundant in the higher part of the intertidal zone, honeycomb barnacle (*Chamaesipho tasmanica*), surf barnacle (*Catomerus polymerus*) found only on high-energy coasts, common surf barnacle (*Tesseropora rosea*) found only in far east Gippsland, and giant rock barnacle (*Austromegabalanus nigrescens*). The hairy stone crab (*Lomis hirta*), the sole member of an endemic superfamily, is also found beneath boulders on open rocky shores. A number of sessile colonial invertebrates occur on the underside of boulders and ledges in the intertidal zone. These filter-feeding organisms include encrusting sponges, bryozoans, and ascidians.

Several sea anemones (such as *Actinia tenebrosa* and *Cnidopus verater*) occur in the crevices and pools, feeding on a mixture of water-borne plankton and benthic invertebrates.

Many intertidal rocky shore species are scavengers with omnivorous diets. They include gastropod molluscs such as the lineated cominella (*Cominella lineolata*) abundant in pools and under rocks at mid-tide level, the small green sea star (*Patiriella exigua*), and several crabs: notched shore crab (*Paragrapsus quadridentatus*), purple-mottled shore crab (*Cyclograpsus granulosus*), and red bait crab (*Plagusia chabrus*). Sea stars including the common sea star (*Patiriella calcar*), crimson sea star (*P. brevispina*), and the otherwise predatory eleven-arm sea star (*Coscinasterias calamaria*), hermit crabs, and the rock pool shrimp (*Palaemon serenus*) also scavenge in rock pools formed during low tides. Another inhabitant, the common brittle star (*Ophionereis schayeri*), emerges at night to feed.

Resident predators include molluscs such as the dog winkle (*Thais orbita*), the abundant wine-mouthed lepsiella (*Lepsiella vinosa*), which feeds on the mussel *Xenostrobus pulex*, and the cone shell (*Conus anemone*) common in many localities in central and western Victoria, as well as a number of fishes: common shore-eel (*Alabes dorsalis*), Tasmanian clingfish (*Aspasmogaster tasmaniensis*), cardinal clingfish (*Creocele cardinalis*), Tasmanian blenny (*Parablennius tasmaniensis*), and dragonet (*Bovichthys variegatus*). Among other major predators in this system, birds such as the white-faced heron and sooty oystercatcher feed during low tides. Subtidal fish species, such as sweep and wrasses, move in to feed during high tides. Wrasses appear to be very important predators in Victorian waters, while sweep are only important in very exposed locations.

No species are legally harvested for commercial purposes from Victoria's intertidal rocky shores. Recreational collection of intertidal organisms was beginning to have such an impact at heavily visited sites in the 1980s that it is now prohibited along much of Victoria's coast. Molluscs and crustaceans are the primary targets for human consumption and for bait. Exploited species include warreners, abalone, elephant snails, dog winkles, limpets, top shells, crabs, and cunjevoi. Human trampling of intertidal biota in areas of high visitation has also been shown to affect certain species, especially the brown alga - Neptune's necklace (Povey and Keough 1991).



Intertidal rocky shores at Blanket Bay.

Subtidal rocky reefs

Documented biological information on these reefs is limited. A survey conducted in 1982 (Wilson *et al.* 1990) described marine habitats at Wilsons Promontory and the Bunurong coast at Inverloch. This study was supplemented by work conducted in 1987 and 1988 on reef fish populations at Wilsons Promontory. No similar studies have been published for western Victoria, although a considerable amount of data is contained in unpublished consultants' reports. Reef-associated fishes were surveyed at five sites in Victoria between Portland and Mallacoota in 1981/82 by Barry Hutchins of the Western Australian Museum as part of a larger survey of the coastal fish fauna of Southern Australia (Hutchins and Swainston 1986). Subtidal reefs frequently support biological and ecological studies, professional abalone dives, and recreational dives which provide some anecdotal information on species assemblages.

Subtidal reefs occur either as extensions of intertidal rocky reefs or as isolated offshore reefs. An indication of the distribution of shallow kelp reefs is provided in McShane *et al.* (1986). Artificial reefs, such as shipwrecks and marine structures, like jetty piles and breakwaters, also provide refuge and substratum to biota.

Distinctions can be drawn between reefs in open ocean and sheltered locations as well as between those in shallow water (to 5 m), moderate depths (5—20 m), and deep water (below 20 m). The communities of each habitat or depth category can differ markedly, both in species composition and abundance of organisms.

Shallow (0—5 m) and moderately deep reefs (5—20 m)

Good examples of sheltered shallow reefs include underwater extensions of the Port Phillip Bay shore platforms at Williamstown, Queenscliff, Portsea, and the eastern coastline of Port Phillip Bay between St Kilda and Ricketts Point. Some of these are artificial, formed by breakwater construction. In western Victoria, shallow ocean coastline reefs occur between Barwon Heads and Bridgewater Bay. The eastern coastline has shallow reefs from San Remo through to Wilsons Promontory and in the Cape Conran—Rame Head area. Good examples of moderately deep reefs at or near Port Phillip Heads include Lonsdale Bight, the 'wall', Portsea Hole, and Popes Eye.



Subtidal rocky reefs adjoining a rocky shore.

Shallow subtidal reefs in Victorian waters are dominated by several species of large kelps. These brown algae form extensive beds, often with a rich algal understorey and associated fauna. Two species, bubble weed (*Phyllospora comosa*) and the large and fleshy bull kelp typically occupy exposed localities, the latter more commonly found in the surge zone from the low tide mark down to approximately 5 m deep. Leather kelp (*Ecklonia radiata*) usually dominates on sheltered reefs. Small beds of the southern giant kelp (*Macrocystis angustifolia*) also occur in several moderately sheltered localities in Victoria, such as inside Lonsdale Bight and between Barwon Heads and Torquay. Individual plants of this kelp can reach lengths in excess of 10 m, with air bladders supporting the bulk of the plant on the surface.

Other algae occur among these, often forming an understorey among the holdfasts of the larger kelps, including species of *Cystophora*, *Sargassum*, *Codium*, *Cladophora*, and *Caulerpa*. Many small red algae such as *Laurencia*, *Champia*, *Plocamium*, and *Polysiphonia* form turf-like beds, as do encrusting and arborescent coralline red algae (of the family Corallinaceae).

Understorey biota of moderately deep reefs consist of red algae, small sponges, ascidians, bryozoans, and hydroids - all taxa that can withstand constant brushing and abrasion by algal thalli, like the hydroids *Sertularia macrocarpa* and *S. unguiculata*. Epiphytic species on kelp fronds include bryozoans and hydroids such as *Orthopyxis caliculata* and *Silicularia rosea*.

Sargassum, *Cystophora*, and *Caulocystis* brown algae prefer sheltered reefs of shallow to moderate depths - e.g., Governor Reef in Port Phillip Bay - and the lee side of some

islands and coastline of Wilsons Promontory - e.g., Cliffy Island, Waterloo Bay, and Refuge Cove.

Reefs in eastern Victoria (off the Ninety Mile Beach to 4 km offshore at 15—20 m) consist of flat-lying wave swept Tertiary limestone. Biota is not dominated by plants, probably because of poor light and degree of exposure, but by invertebrates. Species present are large sponges (*Iophon laevistylis, Phyllospongia calyciformis, Crella* sp., *Clathria* sp., *Raspallia* sp.), ascidians (*Polycitor gigantea, Botrylloides magnoecius, Sycozoa cerebriformis*, and, very commonly, the stalked ascidian (*Pyura australis*), bryozoans (*Amathia tortuosa, A. biseriata, Scuticella* sp.), and hydroids (black feathery *Agalophenia divaricata*, white feathery *A. whiteleggi*, orange *Halopteris campanula*, red *H. buskii*).

Interesting reefs occur in Portland Bay at 15 m - flat calcarenite and basalt, supporting a biota dominated by the green algae (*Caulerpa* spp., *Codium pomoides*, and *C.* cf. *fragile*), short red algae, and a fauna of ascidians (*Herdmania, Halocynthia hispida*), bryozoans, and some sponges.

The basis of food webs on shallow rocky reefs appears to be primary production by macroalgae and consumption of these algae by herbivorous animals. The largest herbivores are gastropod molluscs such as the black-lip abalone (*Haliotis rubra*), some green-lip abalone (*H. laevigata*), warrener, and pheasant shell (*Phasianella australis*). Other herbivores include numerous microcrustacea, the purple sea urchin (*Heliocidaris erythrogramma*), and a number of fish species: scalyfin (*Parma victoriae*), herring cale (*Odax cyanomelas*), zebrafish (*Girella zebra*), southern sea carp (*Aplodactylus arctidens*), and rainbowfish (*Odax acroptilus*).

Invertebrates feeding on detritus in this system include echiurid worms such as the green spoon worm (*Metabonellia haswelli*), active at night, and sea cucumbers such as *Pentacta ignava*.

Filter-feeding invertebrates primarily live in crevices and on the vertical faces and underhangs of boulders and outcrops. These animals include sponges such as the rose (*Dendrilla rosea*) and golf-ball sponges (*Tethya* spp.), anemones such as the white-striped anemone (*Anthothoe albocincta*), bryozoans such as sea mat bryozoan (*Membranipora membranacea*), soft orange bryozoan (*Orthoscuticella ventricosa*) and soft blue bryozoan (*Bugula dentata*), polychaetes such as the feather duster worms (*Sabellastarte* spp.), bivalves such as *Barbatia* spp., feather stars such as common feather star (*Comanthus trichoptera*), and ascidians such as the pink throated ascidian (*Herdmania momus*).

Many animals found on Victoria's reefs are scavengers, typically with omnivorous diets over a wide range of prey. They include sea stars (e.g., eleven arm and crimson sea stars), southern rock lobster (*Jasus edwardsii*), and many fishes including the blue-throat wrasse (*Notolabrus tetricus*), saddled wrasse (*N. fucicola*), senator wrasse (*Pictilabrus laticlavius*), old wife (*Enoplosus armatus*), Shaw's cowfish (*Aracana aurita*), leatherjackets (family Monacanthidae), globefish (*Diodon nichthemerus*), and the nocturnally active species southern gobbleguts (*Vincentia conspersa*), common bullseye (*Pempheris multiradiata*), and roughy (*Trachichthys australis*).

Predators on rocky reefs can be divided into sedentary resident species and more mobile animals that forage over the reefs. The former include octopuses (e.g., *Octopus maorum* and the blue-ringed octopus, *Hapalochlaena maculosa*), southern giant cuttlefish (*Sepia apama*), Port Jackson shark (*Heterodontus portusjacksoni*), varied catshark (*Parascyllium variolatum*), draughtboard shark (*Cephaloscyllium laticeps*), southern red scorpioncod (*Scorpaena papillosa*), and beardie (*Physiculus barbata*). Transient predators over the reefs regularly include the southern calamary (*Sepioteuthis australis*), long-finned pike (*Dinolestes lewini*), bastard trumpeter (*Latridopsis forsteri*), and barracouta (*Thyrsites atun*).

A number of reef fishes feed mid-water on water-borne prey or organic matter: they include sea sweep (*Scorpis aequipinnis*), silver sweep (*S. lineolatus*), barber's sea perch (*Caesioperca rasor*), butterfly sea perch (*C. lepidoptera*), and southern hulafish (*Trachinops caudimaculatus*). Other reef fishes such as the magpie morwong (*Cheilodactylus nigripes*) and red mullet (*Upeneichthys lineatus*) feed on the associated rich microfauna.

Deep-water reefs

Beyond approximately 20—30 m, most of the algae are replaced by invertebrates, particularly sponges, bryozoans, corals, sea whips, and ascidians. Good examples occur at and outside

Port Phillip Heads (the 'wall' in Lonsdale Bight at the edge of the shipping channel), off Cape Woolamai (the 'Pinnacles'), Wilsons Promontory, and the Portland area. Little is known of these reefs as they are too deep to be easily surveyed on scuba and cannot be censused with the trawl-and-grab techniques used on soft sediment substrates.

Deep water reefs generally lie below any appreciable wave motion, and so support numerous delicate forms. Examples of invertebrates are the mauve- or yellow-stalked ascidian *Pyura spinifera*, orange to red gorgonians (*Mopsella* spp.) and pink *Mopsea whiteleggei*, bryozoans including the pink *Cornucopina grandis* and mauve *Vittacella* sp., hydroids including the large brown fan-shaped *Clathrozoon wilsoni*, arborescent black *Halopteris sulcata*, and the flower-like *Halocordyle wilsoni*. Sponges include the stinging purple species *Spirastrella* sp., *Crella* sp., and *Clathria* sp. One of the most conspicuous deeper-water invertebrates is an unnamed zoanthid (*Zoanthus* sp.) that spreads in bright yellow sheets of flower-like polyps across large areas of rock face.

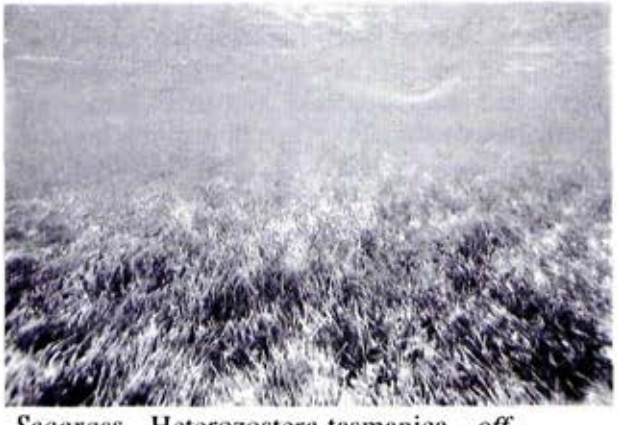
A number of species are harvested from both shallow and deep subtidal rocky reefs. Invertebrate commercially harvested include black-lip and green-lip abalone, mostly in depths of less than 20 m, southern rock lobster, often from deep water off western Victoria, and purple sea urchin. Commercial and amateur fishing also take a number of reef fish species using line, spear, and traps. Exploited species include wrasses, sweep, morwong, long-finned pike, and bastard trumpeter. The southern calamary is also taken on jiglines by amateur fishers. Anecdotal evidence suggests that the abundance of wrasses, abalone and southern rock lobster has been reduced over the last 100 years.

Seagrass beds

This is perhaps the best-studied of Victoria's marine habitats. All Victoria's major seagrass areas have been surveyed, often in considerable detail. Despite that, substantial gaps in the knowledge of seagrass ecosystems remain (see Marine Habitats and Communities - Case Studies, later in this chapter). The distribution of seagrass beds within inlets and embayments appears very variable, suggesting that here, in contrast to reef habitats, ongoing survey and monitoring are critical. A suspected decline in seagrass in the 1970s (Shepherd *et al.* 1989) gave the impetus for a number of studies in Victoria. Bulthuis and others found an extensive reduction in *Heterozostera tasmanica* and *Zostera muelleri* in Western Port from 1973 to 1984, and *Posidonia australis* declined in Corner Inlet over a similar period (Poore 1978, Morgan 1986). Many aspects of the ecology of the seagrass meadows of Western Port have been investigated - e.g., Watson *et al.* (1984). The distribution of beds in Port Phillip Bay (Bulthius, 1981a) and Swan Bay (Kerr 1983) has also been documented.

Seagrasses occur in the shallow waters of all major bays and inlets of the Victorian coastline, as well as in most estuaries. Several species, primarily *Heterozostera*, also grow in slightly deeper or more sheltered areas of the open coastline - for example, at Wilsons Promontory.

Although seagrasses are marine flowering plants (angiosperms) their ancestors were terrestrial. They are typically found in sheltered waters on silty or sandy substrates. Seagrass beds bind together unstable sediments and provide substrate, habitat, and food sources for many other organisms. Food webs



Seagrass - Heterozostera tasmanica - *off Point Richards.*

in seagrass systems differ from those on rocky reefs in that few organisms directly consume the seagrasses themselves. Instead, the system is based primarily on detritivores, feeding on seagrass detritus and the small epiphytes and epifauna living on the leaves or among the rhizomes.

Five genera (and seven species) of seagrasses are represented in Victorian coastal waters. The five major species are: eelgrasses (*Zostera muelleri* and *Heterozostera tasmanica*); sea nymph (*Amphibolis antarctica*); fibre-ball weed (*Posidonia australis*); and paddle weed (*Halophila australis*). All five occur on muddy or sandy substrates, binding loose sediments

together with extensive rhizomatous root systems. The species show clear patterns of distribution. The eelgrasses occur along the entire Victorian coastline, and are common in bays, inlets, and estuaries. *Zostera muelleri* has fine leaves with few branches and typically occurs on intertidal mudflats, covering very large areas in Western Port. *Heterozostera tasmanica* also has long fine leaves but with considerably more branching. It occurs more commonly subtidally, on both mud and sand. Sea nymph has short, twisted, strap-like leaves, many branching off each major stem, and is found on sandy bottoms in slightly more exposed conditions such as those around the western entrance of Western Port and Port Phillip Heads. Fibre-ball weed has long, wide, strap-like leaves and is more commonly associated with the warm temperate waters of New South Wales. It is considered rare in Victoria (Gullan *et al.* 1990), but is more appropriately classified as restricted, found only at Corner Inlet and the adjacent Nooramunga area, Barwon Heads and Great Glennie Island off Wilsons Promontory. Paddle weed is typically subtidal and occurs in very low densities, often found as individual plants. It has also has been reported to form patchy, moderately dense beds on sand flats in Corner Inlet, Port Phillip Bay, and Western Port.

Many epiphytic organisms such as hydroids, corraline and filamentous red algae and bryozoans live on the stems or leaves of seagrasses. Screw-shaped colonies of the bryozoan - *Densipora corrugata* are particularly abundant on the stems.

Invertebrates in seagrass beds include sponges, bryozoans, ascidians (such as *Didemnum* sp.), and cnidarians, including the wandering anemone (*Phlyctenactis tuberculosa*). A number of bivalves are also present, including *Mysella donaciformis*, *Solemya* cf. *australis*, *Tellina (Macomona) deltoidalis*, *Melliteryx helmsi*, and less commonly *Nucula pusilla*, *Katelysia scalarina*, and *K. rhytiphora*. *K. rhytiphora* is an important inhabitant of blowouts in the seagrass beds.

The beds support a rich infauna and epifauna. Polychaetes are particularly abundant in eelgrass beds, making up 50% of the volume of macrobenthos (Ministry for Conservation 1980), while *Lumbrineris latreilli* is ubiquitous. Gammaridean and caprellidean amphipods are also very common, with other small crustaceans such as ostracods, cumaceans, and isopods locally common.

Seagrass communities support a wide range of crustaceans, many of which are generalist scavengers. Examples are the smooth pebble crab (*Philyra laevis*), the small spider crabs (*Halicarcinus ovatus* and *H. rostratus*), the introduced European common shore crab (*Carcinus maenas*), *Nectocarcinus tuberculosus*, xanthid crabs (e.g., *Pilumnus fissifrons*) and the grapsid crabs (*Paragrapsus laevis* and *P. gaimardi*). A number of shrimp species are also found among seagrass leaves or burrowing among the rhizomes. These include the snapping shrimp (*Alpheus euphrosyne*), *Macrobrachium intermedium*, *Parapandalus leptorhynchus*, and *Pontophilus intermedius*. In more open patches in the beds, the ghost yabby (*Trypaea australiensis*) and the sentinel crab (*Macrophthalmus latifrons*) dominate.

Sea stars in Victorian seagrass systems include *Patiriella brevispinna* and *P. calcar*. The brittle star *Ophiacantha alternata* is common and the small sea cucumber (*Leptosynaptera* cf. *dolabrifera*) may be common.

Predators in this habitat include the cephalopod species - southern calamary, pygmy squid (*Idiosepius notoides*), and the dumpling squid (*Euprymna tasmanica*). Certain fish are associated with *Zostera* beds throughout their life cycle, including the cobbler (*Gymnopistes marmoratus*), common weedfish (*Heteroclinus perspicillatus*), bridled goby (*Arenigobius frenatus*), and the long-finned goby (*Favonigobius lateralis*). Most of these permanent residents are nocturnally active. The juvenile, sometimes quite large, stages of other species are associated with these beds, including yellow-eyed mullet (*Aldrichetta forsteri*), greenback flounder (*Rhombosolea tapirina*), and King George whiting (*Sillaginodes punctatus*). Other species are tidal transients, moving in over the *Zostera* beds during high tides. They include the smooth toadfish (*Tetractenos glaber*), hardyheads (*Atherinosoma lentatherina* and *A. microstoma*), and the southern garfish (*Hyporhamphus melanochir*).

Other fish species commonly seen in seagrasses are the dusky morwong (*Dactylophora nigricans*), pipefishes (*Stigmatopora nigra, S. argus*, and *Vanacampus poecilolaemus*), seahorses (*Hippocampus breviceps* and *H. abdominalis*), weedy sea dragon (*Phyllopteryx taeniolatus*), Shaw's cowfish, and the ornate boxfish (*Aracana ornata*).

Commercial and recreational fishers seek a number of these fish species including King

George whiting, yellow-eyed mullet, southern garfish, and southern calamary.

The decline in the area of seagrass, particularly in Western Port in the 1970s and 1980s, may to be due to a number of factors, including increased turbidity and sedimentation from agricultural run-off, dredging and/or increased shipping, and small-boating activity in this bay. Seagrass systems act as nursery grounds for many fish of commercial and recreational species. Loss of seagrass areas may reduce recruitment of some of them.

Sheltered intertidal flats

This habitat type is relatively well documented for Port Phillip Bay, Western Port, and Corner Inlet.

Sheltered intertidal flats with few macro-algae or vascular plants can be divided into two categories: sand flats and mud flats. In many locations, the distinction between bare flats and seagrass flats is difficult to define as bare flats often grade into seagrass beds.



Sheltered intertidal flats.

Intertidal sand and silt flats are characterised by sand and silt-sized particles and moderate instability of the sediment, with wave action and currents shifting the substrate. This instability provides little opportunity for establishment of macro-algae or vascular plants, and hence these sand flats support little plant life. They occur primarily in sheltered waters of Port Phillip Bay, in some regions of Western Port, and in smaller inlets. Sediment instability also prevents establishment of microflora. In the absence of significant primary plant production, sand flats support low biomass.

Soldier crabs - *Mictyris longicarpus* in eastern Victoria and *M. platycheles* throughout most of the state - are one of the dominant species on these sand flats. The gastropod snails *Polinices conicus* and *P. sordidus* also occur. Infauna includes polychaetes, such as *Nephtys longipes*, and bivalves including the pipi (*Plebidonax deltoides*). Fish species from adjacent subtidal habitats may move over these sand flats when submerged at high tide. Recreational fishers collect pipis and larger polychaetes as bait. Snails (*Polinices* spp.) are also collected for human consumption.

Intertidal mud flats are characterised by very fine particle size, sediment stability, and high biomass of micro-algae and some fine macro-algae (typically reds). They support a moderate to high biomass based on the micro-algal surface film and associated grazers, together with a large number of wading birds. They are found in the sheltered waters of bays, inlets, and estuaries with less exposure to wave action.

Intertidal mud flats contain a number of bivalve molluscs including the triangular tellin (*Tellina [Macamona] deltoidalis*), elongated lantern shell (*Laternula creccina*), and mud ark (*Anadara trapezia*). Several crustaceans occur in large numbers on (or in) mud flats including the crab *Macrophthalmus latifrons*, the semaphore crab (*Heloecius cordiformis*), and the ghost yabby.

Many transient fishes move in over intertidal mud flats during high tides, particularly the smooth toadfish, stingarees (*Urolophus* spp.), King George whiting, and greenback flounder (*Rhombosolea tapirina*). Recreational fishers collect certain intertidal mud flat species as bait, particularly large polychaetes and the ghost yabby. Dredging, boat traffic, human trampling, and bait collection may all have an impact on these systems.

Mangroves

The Victorian mangrove (*Avicennia marina*) is restricted to sheltered, intertidal areas of bays, inlets, and estuaries, mainly on muddy and fine sandy sediments (Ashton 1971). Its distribution has been described in the previous section. White mangrove is restricted to the intertidal zone between mid and mean high-water mark and it is almost entirely submerged at high tide and use emergent roots (pneumatophores) to obtain oxygen for the submerged root system. The lower trunk, roots, and pneumatophores provide suitable substrates for colonisation by a variety of intertidal marine flora and fauna. The associated biota has been described by

Morgan (1986) for Corner Inlet, by Watson (1971) for Western Port, and in unpublished consultants' reports.

Algal mats are usually associated with the pneumatophores, typically made up of the red algae *Bostrychia* spp. and *Catanella nipae*.

In mangrove shrublands, the fauna usually exhibits strong zonation. Pulmonate gastropods and crabs dominate the landward edge. Further down, algal cover increases and there is a rich microcrustacea (amphipods, isopods) and polychaete fauna. Crab holes are often densely distributed, dominated by the grapsid crabs (*Paragrapsus gaimardii* and *P. laevis*), the semaphore crab, the mud crab (*Helograpsus haswellianus*), and the red-fingered crab (*Sesarma erythrodactyla*). The exotic European common shore crab also frequently occurs in the mangrove communities and a mud crab (*Macrophthalmus latifrons*), is patchily distributed on mud surfaces. Molluscs are among the most characteristic elements. In particular, hard substrate gastropods such as black-mouthed conniwink (*Bembicium melanostomum*) and ribbed top shell (*Austrocochlea constricta*) are conspicuous. *Zeacumantus diemenensis* and the southern mud whelk (*Velacumantus australis*) can be common among the algae, and the dog whelk (*Nassarius pauperatus*) and juveniles of the solid air breather (*Salinator solida*) and fragile air breather (*S. fragilis*) can occur in the sediment. Bivalves are most numerous in sediments lower down the shore, usually dominated by *Legrandina bernardi* and *Melliteryx helmsi*. The acorn barnacle (*Elminius modestus*) is densely distributed on pneumatophores and tree stems and on some gastropod shells, particularly in the seaward fringe of the community.

A number of fish from neighbouring subtidal habitats, usually seagrass beds, move in to forage among the mangroves during high tides. Mangrove habitats are considered to be valuable nursery areas for fish, but no data at all are available on such utilisation of these Victorian communities.

No commercial exploitation of mangroves occurs here, as it does in south-east Asia, but areas have been lost in some regions by reclamation, through dredging associated with industry and port development, particularly in Western Port. Ministry for Conservation, Victoria reports recovery and growth of some mangrove stands in Western Port since the 1960s.

Sandy beaches

Beaches included in this habitat type are accumulations of sediment deposited by waves and currents in the shore zone, and typically consist of sands (Bird 1984). Most of those along the Victorian coastline are exposed to high wave action and are characterised by unstable coarse sediment. They are found along the length of the open coast, around the periphery of most of Port Phillip Bay and in a number of locations in Western Port. The habitat type supports few organisms and a depauperate biota, but few studies have been published. Some data are available from consultant's reports on the Ninety Mile Beach and beaches in Port Phillip Bay.

Calcareous beach sands dominate the south and west coasts of Australia, and quartzose beach sands are characteristic in the south-east, with the junction of the two provinces occurring at Wilsons Promontory. Calcareous sand is largely of biogenic origin. Gell (1978) found that shelly beaches in Victoria comprised rocky reef species while others came from shallow sandy and muddy environments in sheltered bays and estuaries. The quartzose sands are of granitic origin.

It appears that the coarser the beach sand, the lower is the population density of invertebrates living in the substrate. For example, the high-energy beaches of Ninety Mile Beach support few organisms, mainly amphipods and isopods in the swash zone and the bivalve pipi in the lower intertidal zone. Another bivalve, *Paphies (Amesodesma) angusta*, and a number of polychaetes can occur in the sand at the lower edge of the intertidal zone. The coarse sandy beaches of the eastern coast of Port Phillip Bay are similarly depauperate, also containing a few amphipod and isopod crustaceans.

Organic matter washed up on sandy beaches, primarily drift algae, provides the diet for a number of animals including tenebrionid beetles (*Sphargeris physodes*), sand hoppers (*Talorchestia* spp.), and kelp flies as well as small amphipods and isopods.

Recreational fishers often collect pipis and worms for bait.

Subtidal soft substrates

The marine communities of subtidal soft substrates can be categorised according to sediment type and degree of exposure - i.e.,



An orange seapen common in areas of fine sediments.

sheltered or exposed coasts. Sediment type - believed to be extremely important in controlling species distribution and community structure - determines the following habitat subtypes, but it is important to realise that these may not be distinct. Subtidal soft substrate habitat can be considered as a spectrum from sandy to muddy sediment. Seagrass communities occur across the range of sediment types, but are considered here as distinct systems containing different biota and hence are treated separately.

Although the soft-bottom benthos of sheltered embayments, inlets, and estuaries is relatively well known, there are fewer reports for soft sediment communities offshore. The information that is available (e.g., Parry *et al.* 1990) comes from eastern Victoria, although data from the Bass Strait Study are also relevant. Current work in east Gippsland and off Ninety Mile Beach will add considerably to knowledge of the Bass Strait fauna. No such comprehensive quantitative studies for western Bass Strait are available, but consultant's reports contain some data on the soft-bottom benthos of the Portland area. Survey programs undertaken in Port Phillip Bay and Western Port (Poore and Rainer 1979, Coleman *et al.* 1978, Carey and Watson 1992) provide quantitative measures of differences in community structure and species diversity associated with differences in sediment type.

Generally, it appears that poorly sorted coarse sediment often supports a more diverse fauna than does mud. In fact, the diversity of the benthos of offshore sandy bottom environments in eastern Victoria appears to be extremely high, and certainly higher than any reported for temperate waters.

Muddy bottom environments are only found in sheltered embayments, estuaries, or very deep offshore waters. Sandy bottoms, however, can occur in areas of negligible current flow (e.g., the shallow periphery of much of Port Phillip Bay), of moderate current flow (e.g., along Ninety Mile Beach), and of high current flow (e.g., off Point Nepean at Port Phillip Heads and in northern Western Port). Sandy habitats in embayments can be distinguished from sandy habitats along the open coast on the basis of their fauna, and generalisations extrapolated from work conducted mainly in the sheltered bays may have little applicability to open coast.

Subtidal sandy bottom occurs along much of the open coast as well as in Port Phillip Bay, Anderson Inlet, and Shallow Inlet. Western Port and Corner Inlet contain relatively small areas of coarse shelly sand. Different faunas are found depending on amount of water movement or current flow.

Sandy bottom epibenthos off Ninety Mile Beach is dominated by the straplike mauve-coloured alcyonacean - *Pseudogorgia goddefroeyi*. The large pink seapen (*Sarcoptilus grandis*) can be found on coarse sediments along the open coast, such as in Waratah Bay, and also in Western Port where the current flow is moderate. In northern Western Port another, undescribed species of orange seapen, *Sarcophyllum* sp., is common in areas of fine sediments with good current flow. Epibenthos areas include small algae, stalked ascidians (*Sycozoa pedunculata*), and most importantly *Pyura stolonifera* (in Port Phillip Bay and elsewhere), hydroids *Obelia australis*, small bryozoans, and sponges. Scallops are epibenthic, and the commercial scallop (*Pecten fumata*) occurs on fine sands in waters about 30 m deep in eastern Bass Strait.

The composition of deeper-water epibenthos appears to be largely determined by water movement. For example, in deep water (30—50 m) off Cape Woolamai, the bed consists of gravelly-sand heaped into waves by ocean swells and has an ascidian-dominated epibenthos with some seapens. Other areas, such as Port Phillip Heads, with strong current flow and little swell, have more delicate forms such as calcareous bryozoans *Petralia undata*, *Adeona cellulosa*, and *Lanceopora obliqua*, the last two species with flexible stalks allowing movement with the currents. Other species in strong flow are the sponges *Ciocalypta* sp. and *Ancorina corticata*. Hydroids adapted to fast current flow are *Amphisbetia operculata* and *Nemertesia wattsi*.

Infaunas appear to be dominated by polychaetes and crustaceans (mostly amphipods). Subordinate groups are bivalves, brittle stars, holothurians, sipunculans, gastropods, nematodes, and nemerteans. Common bivalves found in sand are the pipi, narrow wedge shell (*Donacilla angusta*), stepped venerid (*Katelysia scalarina*) in quiet water, flame dog cockle (*Glycymeris flammeus*) in gravelly to coarse sand in open waters, *Mysella donaciformis*, and *Legrandina bernardi*.

Several gastropod molluscs are found primarily on sand including the blemished dog whelk (*Nassarius burchardi*), flat sand snail (*Polinices incei*), and conical sand snail (*P. conicus*). The sand octopus (*Octopus kaurna*) also appears to be restricted to sandy sediments.

The sand crab (*Ovalipes australiensis*) commonly occurs on shallow sand substrates, scavenging close to shore, often in the surf zone, where it is known to take fish from the lines of surf fishers.

Fish species found on sandy bottoms include the greenback flounder (*Rhombosolea taparina*), long-snouted flounder (*Ammotretis rostratus*), southern sand flathead (*Platycephalus bassensis*), eastern stargazer (*Kathetostoma laeve*), gummy shark (*Mustelus antarcticus*), saw shark (*Pristiophorus nudipinnis*), elephant shark (*Callorhynchus milii*), and stingarees. Southern school whiting (*Sillago bassensis*) are characteristically fish of the open coast, while King George whiting are predominantly taken from bays and estuaries.

Commercial dredging of scallops occurs on sandy to muddy bottoms in Port Phillip Bay and in Bass Strait off Lakes Entrance. Fish species harvested by trawl over sandy bottoms include school whiting, flounder, sand flathead, gummy shark, saw shark, and elephant shark.

Subtidal muddy bottom occurs in sheltered, shallow coastal waters of bays and inlets and in the deeper waters off the open coast less influenced by surface wave action and currents.

Subtidal muddy substrates are often dominated by surface deposit feeders and scavengers. The channels of northern Western Port contain the brachiopod *Magellania flavescens* at high densities. In shallower waters, fine red algae can also occur.

In some regions, such as Western Port, large aggregations of cunjevoi form 'micro-reefs' (Carey and Watson 1992), supporting flora and fauna more typical of rocky reefs. The most abundant mollusc in northern Western Port is the purple bivalve *Neotrigonia margaritacea*. Trigoniid bivalves are common world wide as fossils, but living species are only found around Australia (see Gould 1968). In northern Western Port *Solen vaginoides* (often referred to as the Chinese fingernail shell) is very common in muddier sediments. Port Phillip Bay contains scallops on silty to muddy bottoms.

Brittle stars (e.g., *Ophiura kinbergi* and *Ophiocentris pilosus*) commonly occur on these soft sediments. The heart urchin, (*Echinocardium cordatum*), a detritivore, is widely distributed on clay and silty-clay sediments in Port Phillip Bay such as those in Corio Bay. It lives submerged in the top layer of sediments, burrowing through to feed on buried organic matter.

Several fish species are found in association with mud substrates. These include the smooth toadfish, also commonly associated with seagrass beds, tiger flathead (*Neoplatycephalus richardsoni*), school whiting, sparsely-spotted stingaree (*Urolophus paucimaculatus*), Tasmanian numbfish (*Narcine tasmaniensis*), crossback stingaree (*U. cruciatus*), angel shark (*Squatina australis*), saw shark (*Pristiophorus nudipinnis*), prickly toadfish (*Contusus brevicaudatus*), and several leatherjackets (Family Monacanthidae).

A number of muddy bottom fish are commercially harvested, primarily by trawl. These include tiger flathead, school whiting, angel shark and saw shark.

Pelagic environments

A number of marine organisms either reside in open waters or spend long periods there in transit. The open waters off Victoria's coast contain a low biomass of suspended flora and pelagic fauna, either actively swimming or carried by water currents. Many of the more mobile fauna, particularly the fishes and squid, frequently visit different habitat types seeking prey. Hence they may be observed or captured in the subtidal systems previously discussed.

Phytoplankton and some drift algae suspended by gas floats such as *Sargassum* and *Cystophora* form the plant component of these communities.

Jellyfish, comb jellies (ctenophores), and salps feed on phytoplankton and zooplankton carried in the currents. Jellyfish species include the by-the-wind-sailor (*Velella velella*) and the bluebottle (*Physalia physalis*), plus many small forms such as narcomedusae (*Liriope* sp.), and the medusa stage of many hydrozoans. The goose barnacle (*Lepas anserifera*) also filter-feeds in open waters, remaining suspended on the surface by attaching to flotsam.

Several molluscs have adapted to a life style of being carried in open water currents, being suspended by the water surface tension. These include the violet snail (*Ianthina janthina*) and the silver sea slug (*Glaucus atlanticus*), both of which prey on jellyfish. The paper nautilus, (*Argonauta nodosa*), also appears to feed exclusively in open surface waters.

Predators here are primarily pelagic species travelling to coastal reefs or the bottom to feed. They include the arrow squid (*Nototodarus gouldii*), silver trevally (*Pseudocaranx dentex*), warehou (*Seriolella* spp.), barracouta, pilchards (e.g., *Sardinops neopilchardus*), anchovies (e.g., *Engraulis australis antipodum*), and Jack mackerel (*Trachurus declivis*).

A number of cetaceans travel through Victorian coastal waters. Southern right whales regularly pass through Bass Strait, some calving off Warrnambool. Others sighted include pilot, killer, false killer whales, and the humpback whale (*Megaptera novaeangliae*). Two dolphin species, the bottlenose dolphin (*Tursiops truncatus*) and common dolphin (*Delphinus delphis*), regularly appear. The little penguin also feeds on pilchards and anchovies in these waters.

Trawl and line fisheries harvest many species here, both finfish and the arrow squid (*Nototodarus gouldii*).

MARINE HABITATS AND COMMUNITIES - CASE STUDIES

(Prepared by Jeanette E. Watson of Marine Science and Ecology, 35 Tilba Street, Essendon 3040.)

The diversity of species and the complexity of their interactions in the marine ecosystems of the Victorian coast are not well known. The biological systems that have received most attention in Victoria are those of the subtidal soft bottom in Port Phillip Bay and Western Port, the former because of continuing impacts of urbanisation and the latter when, some 20 years ago, it was selected as the future deep-water port for the city of Melbourne. The impetus for much research has come from the threat to other coastal habitats or from expectations of new impacts of pollution. This has resulted in a fragmented knowledge of coastal and marine habitats and has provided little State-wide information on the spatial or temporal distribution or how long-term changes will affect communities.

Although we have a reasonable knowledge of reef-dwelling species through taxonomic collecting over many years, there is no published quantitative study of the populations of any reef ecosystem. Hence we have no basis for comparison of reef ecosystems east and west of Wilsons Promontory, even though the most casual observation shows them to be very different. The benthic ecology of the muddy bed of mangrove stands, the epibenthos of the soft bottom, and the plankton of bays and the open coastline are also only poorly known.

Victoria's coast owes its physical complexity to the interaction of many physical factors, including coastal lithology, geomorphology and orientation, exposure to swell and wind-generated seas, differences in temperature and tide and current regimes between the east and west, and, not least, exposure to the physical influences and larval recruitment from the Southern and South Pacific Oceans.

The following discussion provides case studies for five habitats described in the previous section (intertidal rocky shores, sandy beaches, mangroves, subtidal soft substrates, and seagrasses); two groups of marine organisms (plankton and epibenthos); and some marine species and communities used for



Southern giant kelp (subtidal reef flora).

biomonitoring. The case studies have been selected from published and unpublished studies and are presented to highlight the complexity of marine ecosystems not shown by broad habitats described earlier.

This discussion is not exhaustive, nor have all available data been considered. Unless otherwise cited, data used in the following discussion are drawn from unpublished reports prepared by Marine Science and Ecology, environmental consultants, Melbourne.

INTER-TIDAL ROCKY SHORES

Rocky shores occur where hard rock outcrops in the intertidal zone. Such places are usually part of exposed headlands, but sometimes platforms are cut in quieter waters - for example, those in granodiorite at Mount Martha and in basalt at Williamstown in Port Phillip Bay.

Ease of access to such areas has resulted in several ecological studies of rock platforms; however, the only State-wide distributional studies have been the classical biogeographical study of Bennett and Pope (1953) and that of the Marine Research Group of Victoria (Phillips *et al.* 1984) which published a survey of key intertidal species along the entire Victorian coast. Several studies of platforms are in progress, including ongoing student projects at Williamstown (Melbourne University), Point Lonsdale (Deakin University), and Point Nepean (Melbourne University).

Portland

An example of the contrast in the species and distribution of biota resulting from differences in exposure in the same geographical region, and on the same type of rock, occurs at Portland.

The organisms on a natural, flat-lying, basaltic platform in Grant Bay, west of Portland, exposed to south-westerly swells, were compared with those on a breakwater near Portland Harbour, constructed of large blocks of the same basalt. While sheltered from south-westerly swells to which Grant Bay is exposed, the breakwater is an extremely uneven habitat, compared with that in Grant Bay. The biota of the platforms includes algae, barnacles, bivalves, gastropods, and anemones. Both sites were studied several times between 1982 and 1990.

Similar numbers of organisms were found at both sites (166—200 per sq. m). The sheet-forming mussel *Xenostrobus pulex* covered 27% of the rock surfaces at Grant Bay, but was unimportant on the breakwater, which has fewer horizontal surfaces. The difference may be related to its ability to withstand breaking waves, or its lower populations at Portland Harbour might have been due to predation by the purple wrasse (*Pseudolabrus fucicola*), or it might have been taken incidentally in the diet of the limpet *Cellana tramoserica*, which was common on the breakwater.

At Grant Bay, the most important alga was the green sea lettuce (*Ulva* sp.), with 3—7% cover over several years. Growth of this alga is apparently encouraged by a fresh-water discharge over the platform from a small natural creek. It was unimportant on the breakwater where the dominant algae were the red turfing species *Laurencia* and *Asparagopsis* and the short brown filamentous species *Scytosiphon lomentaria* and *Zonaria spiralis*, with covers of 50% and 6% respectively.

These differences in algal species and cover and, to a lesser extent, in populations of invertebrates relate to different responses of biota to exposure to the physical environment. The much greater cover of turfing and filamentous algae on the breakwater is due to the uneven, blocky topography, which provides a large variety of micro-habitats in the form of sheltered clefts and crevices that favour species that cannot survive much exposure to breaking waves or desiccation during periods of low tide.

Biotic relationships are usually complex and, even over a short length of coastline that is lithologically similar, the communities may differ markedly.

SANDY BEACHES

Although several studies have been completed or are in progress, the only data available apply to McGaurans and Woodside Beaches - Ninety Mile Beach; to near outfall drains from the Werribee Treatment Complex to Port Phillip Bay (Dorsey 1982); and to other beaches around Port Phillip Bay.

Ninety Mile Beach

Eight intertidal surveys conducted at McGaurans Beach and Woodside Beach on the Gippsland coast, between 1983 and 1990, illustrate the relatively depauperate nature of

the ocean beach infauna. In 1990, nine species were recorded, four of which were isopods of the genera *Cirolana*, *Scyphax*, and *Armadilloniscus*. These contributed 86% of the total number of organisms. The remaining organisms included bivalves, polychaetes, amphipods, and insect larvae. The abundance of organisms varied from 5 to 102 per sq. m over the 8-year period (Table 4.2).

Table 4.2: Intertidal Infauna - Ninety Mile Beach

	Mean number of organisms per sq. m	
Year	McGaurans Beach	Woodside Beach
1983	20	26
1984	96	12
1985	11	96
1986	5	31
1987	30	54
1988	54	102
1989	64	40
1990	32	24
Mean	39	48

Populations over the survey period were extremely variable, fluctuating considerably between years. This is probably due to the dynamic nature of the ocean regime and exposure of the beach, the profile of which changes constantly according to prevailing weather conditions. For example, when severe storms occurred along the Ninety Mile Beach just prior to the 1984 survey, large volumes of sand were transported offshore, leaving wave-cut cliffs and very coarse sands behind. The infaunal populations at the two beaches responded differently to this factor. At McGaurans Beach, the highest mean populations over the 8-year survey period were found just after the storms; by contrast, the lowest populations ever were recorded at Woodside Beach. Such discordance between two adjacent beaches only a few kilometres apart and subject to the same physical regime is probably a response to the availability of organic detritus (chiefly algae and sponges) cast up on the beach from offshore reefs. This decaying material provides both transient microhabitat and a food resource for mobile beach organisms such as isopods and amphipods.

Port Phillip Bay beaches

The beaches in Port Phillip Bay range from coarse sands to fine silt. Most of the southern beaches from Rye to Queenscliff consist of fine sand, while coarse, shelly sands cover some northern and western beaches. A small silty beach occurs in the quiet waters of Corio Bay on the western side of Point Henry.

Bay beaches have the same major invertebrate taxa as those on ocean beaches: amphipods, isopods, polychaetes, and bivalves. Species may differ however. Other less common species found there but seldom in ocean beaches are brachyurans, nematodes, and gastropods.

A recent study of several Port Phillip Bay beaches found that the fauna comprised fewer than three species per 0.25 sq. m and fewer than 40 organisms per sq. m at all but three sites (Table 4.3). The exceptions were Campbells Cove (near Werribee), Avalon, and Point Henry. At Campbells Cove, more than 300 individuals of a single species of oligochaete were recorded, and at Avalon, more than 1200 individuals of one species of nereid polychaete were found. Only the silty beach at Point Henry provided a rich diversity and abundance of organisms, with more than 20 species and almost 3000 individuals per sq. m recorded.

As Table 4.3 shows, population density and diversity of species are often inversely related to increasingly coarse grain size of the sediments. Thus, coarser sands may have a more depauperate fauna than the silty beaches. However, other factors also operate in determining populations of beach infauna, since the fine compacted sands at Queenscliff and Observatory Point are depauperate compared with some of the coarser beaches in the northern bay. The reason may be that wave action compacts the fine grain sediments of the beaches near Port Phillip Heads, leaving little interstitial space for infauna, whereas the less compacted sand of northern beaches provide better micro-habitat for burrowing infauna.



Soldier crab - a feature of estuarine beaches.

Table 4.3: Beach infauna - Port Phillip Bay

Location	Mean number of species (per 0.25 sq. m)	Mean number of organisms (per sq. m)	Sediment type
Point Henry	21	2776	silt
Observatory Point	1	4	fine sand
Rye	3	32	fine sand
Queenscliff	2	36	fine sand
Sandringham	1	24	coarse sand
Sandridge	1	16	coarse shelly sand
Safety Beach	2	28	coarse shelly sand
Campbells Cove	3	588	coarse shelly sand
Avalon	1	1424	coarse shelly sand
St Leonards	5	28	coarse shelly sand

A further important determinant of population density of the beach fauna, particularly in northern beaches during summer, is the large amount of red algae that drifts in from shallow water onto beaches such as Campbells Cove. Large masses of decaying seaweed also provide seasonal habitat and an abundant direct and indirect food resource for the beach infauna. In contrast to the large, intertidal populations of up to 400 000 per sq. m living on the permanently nutrient-enriched beaches at the nearby outfall drains from the Werribee treatment complex, the Campbells Cove populations are relatively sparse and may change according to the seasonal availability of beach drift.

Artificial beach renourishment, by pumping sands from offshore onto beaches, is used to maintain some coastal bay beaches. The effects of such activities on the beach infauna are unknown, but re-adjustment in species distribution would probably occur according to changes in grain size and exposure to wave action.

In summary, only a few species, chiefly scavengers, can tolerate the harsh physical conditions of ocean and bay beaches. Because of their irregular food supply, populations are mobile and thus fairly unpredictable. The more sedentary organisms, such as polychaetes, are usually associated in greater numbers with silty to muddy environments.

MANGROVES

The only few quantitative surveys of the biota present in the muds beneath mangroves have been discussed in the previous section. This lack of study of a habitat that is considered vitally important to certain commercial and recreational fisheries is due to the considerable difficulty in accurately sampling deep, fluid mud around the mangrove trees and the very time-consuming task of sorting small organisms from a matrix of decayed leaf litter.

Toora

Surveys conducted at three mangrove stands near Toora in Corner Inlet recorded 34 infaunal taxa, the dominant ones being nereid, nephtyid, spionid, capitellid, and lumbrinereid polychaetes together with amphipods and brachyurans. Four crab species were present, the most common being *Heloecius cordiformis*; the others were *Macrophthalmus latifrons*, *Helograpsus haswellianus*, and *Brachynotus spinosus*. Several less-common species occurred along the seaward edge of the mangroves where the trees bordered the mud flat. These included bivalves, a penaeid prawn, and the seastar *Patiriella exigua*. The most visually dominant species of the epibiota on the branches and pneumatophores was the barnacle *Elminius modestus*, and amphipods and isopods were found sheltering in accumulations of algal and seagrass drift and epiphytic algae on the pneumatophores.

The survey found that infaunal populations doubled from winter to summer, although the number of species remained almost unchanged.

Nooramunga

In a survey of the macrobenthos of the mangrove stands at four localities (Manns Beach, Port Welshpool, Port Franklin, and Millers Landing), Morgan (1986) reported a fauna of 23 species dominated by corophiid amphipods, small bivalves, and oligochaetes, although hard-substrate gastropods and barnacles were the visually dominant species. The Nooramunga survey recorded populations

of corophiid amphipods that in places exceeded 20,000 per sq. m. Similarly to the fauna in the northern part of Corner Inlet, capitellids were the dominant polychaetes together with syllids, nereids, and nephtyids. Crab holes were densely distributed, sometimes exceeding 50 per sq. m.

Western Port

A study of the biota at high-, mid-, and low-tide levels in the mangrove stands at two sites (Jacks Beach and Hastings) 5 km apart in Western Port found that, as at Corner Inlet, the barnacle *Elminius modestus* was the most abundant organism on the leaves, branches, and pneumatophores. Polychaetes, bivalves, and several species of small crustaceans dominated the 23 infaunal taxa. The greatest diversity of polychaetes was in the lower intertidal zone, with nereids and nephtyids the most abundant taxa. However, there were differences between the two sites: the bivalve *Tellina deltoidalis* had a high population density at Jacks Beach, whereas at Hastings, *Notospisula* sp. was dominant. The mangrove crab (*H. cordiformis*) was abundant at both locations whereas *Macrophthalmus latifrons* and *Paragrapsus* sp. occurred only at Jacks Beach. *Sesarma erythrodactyla* was present only at the Hastings.

Faunal differences between these two adjacent mangrove localities probably reflect of the more open mangrove stands and, siltier and more compacted sediments at Jacks Beach, compared with the very muddy habitat and dense stand at Hastings. The evidence suggests that the intertidal flats seaward of the mangrove fringe may support a richer biota than the muds beneath the trees.

SUBTIDAL SOFT SUBSTRATES

Soft substrates form the most extensive habitat along the Victorian coastline and include gravel, rubble, sand, silt, and mud bottoms in open coastal and enclosed waters. These habitats support infaunal assemblages of small, mobile, or sedentary organisms that live in the sediments and an epibenthos of animals and plants that live at the sediment—water interface.

Several large-scale surveys of the soft-bed ecosystem in Victorian waters have been been described in previous section. Other, smaller surveys have been conducted in areas such as Portland and the Snowy River estuary. A survey off the east Gippsland coast by MSL included one site inside territorial waters (Parry *et al.* 1990).

The soft substrate in Port Phillip Bay varies from sands along the eastern shoreline to fine unconsolidated muds in the central basin. Western Port has a more complex bed, varying from rubbly or coarse shelly sands in the channels to fine silts and muds around the shorelines. Because of its geomorphological uniformity, the soft-bed habitat of the Ninety Mile Beach is much more uniform, consisting of sands of fine to medium grain size.

As in the intertidal zone, grain size of sediments is an important determinant of the species composition and distribution of subtidal infaunal communities. The amount of interstitial space between the grains provides habitat for some species but excludes others. Thus, a bed composed of coarse sand with considerable interstitial space will support a very different community from that in fine sand or mud.

Subtidal sandy bottom

The infauna of sands of the ocean coastline chiefly comprises small crustaceans (amphipods, copepods, decapods, isopods, mysids, ostracods, tanaids), bivalve molluscs, polychaete worms, echinoderms (ophiuroids, holothurians), and minor taxa such as gastropods, turbellarians, nemerteans, nematodes, and sipunculans. The species and distribution depend upon sediment texture, grain size, and the degree of sorting and compaction by wave and current action.

Ninety Mile Beach

Continuing studies of the infauna of coastal sands over periods of 3—12 years at four localities along Ninety Mile Beach and at distances up to 4 km offshore and to depths of 18 m have produced considerable information on the composition and distribution of the infaunal communities and turnover in species and populations over time.

Between 1989 and 1991, infaunal populations varied from 3300 - 7800 organisms per sq. m and the number of species from 55 to 74 per 0.375 sq. m (Table 4.4). A decade of monitoring at two localities (McGaurans and Woodside Beaches) yielded a total of 390 species. (It should be noted that the number of species present in a sample collected from an area of 0.375 sq. m cannot be multiplied up to give the number of species per sq. m: for

Table 4.4: Subtidal Infauna - Ninety Mile Beach 1989/91

Location	Mean number of organisms (per sq. m)	Mean number of species (per 0.375 sq. m)
Woodside Beach	3381	74
McGaurans Beach	3334	55
Seaspray Beach	7861	85
Delray Beach	4629	80
Mean	4801	74

example, if 50 species occur in an area of 0.5 sq. m, it does not follow that 1 sq. m will contain 100 species).

Crustaceans were the most important taxonomic group, the amphipods *Urohaustorius* sp. and *Platyischnopus mirabilis* and the ostracod *Euphilomedes* sp. being the most numerous. Off Woodside Beach in 1990, the mean populations of *Urohaustorius* sp. (360 per sq. m), and *Euphilomedes* sp. (1281 per sq. m) represented 7% and 12% respectively of the total infauna.

The large differences in populations over a 3-year period illustrate the major changes that can occur along a 70-km stretch of coastline with a relatively uniform physical environment and apparently similar habitat.

As well as differences in populations on the regional scale, distribution of dominant species can also be very patchy at the local scale. For example, in 1989 off Woodside Beach, glycerid polychaetes and the holothurian *Themiste* sp. were abundant at only one of seven sampling sites in a survey area of 1 sq. km, the mean populations of these species being 2883 and 1133 per sq. m respectively at this one site. By contrast, other species such as *Urohaustorius* and the *Euphilomedes*, abundant at all other sites, were absent. It was noted that sediments here were much coarser than elsewhere, suggesting that distribution of these species is related to the coarseness of the sediments.

Such localised variations in grain size are a common textural feature of the top few centimetres of the sand ocean bottom and result from winnowing and sorting of the sediments by wave and current action. This is especially evident around the base of reefs and very close to shore, where wave action is greatest.

Temporal variations in populations are a normal feature of community composition, but, because of the short-term basis upon which most surveys are conducted, are largely unrecognised. The population dynamics of the small bivalve *Mysella donaciformis* provide a striking example of such variability over time. Between 1982 and 1985 this was a minor contributor to the community; from 1985 to 1987, numbers increased rapidly until populations reached 1744 per sq. m, the species then being dominant in the community (Table 4.5). After 1987, populations declined until, by 1990, numbers had returned to pre-1985 levels. It was noted that the decline of *M. donaciformis* coincided with an increase in numbers of the carnivorous opisthobranch *Philine angasi*, a species known to prey upon this bivalve.

Such apparently unpredictable changes in community composition are part of slow, continuing biological cycles, indications of which only become evident from long-term studies. These cycles may be a response to subtle changes in the physical regime - for example, variations in annual water-temperature maxima and minima from one year to another, which cannot be fully explained in terms of our present knowledge of local marine ecosystems. They must, however, be recognised as inherent in any marine community.

The 390 species recorded from four localities along Ninety Mile Beach and the high population density of 4800 organisms per sq. m indicate a very rich and abundant infauna with a population density greater than the 3400 organisms per sq. m recorded from a similar depth in coral sand close to shore in a tropical environment in Papua New Guinea and the

Table 4.5: Percentage of *Mysella donaciformis*, Woodside Beach infauna, 1991

Year	Per cent
1985	negligible
1986	13
1987	47
1988	41
1989	28
1990	negligible

770—1600 per sq. m reported from a *Heterozostera tasmanica—Zostera muelleri* meadow in Western Port by Watson *et al.* (1984).

Mixed fine and coarse sediments

Mixed fine, coarse, and rubbly material provides a great diversity of microhabitats for infauna and, although possibly not as populous as subtidal ocean sands, may contain a more diverse infauna.

Western Port

The mixed sediment habitat is best exemplified by the community of the channel system of the North Arm of Western Port, where the infaunal community, sampled over 9 years near Buoy No. 35, averaged 2100 organisms per sq. m with 68 species per 0.375 sq. m.

Perhaps more so than in ocean sands, faunal distribution can be very patchy due to considerable local variations in grain size; for example, populations from three samples collected from an area of 0.3 sq. km in the one survey ranged from 1170 to 2850 organisms per sq. m. As in ocean sands, crustaceans predominated and, for example, in 1991 comprised 66% of the community, with polychaetes 19%, molluscs 7%, and echinoderms and minor groups 8%.

The infauna of the channel system also includes the bivalves *Neotrigonia margaritacea* and *Eucrassitella kingicola*. These species are uncommon elsewhere along the Victorian coast, but have been recorded off east Gippsland. *N. margaritacea* is the most abundant mollusc in the channel system: from 1980 to 1989, populations ranged between 4 and 211 per sq. m, with a mean of 61. Since the biology of this species is unknown, no reason can be advanced to explain its high population in the North Arm. It may result from the interaction between the physical environment of mixed sediments, sheltered waters, strong tidal currents, and abundant nutrients.

Silty and muddy bottoms

Silts and clays are the finest bed sediments, of grain size <0.063 mm. Unconsolidated clays are usually referred to as mud. The most extensive silty to muddy coastal habitats are in the central, western, and northern basins of Port Phillip Bay, some parts of Western Port, and coastal inlets and estuaries.

In contrast to the dominance of small crustaceans in sandy or mixed sediments, polychaetes usually dominate the infauna of muddy and silty habitats. These organisms are better adapted to burrowing among the smaller and more closely packed grains. Compaction of sediments can also influence the composition of muddy bottom communities by reduction of space between the grains. Thus well-compacted clays and unconsolidated muds may have quite different infauna, despite similar grain size. For example, soft-bodied polychaetes may be unable to burrow in firm clays, which favour hard-shelled organisms such as molluscs.

Port Phillip Bay

A recent study in the Outer Harbour of Corio Bay in Port Phillip Bay found that polychaetes comprised 44% of the population. *Nephtys inornata, Tharyx* sp., *Leitscoloplos bifurcatus, Polyopthalmus pictus*, and *Armandia* sp. were the most abundant species. Crustaceans were next most abundant; one species of cumacean, *Dimorphostylis cottoni*, comprising 24% of the total infaunal population (Carey and Watson 1992).

Some comparison of the numbers of species and population densities in sandy and muddy habitats can be gained from results of two surveys undertaken in the same season, in the Geelong Arm of Port Phillip Bay and along Ninety Mile Beach. Between 1989 and 1991 populations in the latter area averaged 4800 per sq. m with 74 species per 0.375 sq. m (Table 4.4), while those in the Geelong Arm in the late summer of 1992 averaged 9450 per sq. m with 52 species per 0.1 sq. m. Although the numbers of species cannot be directly compared as previously explained, in this particular case it is evident that the infauna of the quieter-water muddy bottom of Port Phillip Bay is more abundant than the sandy subtidal habitat off the Ninety Mile Beach, and may be equally rich, or even richer in species.

An example of small-scale distributional patterns resulting from sediment compaction was found in a survey inside Webb Dock where the crab *Macrophthalmus latifrons* and the bivalve *Pholas australasiae* burrowed only in the firm natural clays forming the dredged batters. By contrast, the very fluid mud in the bed of the dock, constantly disturbed by shipping, supported large populations of the delicate-shelled bivalve *Theora fragilis*, which comprised 93% of the community, despite its mere 57% of the community in the more

consolidated mud of Hobsons Bay outside the dock.

SEAGRASS BEDS

As discussed previously, apart from the soft-bottom infauna, marine angiosperms form one of the better-known groups of the Victorian coastline; however, there are still many gaps in knowledge of seagrass ecosystems.

The eelgrass *Heterozostera tasmanica* is the best studied seagrass and its distributions in Port Phillip Bay (Figure 4.3), Western Port (Figure 4.4), and Corner Inlet (Map 2) have been described (e.g., Bulthuis 1981a, 1981b, 1983; Bulthuis and Woelkerling 1983a, 1983b; Morgan, 1986; Kerr and Strother 1990). Decline of seagrasses was first noticed in Western Port in the 1970s and continued in both Port Phillip Bay and Western Port in the 1980s. There have been no recent surveys to trace the extent of decline since then.

Seagrass meadows are considered one of the more complex systems of shallow inshore waters, including the sediment habitat in which the rhizomes grow and the habitat of leaves growing above the substrate.

Seagrass leaves support large populations of epiphytes, but neither the species nor their spatial or temporal distributions are well known. Ducker *et al.* 1977 found 116 species of algae and 20 invertebrate species on *A. antarctica*, and Watson (1992) recorded 13 hydroid species, some of which were obligate epiphytes, on the leaves. Because of its finer and more flexible leaves, *Heterozostera tasmanica* supports fewer invertebrate epiphytes than does *Amphibolis*, but it often bears a heavy load of filamentous red algae. These seasonal algae are particularly abundant on the seagrass in the North Arm of Western Port and undoubtedly play a very important part in the detrital system of the area. However, nothing is known of the species or their role in the local ecosystem.

The infaunal community of the *Heterozostera spp.* meadow is a vital part of the food chain leading to commercially and recreationally important fish species.

The role of *A. antarctica* as a fish and invertebrate habitat and as a baffle to wave erosion has not been properly explored. With some exceptions - as at Rabbit Island near Wilsons Promontory, Balnarring in lower Western Port, and in Portland Bay - stands of *Amphibolis* are usually small and disjunct. The standing crop of this seagrass has been recorded in two brief studies, at Balnarring and at Portland. However, because of differing methodologies, the data cannot be compared. The commercially important calamary (*Sepioteuthis australis*) especially favour *Amphibolis* meadows for deposition of eggs, and garfish seasonally graze on the small animal epiphytes living on the leaves.

Portland

Because of the lack of data, it is not known whether *Amphibolis* seagrasses have declined regionally in Victoria over the past 20 years as have the Zosteraceae and *Posidonia spp.* Interestingly, however, in the 25 years since construction of the shipping harbour at Portland, anecdotal evidence from local residents suggests that the extensive *Amphibolis* meadow bordering the Dutton Way declined in area. Observations in 1991 indicated that, in some places, only a minimal depth of sand secured the root system. This might have caused reduction of standing crop in the meadow. Intermittent observations along the northern side of the breakwater below the Portland lighthouse since 1968 showed a gradual replacement of an extensive mixed meadow of *Amphibolis, Sargassum*, and *Cystophora* by *H. tasmanica*, with accompanying loss of sandy habitat and deposition of fine silt. This change in habitat leading to *Amphibolis* replacement probably results from disruption of the natural pattern of sand drift along the coast following construction of the harbour in the early 1970s.

Western Port

Bulthuis (1981b) mapped the dominant seagrasses in Western Port with the following results: *H. tasmanica* 136.3 sq. km, *A. antarctica* 20.6 sq. km, and *Zostera muelleri* (in the intertidal and shallow subtidal) 39.8 sq. km. Dieback of seagrasses (chiefly *Z. muelleri*) was mapped over an 11-year period to 1984, during which the seagrass (and the alga *Caulerpa cactoides*) declined from 250 sq. km to 72 sq. km (Bulthuis 1984).

In experimental studies in Western Port, Bulthuis (1983) found that *H. tasmanica* plants require a minimum of 5% of surface illumination to survive and that plants may die if irradiance falls below this level for 2 months over summer or 4 months over winter. Death of seagrasses in Western Port (as well as Corner Inlet) in the 1980s resulted in

mobilisation of the bed sediments from the intertidal and shallow subtidal zones, a self-perpetuating cycle that further increased water turbidity and depressed seagrass growth. However, no definite cause or causes for the dieback have been identified.

Leaf cluster density varied from 600—2000 leaves per sq. m in winter to 2700—5000 leaves per sq. m in summer, each cluster producing approximately 30 leaves per year. Leaf turnover is a vital link in the detrital food web of the Western Port ecosystem. The detritus is grazed by small invertebrates or is further broken down by bacterial action and then passed into the nutrient cycle.

Depending upon physical conditions of irradiance and shading, water movement, and substrate, standing crop of seagrass may vary considerably from one place to another and over time in the same area. For example, a study of summer standing crop of *H. tasmanica* in the North Arm found 139—190 g dry biomass per sq. m. (Bulthuis 1981b), while a 9-year study in the same general area found a mean annual summer dry biomass of 320 g per sq. m. The disparity between these figures for standing crop probably reflects local differences in density of the plants, or possibly, the load of filamentous algal epiphytes that grow on *Heterozostera* stems over the summer months. These epiphytes are shed towards the end of summer, the decomposition products providing a readily available food resource for many detritivorous organisms both in the seagrass meadow and other parts of the Western Port ecosystem.

Figure 4.3: Distribution and Percentage Cover of Seagrasses in Port Phillip Bay

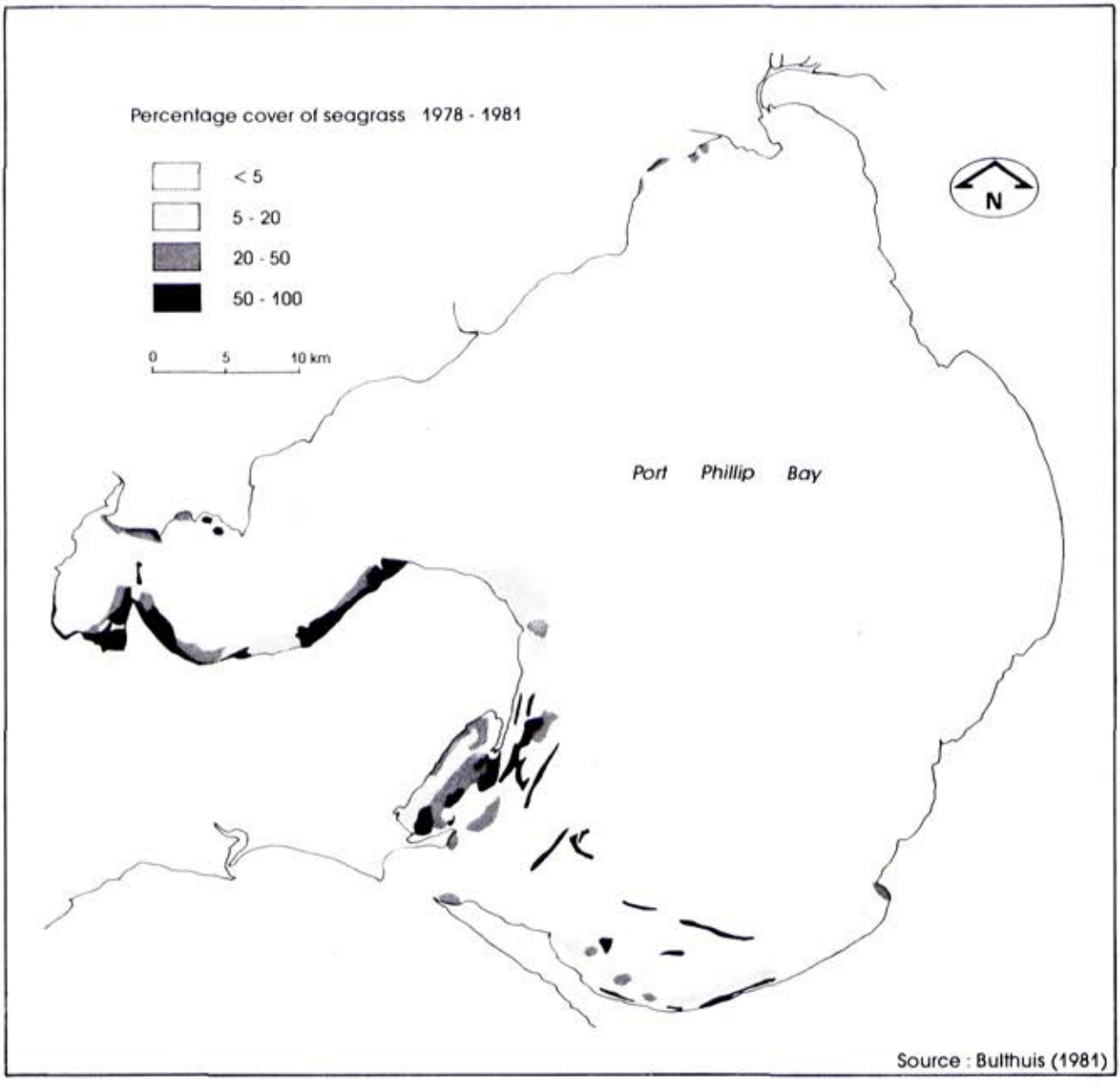
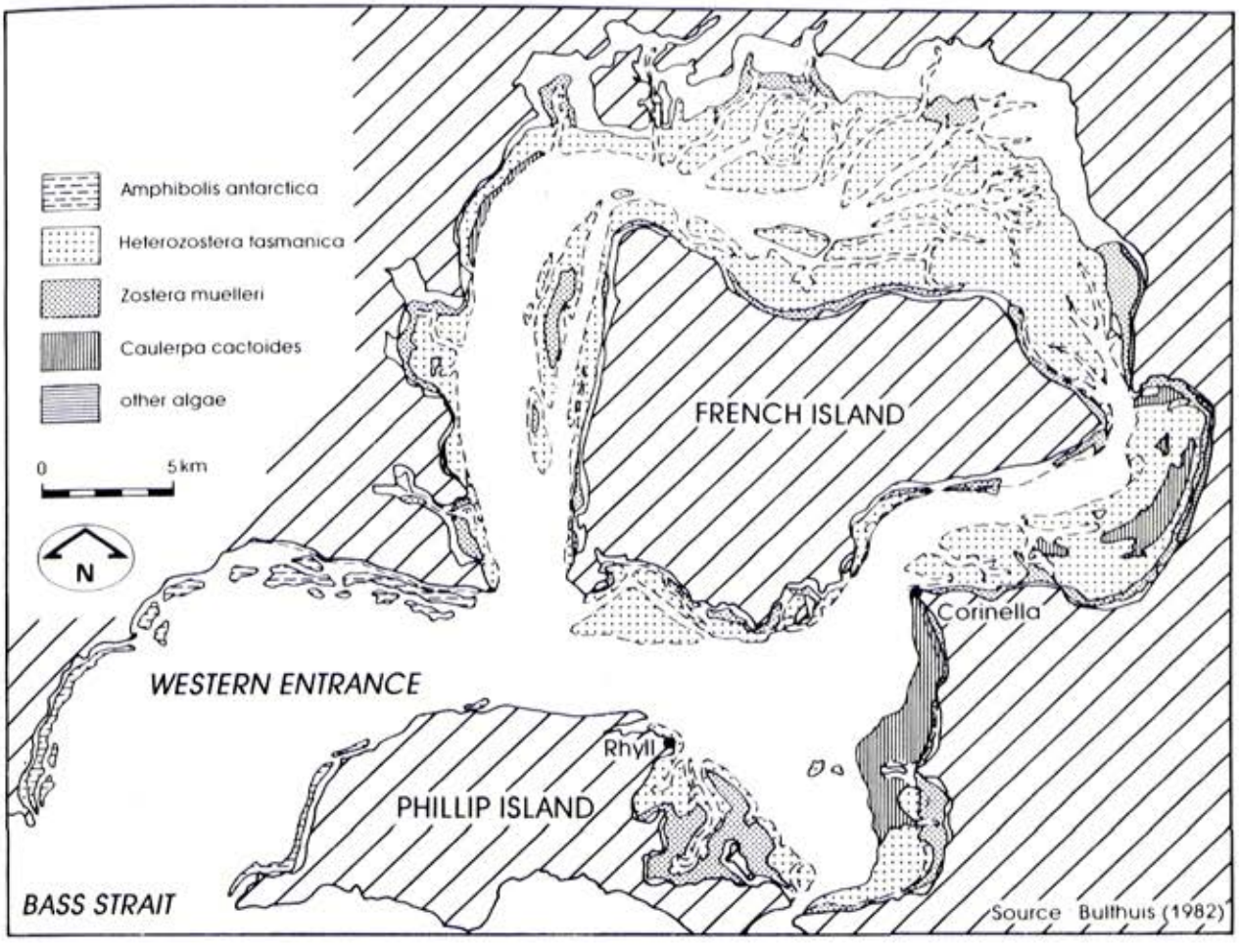


Figure 4.4: Distribution of Seagrass Species and Macro-algae in Western Port



Clearly, seagrass systems are important physical and ecological components of marine ecosystems. The integrity of seagrass meadows is vital to the biota that depend either directly or indirectly on the plants for shelter, food, or reproduction. Unfortunately, our lack of historical knowledge of the dynamics of seagrass systems makes it impossible to determine whether the recession of the meadows of Western Port and in Corner Inlet over the past decade is a transient expression of a long-term natural cycle that will eventually readjust, perhaps at a different level, or whether it is a continuing reaction to human impact.

PLANKTONIC HABITAT

The planktonic habitat includes a mixture of plant (phytoplankton) and animal (zooplankton) species that float or swim weakly in the water column. Plankton are, either directly or indirectly, the basis of most marine food chains. After reefs, plankton are perhaps the least-known of the coastal marine systems. Neale and Bayly (1974) studied the zooplankton in four Victorian estuaries and Kimmerer and McKinnon (1985) compared zooplankton populations in Port Phillip Bay, Western Port, and Bass Strait.

Port Phillip Bay and Western Port

Most studies undertaken in these embayments are largely unpublished student theses or government technical reports (Arnott, 1974a, Ministry for Conservation, 1975, Melbourne and Metropolitan Board of Works and Fisheries and Wildlife Division 1973). Some studies in Port Phillip Bay examined specific components of the plankton such as the icthyoplankton (Jenkins 1986) and eggs of commercial fish species (Arnott and McKinnon 1985).

Kimmerer and McKinnon compared zooplankton abundance and found that both bays had a resident zooplankton fauna distinct from that of Bass Strait. The plankton of Western Port was less diverse, with only five taxa occurring in more than 50% of the samples, compared with 11 from Port Phillip Bay. Mean total plankton abundances were 1480 per cu. m in Port Phillip Bay and 1350 per cu. m in Western Port. Although the resident communities had many species in

common, patterns of abundance and dominance were quite different. More than 50% of plankton in Port Phillip Bay, for example, comprised copepods (mostly *Paracalanus indicus*) with 23% cladocerans, whereas the Western Port zooplankton was dominated by *Acartia tranteri* and no cladocerans were recorded. Most of the zooplankton species showed seasonal patterns of abundance. Possible causes of differences in abundance between the two bays include differences in physical characteristics such as currents, depth profile and suspended particulate matter, zooplankton behaviour, and predation.

Fish-egg in Port Phillip Bay were dominated in number by those of the southern anchovy (*Engraulis australis*) and were particularly abundant in summer. Clupeiod and gobiid larvae were co-dominant, with 34.2% and 29.8% of the populations respectively. Abundances of fish larvae here were highest in summer and winter to spring (Jenkins 1986). There also appeared to be marked variation in the distribution of larvae throughout the Bay.

Thus, the few data available suggest a very marked difference in the zooplankton between the embayment habitats, and between these and Bass Strait. However, virtually nothing is known of the plankton of the coastal zone, since few if any of the Bass Strait plankton collections were less than 6 km from shore.

EPIBENTHOS

Epibenthic species are organisms that are fixed in or lie on the sediment surface, but feed at or above the sediment—water interface. Most are sessile invertebrates that are fixed in the one place for life, although some creep across the surface to seek prey or feed on organic detritus. Sessile epibenthic species settle as larvae from the plankton onto hard surfaces of rocks, pebbles, tiny fragments of shell, or other already established sessile organisms.

Studies of the epibenthos of the soft bottom along the Victorian coastline have largely been neglected. General accounts are found in the descriptive literature, for example, that of the invertebrate fauna of Western Port by Smith *at al* (1975). The few published general accounts of the soft-bed epibenthos have been incidental to or part of other studies, in which the epibenthos has been inadvertently included in quantitative data of the infauna. For example, data on the ascidian *Pyura stolonifera* and the bivalve *Electroma georgiana* are included without mentioning that they form epibenthos of Port Phillip Bay (Poore and Rainer 1979).

Because of the scattered and patchy distribution of epibenthic organisms, quantification is virtually impossible using remote sampling methods such as grabs operated from a boat. The most useful technique is counts *in situ* by biologist-divers to depths accessible to scuba and, in deeper water, by remotely operated video (ROV). Neglect of the epibenthos as a monitoring tool is regrettable, since it is the component of the benthos most vulnerable to environmental stress from sources of pollution or from changes in the hydrodynamic regime.

Western Port

A 20-year study (1972—91) of selected visually dominant epibenthos in a part of the North Arm channel, undisturbed by shipping, included counts of the brachiopod *Magellania flavescens* (a species rare along the Australian coastline but common in the North Arm) and an equally common but undescribed species of seapen, *Sarcophyllum* sp.

Populations of *M. flavescens* in the channel rose to a maximum of 26 per sq. m in 1976, declining to <1 per sq. m in 1990. For the seapen, very high populations of up to 47 per sq. m were recorded in the early 1970s, after which time it declined until, in 1981, it had entirely disappeared from this part of the channel system. The only observed physical change that might have instigated such decline was mobilisation of sediments in the channel caused by dieback of seagrasses in the intertidal zone.

MARINE SPECIES AND COMMUNITIES AS MONITORS OF THEIR ENVIRONMENT

Surveys of the communities provide one means of determining the impacts of human activities on marine biota. The advantage of using natural communities for monitoring is that the organisms are exposed to the surrounding physical regime and are thus integrated monitors of their environment. The following examples of Victorian studies demonstrate the capacity of marine organisms to act as monitors of their habitat and their response to chemical or mechanical impacts.

Impact of sewage discharge on kelp

The impact of discharge of primary-treated sewage on the subtidal brown kelp *Ecklonia*

radiata, from a sewage outfall (now abandoned) at Breamlea, was investigated using the parameters of length, biomass, and the degree of epiphytisation of plants from a depth of 3—4 m near the outfall (Table 4.6).

Although suitable substrate was available, no kelps grow within 50m of the outfall, suggesting that environmental conditions inhibited settlement and growth. Further away, size and biomass of the plants did not vary greatly with distance from the outfall. The most striking result, however, was the heavy epiphytisation of thalli by small algae such as *Giffordia, Porphyra*, and *Bangia* and the bryozoan *Membranipora membranacea* in places under influence of the discharge. Breakdown of the protective coating on the *Ecklonia* thallus by the discharge probably may have permitted this degree of epiphytisation. Furthermore, the thalli of the plants nearest the outfall had also developed unusual tumorous growths, presumably as a result of exposure to the effluent. The reaction of *Ecklonia* to sewage effluent suggests that this common alga may be a useful indicator of impact of waste-waters in habitats where it grows.

Impact of sewage discharge on platform algae

At Boags Rocks, secondary-treated effluent from Melbourne Water's south-east sewage system is discharged to Bass Strait at low-tide level over a calcarenite shore platform. Brown *et al.* (1990) assessed the effects of the discharge on algal communities over the period 1980—88. The major effects close to the outfall were the virtual disappearance of the intertidal brown alga *Hormosira banksii* and the coralline *Corallina officinalis* and reduction of cover of turfing algae. Species richness was also lower nearer the outfall (12—13 species) than elsewhere (15—22 species). The red turfing alga *Gelidium pusillum* decreased gradually at Boags Rocks over the study period from undetermined causes, while the green alga *Ulva rigida* varied dramatically, with high cover in summer and low cover in winter. Effects of the discharge on the algal community were apparent within 1 year of commissioning of the outfall.

The very marked effect of sewage waste-waters on intertidal algae, especially *H. banksii* and *C. officinalis*, provides a useful means of monitoring the impact of these effluents on shore platforms.

Disturbance to the epibenthos by shipping

Monitoring of the visually dominant epibenthos over a period of 20 years in a shipping basin in the North Arm of Western Port included counts of the common solitary ascidian *Pyura stolonifera* and the sedentary gastropod *Sigapatella calyptraeformis*. The ascidian lives at the sediment—water interface but is rooted in the sediments, while the mollusc attaches to rubble and old shell. In 1972, dredging removed the pre-existing seagrass meadow, leaving a barren clay bed. This was first colonised by boring organisms, then later, with return of sediments, by a normal Western Port epibenthos. Over time, winnowing by increasing shipping traffic transported softer sediments away from the basin, leaving increasing amounts of rubble and old shell behind. Populations of *P. stolonifera* rose from less than 1 per sq. m in the months after dredging to a maximum of 22 per sq. m in 1980 when there were still relatively few shipping movements. During the past 12 years, however, with increasing movements, especially of tugs, populations of *P. stolonifera* again fell to <1 per sq. m, the decline probably being due to uprooting of older ascidians from the substrate by propeller blast. In contrast, the change in habitat favoured *S. calyptraeformis*, populations of which gradually increased from <1 per sq. m in 1972 to 220 per sq. m in 1989.

Table 4.6: Length, Biomass, and Epiphytisation of *Ecklonia radiata*

Location with respect to outfall	Number of plants examined	Mean biomass of plants (g)	Mean length of plants (mm)	% of biomass epiphytised
200—300m East	20	250	780	11
800m East	18	310	800	25
500m South	20	337	710	11
800m South	20	330	890	<1
5000 m East	40	256	750	<1

These examples demonstrate the potential usefulness of certain species as monitors of their environment. Undoubtedly many other species would make equally good indicators of their environment. However, our knowledge of the responses of the marine biota to environmental stress is so fragmentary that any information acquired is usually incidental to other studies.

CONCLUSIONS

This section has highlighted the poor state of knowledge of many of our coastal ecosystems. The best-documented are the infaunal communities of the soft substrates and seagrass systems of Port Phillip Bay and Western Port. Much less is known about the inshore systems of the open coast, other than on the Ninety Mile Beach. Even in the two bays, however, information is fragmentary and has largely been gathered from short-term studies driven by an urgent need for information, usually in response to potential or actual modification of the environment.

Despite the State-wide absence of data, it seems clear that the infauna of the Victorian coast, including that of the two bays, is among the richest in species in the world (Barnard and Drummond 1978, Parry *et al.* 1990, and this study).

The physical parameters of sediment grain size and compaction, water temperature and movement, and nutrients - and, in the intertidal zone, lithology and exposure to air - are the prime determinants of species and their distribution from the regional level to the micro-scale. However, no ecological surveys in Victorian waters have yet attempted to integrate these factors. Nor have any attempted to trace long-term biological cycles. A major study of Port Phillip Bay recently commenced by Melbourne Water seeks to address some of these deficiencies by investigating both the physical environment and biology of species and will trace nutrient pathways through the ecosystem.

OCEANIC BIRDS

Although over 80 species of sea-birds have been recorded in Victoria (Emison *et al.*, 1987), the majority of these are vagrants from the southern oceans (see Appendix VIII) and are of unknown ecological or conservation significance in the Victorian context. Others, such as several species of albatross and petrels, are regular visitors to Bass Strait, mainly during winter, and are presumably significant predators of pelagic fish and invertebrates. However, 13 species of sea-birds breed on islands or sheltered beaches within Victoria (Appendix VII). These breeding species have most relevance to land-use planning along the Victorian coast, and therefore this chapter focuses on them.

The waters of Bass Strait are fairly shallow (50—100 m) and have relatively low nutrient levels (Gibbs 1991), so the sea-bird populations within it tend to be small. Higher densities and diversities of sea-birds occur off the continental shelf at both ends of the Strait, where upwellings of nutrient-rich sub-Antarctic waters occur. When conditions are right, sea-bird enthusiasts can observe many thousands of birds of up to 25 species during boat trips to the continental shelf - for example, about 20 km (18 nautical miles) due south from Portland. These aggregations, including up to seven species of albatross, provide exciting and spectacular wildlife viewing. They also presumably play an important role in the trophic structure of marine ecosystems by consuming vast quantities of cephalopods, crustaceans, and fish.

All 13 species breed in colonies. Therefore, colony sites have great conservation significance because large numbers of adults and their offspring are susceptible to environmental changes in the vicinity. For this reason all breeding species are included on the list of threatened wildlife in Victoria.

Some species, such as black-faced shags, breed only on inaccessible rock ledges and are probably secure from disruption. By contrast, beach-nesting species such as terns are extremely susceptible to disturbance by people, dogs, foxes, vehicles, and high tides. If such species are to survive, strict protection from disturbance of their breeding sites is essential.

Several species make use of artificial structures. On Phillip Island, little penguins regularly nest beneath buildings and in artificial burrows. Little penguins also breed among basalt boulders in breakwaters at St Kilda and Apollo Bay. In Port Phillip Bay a major colony of white-faced storm-petrels has established on South Channel Fort, an artificial island constructed in the 1880s to house artillery for the defence of Melbourne. Port Phillip Bay also has two small breeding colonies of Australasian gannets, which have established in recent decades on wooden



Little penguin.

platforms associated with navigation lights - Wedge Light and Popes Eye. The Popes Eye colony has almost doubled in size to about 100 pairs following construction of a new platform specifically for extra breeding space for the gannets. Popes Eye is now a popular destination for charter boats and provides spectacular wildlife viewing.

The nightly 'penguin parade' at Phillip Island is an internationally renowned tourist attraction that generates many millions of dollars for the Victorian economy. Another spectacular summer sea-bird display is the dusk return of tens of thousands of short-tailed shearwaters to their colonies on Cape Woolamai, Phillip Island, and Griffith Island, Port Fairy.

Brief summaries of the status and biology of the breeding species are given below. Further details are available in Marchant and Higgins (1990), Blakers *et al.* (1984), and Harris and Norman (1981).

Little penguin (*Eudyptula minor*)

Occurring along the entire Victorian coast, little penguins breed at some 30 sites on islands and protected mainland sites. The breeding population totals at least 28 000 pairs. Most colonies are small (less than 1000 pairs); large colonies occur only on Gabo Island (10 000 pairs) and Phillip Island, particularly the Summerland Peninsula (6000 pairs). These comprise only a very small proportion of the total Australian population, which is estimated at a million birds.

Adults are fairly sedentary around the breeding colonies, although they may make foraging trips of several hundred kilometres over several days. By contrast immature birds disperse widely. For example, young from Phillip Island travel westwards as far as Kangaroo Island, S.A., before returning to their natal colony when sexually mature at about 3 years old.

Food consists mainly of small mid-water shoaling fish or squid. Penguins from Phillip Island take mostly anchovies and pilchards (Cullen *et al.* 1991), and during the non-breeding season many Phillip Island birds move into Port Phillip Bay to feed on these species (Weavers 1992).

Small colonies of little penguins are highly susceptible to predation by foxes and dogs, trampling by unfenced livestock, and disturbances due to urban development. However, most colonies are now protected within conservation reserves and the species is not considered threatened.

Fairy prion (*Pachyptila turtur*)

Fairy prions breed on sub-Antarctic and subtropical islands in the Southern Hemisphere. During the non-breeding season they disperse widely in the subtropical Indian and Pacific Oceans.

In Victoria, small breeding colonies of less than 100 pairs are found on eight islands around Wilsons Promontory (Norman, Dannevig, Citadel, McHugh, Kanowna, Anser, Seal, and Notch), and on Lawrence Rocks and Lady Julia Percy Island in the west. The last-named is by far the largest, perhaps totalling 1000 pairs. However, census of small burrow-nesting petrels is notoriously difficult and more detailed surveys are urgently required.

The movements of fairy prions in Victorian waters are almost entirely unknown, as are their food preferences. They feed by surface-seizing, dipping, pattering, and surface plunging and are presumed to take mostly krill and other crustaceans, with small amounts of fish and pteropods (a group of pelagic molluscs commonly called sea-butterflies).

Short-tailed shearwater (*Puffinus tenuirostris*)

This is by far the most abundant breeding sea-bird in Victoria. It is fully migratory; the entire population leave Victorian waters during April and May and move to northern Pacific waters or south to Antarctic seas. Their return to breeding colonies is sudden and dramatically predictable, with millions of birds moving south along the east coast of Australia during mid to late September.

In Victoria, some 1.3 million pairs of short-tailed shearwaters breed on at least 23 islands and some protected headlands (see Appendix VII). The largest colonies - on Phillip Island (more than 500 000 pairs, mostly on Cape Woolamai), Great Glennie Island (400 000 pairs), and Anser Island (250 000 pairs) - represent only a small proportion of the world population of some 23 million birds, most of which breed on islands in Bass Strait and off southern Tasmania. This breeding concentration forms one of the greatest densities of sea-birds in the world and comprises a staggering 73% of the total biomass of all sea-birds breeding around Australia. Presumably, they take little of their food in the low-productivity waters of Bass Strait; rather they make foraging trips of hundreds of kilometres to the Southern Ocean or Tasman Sea.

Short-tailed shearwaters feed on fish, cephalopods, and krill captured mainly by surface-diving and pursuit-plunging. They commonly feed in flocks of up to 20 000 birds, which take on a rolling appearance as birds at the front dive while those at the back fly forward to the front. The precisely timed and extended breeding season makes this species highly susceptible to fluctuations in prey populations, leading in some years to low breeding success or high mortality of adults and fledglings.

White-faced storm-petrel (*Pelagodroma marina*)

Storm-petrels - small, delicate sea-birds - use the wind to glide and bounce low over the sea, picking small floating organisms from the surface or just below it. The diet consists of surface plankton, small fish, and crustaceans, obtained mainly by aerial dipping and surface-seizing. One species, the white-faced storm-petrel, breeds on three Victorian islands: Tullaberga Island (approximately 23 000 pairs), Mud Islands (6000 pairs), and South Channel Fort Island (6000 pairs). These population estimates are not precise because of difficulties in counting small, nocturnal, burrow-nesting birds, and further detailed surveys are urgently required. This is especially so at Mud Islands, where the impact of burgeoning breeding populations of silver gulls and ibis is unknown.

White-faced storm-petrels arrive at the breeding sites in September or October and the hen lays a single egg in October or November. Young do not fledge until late January or February. The birds then leave Victorian waters, but their movement patterns are poorly understood. Certainly, birds of the Australian race occur in winter in the northern Indian Ocean and in the central Pacific.

Common diving-petrel (*Pelicanoides urinatrix*)

Another small, burrow-nesting petrel that is difficult to census, the common diving-petrel is known to breed in low numbers on 10 Victorian islands. The only substantial colony is at Lady Julia Percy Island where upwards of 1000 pairs may breed. The other islands, all off Wilsons Promontory except for Lawrence Rocks, support only very small numbers. The species breeds on numerous islands in sub-Antarctic and subtropical waters in the Southern Hemisphere. Populations have declined on many islands due to trampling by livestock and predation by introduced rats and cats.

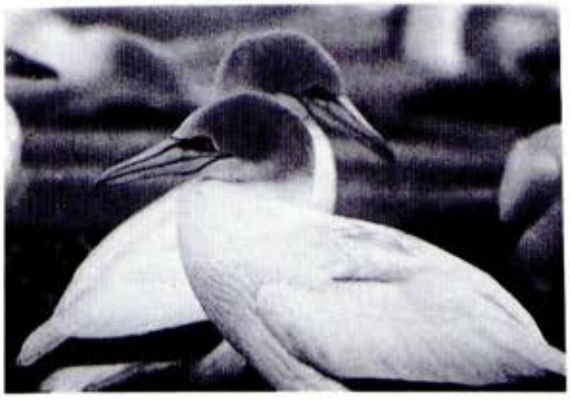
Diving-petrels feed mostly by fast pursuit-diving and pursuit-plunging followed by underwater pursuits using their wings for propulsion. They eat mostly crustaceans, particularly krill and copepods. Nothing is known of the diet or movements of birds breeding on Victorian islands.

Australasian gannet (*Sula serrator*)

Despite being the world's second-rarest member of the family Sulidae (gannets and boobies), the Australasian gannet is commonly observed in all Victorian coastal waters. However, breeding occurs at only three Victorian sites: Lawrence Rocks (at 3000 pairs the largest Australian colony), and the two artificial structures in Port Phillip Bay - Wedge Light (45 pairs) and Pope's Eye Annulus (100 pairs). Menkhorst (1992) documented the history and management of these Port Phillip Bay colonies. The entire world population is about 53 000 pairs of which only 6600 breed in Australia and a large number on islands around New Zealand.

Breeding is protracted. Nests are refurbished in July and August, most eggs are laid in September or October, and most young fledge in January or February, although some chicks from second layings do not fledge until April. After breeding, adults undertake local movements, but are back at the breeding colonies within 3—4 months. Immatures travel long distances, mostly westwards, and return to their natal colony at 3—4 years of age.

Australasian gannets feed by plunge diving, from heights of up to 15 m, and also by surface plunging from 1—2 m. Food consists primarily of small (100—250 mm) pelagic schooling fish and some squid. In Port Phillip Bay, pilchards are by far the most important food item with barracouta and red mullet also frequently taken. The pilchard fishery in the Bay thus has implications for food resources for gannets and little penguins.



Australasian gannet.

Black-faced shag (*Phalacrocorax fuscescens*)

The black-faced shag is endemic to the coast of southern Australia where it breeds on rocky islands and reefs and feeds in inshore waters. Only five or six Victorian breeding colonies are known - on an unnamed island in the Bay of Islands, on one of the Twelve Apostles rock stacks, and on Dannevig, Cleft, Notch, and possibly Granite Islands. A relatively large one apparently occurred on Lawrence Rocks in the early 1900s (Mattingley 1908).

Although Victoria's colonies are all relatively small (up to 120 pairs on Notch island), the total world population is low, perhaps as few as 15 000 pairs, thereby increasing the significance of even small colonies.

Almost nothing is recorded about the bird's movements or feeding habits, but 20 stomach contents analysed by McNally (1957) all contained fish.

Pacific gull (*Larus pacificus*)

These gulls breed only on islands off southern Australia and the total population is probably fewer than 10 000 birds. In Victoria, breeding occurs on most of the islands off Wilsons Promontory (see Appendix VII), involving perhaps 400 pairs. There is also one record of breeding on Cape Woolamai, Phillip Island (Harris and Norman 1981).

Pacific gulls occur on islands and ocean and bay beaches, but rarely inland. They scavenge a variety of food including fish, marine invertebrates, carrion, and sometimes adults or chicks of other sea-birds such as white-faced storm-petrels. They break shellfish and sea urchins by dropping them onto rocks and, as some pairs utilise the same rocks year after year, large 'middens' of broken shells can accumulate.

Very little is known about their breeding biology or dispersal and further research is urgently required.

Kelp gull (*Larus dominicanus*)

While common in New Zealand, South Africa, and southern South America, kelp gulls have recently colonised coastal south-eastern Australia and appear to be increasing in abundance in Tasmania. In Victoria they remain rare, and breeding has been recorded only on Seal Rocks off Phillip Island, where up to eight pairs breed annually.

Caspian tern (*Sterna caspia*)

Small numbers of the cosmopolitan Caspian tern breed on isolated, undisturbed beaches and shoals along the Victorian coast. Regularly used sites include Mud Islands (up to 25 pairs), the barrier islands of Shallow Inlet and shoals in Mallacoota Inlet, with considerable year to year variation in colony site and numbers. No details of movements or diet in Victoria are available, but the birds eat mainly fish obtained by plunge-diving.

Crested tern (*Sterna bergii*)

This is the sea tern common throughout the southern half of Australia. In Victoria, it is common along the entire coast, occurring at sea and in sheltered bays and estuaries. Breeding colonies are formed on isolated, undisturbed beaches, reefs, and islands and location and size of colonies can vary considerably from year to year. Perhaps the largest and most stable colony is on Mud Islands, where up to 2000 pairs nest just above high-tide mark on the beach platform.

Banding of young from Mud Islands and Shallow Inlet shows a clear trend for juveniles to disperse eastwards around the coast as far as southern Queensland. Despite high juvenile mortality once adulthood is reached life expectancy is high, and banded birds are

known to live for up to 25 years (Minton 1992a).

Crested terns plunge-dive for small fish, but no details of their diet in Victoria are available.

Little tern (*Sterna albifrons*)

The little tern has declined markedly throughout its world range and is classified as endangered in Australia and many other countries. In Victoria, it occurs over inshore waters in coastal bays and estuaries and nearby wetlands east of Barwon Heads. It forms breeding colonies on sandy beaches and shell spits in Gippsland, and fewer than 200 pairs now breed in Victoria. Colony sites vary from year to year and include: Mallacoota, Tamboon, and Sydenham Inlets; Lake Tyers; Rigby Island near Lakes Entrance; and Crescent Island near Ocean Grange. Nests are vulnerable to flooding by high tides and storms, disturbance by people, dogs, and horses, and predation by foxes and cats. Breeding success at many Victorian colonies has been extremely low, but fencing to exclude people and predators (including pet dogs and cats), combined with public education programs, has resulted in greatly improved success at some colonies. At Rigby Island and Lake Tyers, artificial islands constructed from dredge spoil now provide more-secure breeding sites. Both these islands have been colonised and breeding success is high.

Little terns feed on small fish and floating invertebrates by plunge-diving from a hovering flight.



Crested tern.

Fairy tern (*Sterna nereis*)

The fairy tern has similar ecological requirements to the little tern but utilises fresh-water wetlands less frequently. It occurs mainly along the coast of central Victoria, particularly Port Phillip Bay and Western Port. The breeding population in Victoria is small, probably less than 100 pairs in most years, and several colonies, including those at Mud Islands and near Queenscliff have recently disappeared. Like the little tern, the bird nests on sand scrapes just above the high-tide line on sandy beaches, which are vulnerable to flooding, disturbance and predation. However, the fairy tern has not received the same level of conservation management.

Victorian breeding colonies are mainly located around western Port Phillip Bay but, except for the colony at the Spit Fauna Reserve, have declined in recent years. Following the construction of an artificial island at Rigby Island, Lakes Entrance, up to 80 pairs of fairy terns have bred there among breeding little terns. This extends the Victorian breeding range eastwards by some 240 km.

MARINE MAMMALS

A variety of marine mammals have been recorded in Victorian marine waters and the descriptions cover their distribution, breeding and numbers, food and feeding, and conservation status.

Australian fur seal (*Arctocephalus pusillus doriferus*)

This resident species has its focus of distribution in Bass Strait. It ranges widely in south-eastern Australian waters, but appears to be restricted to the seas on and near the continental shelf. It is rarely recorded at its northern limit in the vicinity of Port Macquarie, N.S.W. (31^{o} 26'S), but is commonly seen to the south of Tasmania and west to Kangaroo Island.

Breeding occurs at nine sites, all in Bass Strait. Four are in Victorian waters: at The Skerries (with an estimated 800 population), Kanowna Island (6000), Seal Rocks (10 000), and Lady Julia Percy Island (10 000). The Tasmanian colonies are on Moriarty Rocks (3500), Judgement Rocks (6500), West Moncoeur Island (1000), Tenth Island (1500), and Reid Rocks (6500).

In Victoria the species also habitually uses resting sites on Anderson Islets off Wilsons Promontory and White Rock, and in caves near Cape Bridgewater and Cape Nelson. Small numbers rest on navigation structures in Port Phillip Bay where they have become a tourist



Australian fur seal.

attraction and, in favourable weather, on buoys and accessible cross-members of the oil and gas platforms off the Gippsland coast.

The mammal preys on a wide variety of surface, mid-water, and bottom-dwelling fish, cephalopods, and some crustaceans. It is capable of diving to around 200 m and therefore can exploit most of the resources of the continental shelf. At least 20 food species are taken, but the major staples of the diet are squid, octopus, and shoaling fishes such as barracouta, mackerel, and pilchard.

Several local species, including the Australian fur seal were systematically and ruthlessly exploited during decades of unregulated sealing in southern Australian waters during the early 19th Century. At least seven seal colonies were eliminated in Bass Strait, one of which was on Lawrence Rocks in Portland Bay. The other Victorian colonies were reduced to mere remnants by the 1860s. After legal protection in 1891 numbers began to increase and the population now appears to be stable at current levels.

Other seals

Six other seal species have been recorded in Victorian waters: New Zealand fur seal (*Arctocephalus forsteri*); subantarctic fur seal; (*Arctocephalus tropicalis*); Australian sea lion; (*Neophoca cinerea*); southern elephant seal; (*Mirounga leonina*); leopard seal; (*Lobodon carcinophaga*); crab-eater seal (*Lobodon carcinophagus*).

Individual New Zealand fur seals and Australian sea lions range into Victorian waters from colonies off South Australia and have been reported from the coast and on islands, in the Portland area (sea lion), and eastwards as far as Seal Rocks (fur seal). The other four species normally occur in the sub-Antarctic or Antarctic. However, the leopard seal is a regular visitor to the Victorian coast, a few individuals being encountered each winter. The rest occur as vagrants.

The occurrence of these species in Victorian waters generally relates to their annual cycles of breeding and dispersal. Many records involve young animals or aged individuals well past their prime. All six species are common to abundant within their normal range.

Most of the six are generalist feeders on fish and cephalopods, particularly squids. Leopard seals also prey on penguins, other sea-birds, and the young of other seals; in Victorian waters they are known to take little penguins and fluttering shearwaters. Crab-eater seals, the most rarely recorded vagrants, are specialised feeders on krill (*Euphausia* species).

The New Zealand fur seal, Australian sea lion, and elephant seal all once bred on islands in Bass Strait, but were eliminated by sealers early last century. None of the six non-resident species listed are currently relevant to Victorian marine ecosystems, but the New Zealand fur seal is currently expanding in numbers and range and could possibly colonise suitable breeding habitat, such as Lady Julia Percy Island.

Southern right whale (*Balaena australis*)

This whale migrates annually between the higher latitudes of the Southern Ocean, where it feeds in summer, and the south coasts of Southern Hemisphere continental land masses, where calving and mating occur during winter. In Australian waters, the whales mainly concentrate at the head of the Great Australian Bight and in the coastal waters of southern



Southern right whale.

Western Australia. Small numbers are encountered on the Victorian coast from about June to November.

Pregnant cows seek shallow inshore waters, usually near sandy beaches and in embayments, to give birth and to suckle their calves. Nursing cows often spend weeks or months in particularly favoured localities. Logan Beach near Warrnambool is a calving site. While it is not used in all years, numbers have varied from one to as many as eight cow—calf pairs. Cows with calves are encountered elsewhere on the Victorian coast but rarely stay for more than a few days at any one place.

Groups of up to seven adults are occasionally reported and are presumed to include males and receptive females, as mating behaviour has been observed in some instances. As the Australian population slowly increases, larger numbers can be expected to visit Victorian waters and additional areas may become regular calving sites.

The species is highly specialised for feeding on the smaller pelagic crustaceans that swarm in the surface waters of the Southern Ocean each summer. Copepods form its main food, but it also skims euphausiids (krill) from the water. It feeds by swimming with its capacious mouth open, trapping zooplankton on its very long fringed baleen plates. They do not feed during their time on the Victorian coast.

In Australia, these whales were extensively hunted from 1806 to the 1840s, from shore-based establishments strategically placed in localities to which the animals returned each year. They were also taken by ships that worked the whaling grounds off the southern coast, cruising for sperm whales. The combined effects of these two forms of whaling brought the Australian population to the brink of extinction. Signs of a slow recovery have only become evident in recent decades. The species is listed as endangered nationally and by Victoria under the Flora and Fauna Guarantee.

Bottle-nosed dolphin (*Tursiops truncatus)*

Widely distributed in all Australian coastal seas, the dolphin is commonly encountered in Victoria's inshore waters, including the larger bays and estuaries. Little is known of its movements, but no long-distance migrations appear to occur.

Its life history and status in Victorian waters remains similarly clouded. It is highly social, with young animals moving about in closely knit groups or pods of up to 30. Larger herds of 50 or more animals probably represent temporary associations of two or more pods. Births have been recorded in the summer months.

Recent studies of the species in Port Phillip Bay suggest that one or more pods now live there. They have received considerable publicity and have become a tourist attraction.

Bottle-nosed dolphins are capable of deep dives (more than 200 m), but in shallow inshore waters probably feed mainly on surface and mid-water fishes and squids. Smaller shoaling species such as pilchards, anchovies, mullet, and mackerel are favoured food items. Co-operative feeding on fish shoals has been observed.

The species is protected under Victorian law from interference, harassment, capture for display, or killing for any purpose.

Common dolphin (*Delphinus delphis*)

Occurring in all Australian seas, common dolphins are frequently encountered in Victoria's coastal waters, including the larger bays and estuaries, but do not readily venture close inshore. Little is known of local movements, but significant inshore—offshore and alongshore ranging does occur, suggesting that the species is not strictly a resident species in Victorian waters.

We know virtually nothing of its life history or numerical status in Victoria. It is highly social, moving about in closely knit groups or pods of up to 20 or more, but much larger aggregations have been reported numbering many thousands, migrating alongshore.

Newborn have been reported in the summer months and are represented in strandings of the species on the Victorian coast, of which up to six have been reported annually. This reflects the dolphin's presence in local waters throughout the year.

Common dolphins are known to be capable of deep dives and to prey on surface, mid-water, and bottom-dwelling organisms, including fishes, squids, and crabs.

Common dolphins, as well as bottle-nosed dolphin, have not been commercially hunted in Victorian waters, although some have, in the past, been occasionally killed by commercial fishers for rock-lobster bait. Accidental capture in fishing nets rarely occurs. Neither of these forms of mortality would be likely to affect local populations.

The species has the same conservation status as the bottle-nosed dolphins.

Box 4.3: Cetaceans that feature in the Victorian stranding record

Baleen whales	
blue whales	*Balaenoptera musculus*
fin whale	*Balaenoptera physalus*
Bryde's whale	*Balaenoptera edeni*
Minke whale	*Balaenoptera acutorostrata*
humpback whale	*Magaptera novaehollandiae*
pygmy right whale	*Caperea marginata*
Toothed whales and dolphins	
sperm whale	*Physeter macrocephalus*
pygmy sperm whale	*Kogia breviceps*
killer whale	*Orcinus orca*
false killer whale	*Pseudorca crassidens*
long-finned pilot whale	*Globicephala melaena*
Risso's dolphin	*Grampus griseus*
Cuvier's beaked whale	*Ziphius cavirostris*
strap-toothed whale	*Mesoplodon layardii*
Gray's beaked whale	*Mesoplodon grayi*
Andrew's beaked whale	*Mesoplodon bowdoini*
dense-beaked whale	*Mesoplodon densirostris*
True's beaked whale	*Mesoplodon mirus*
southern bottle-nosed whale	*Hyperoodon planifrons*

All these cetaceans are wide-ranging pelagic species. Some such as sperm killer, false killer and pilot whales venture close to the edge or onto the continental shelf for food; others do so seasonally when migrating (humpback whale) or for purposes apparently associated with calving and nursing (Minke, and possibly pygmy right whales).

The pygmy sperm whale strands sporadically on the Victorian coast, but not often enough to suggest that some particular but unknown aspect of its life history is involved. This deep-diving species feeds on small fishes, squids and crustaceans, and its dietary preferences may bring it close to the continental shelf at certain times of the year.

All seven beaked whales (*Ziphius, Mesoplodon, Hyperoodon* spp.) are widely distributed in the Southern Hemisphere. Most are known primarily or wholly from stranding records, the distribution of which indicates that the majority prefer colder waters. *Z. cavirostris, M. densirostris*, and *H. planifrons* have more northerly distributions, extending to tropical waters. Beaked whales appear to enter continental seas infrequently and rarely strand.

All the large baleen whales and the sperm whale were hunted extensively in the Southern Hemisphere post-war. Whaling in Australian waters was confined to humpbacks (to 1962) and sperm whales (to 1978).

All cetaceans are now protected in Australian territorial waters (from 3 to 200 miles) under federal law and within 3 miles of the coast under State laws. Blue and humpback whales are listed nationally as endangered species.

ISSUES

* Lack of knowledge on Victorian marine communities resulting in difficulty in identifying significant and rare communities.

* Need for a systematic and complete survey of Victorian marine environments.

* Implications of visitor use on intertidal biota, especially algae, in areas of high visitation.

* Implications of marine resource utilisation on biodiversity and habitat modification including recruitment of commercial marine organisms.

* Coastal and marine habitat modification due to urban and agricultural development.

* Disturbance to breeding, feeding, and roosting sites of oceanic birds and waders by people, pollution, dogs, foxes, cats, and horses.

* Introduced flora and fauna including spartina, marram grass, and biota in ballast waters.

* Protection of marine mammals, including the Southern right whale, and bottle-nosed and common dolphins.

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5. CULTURAL RESOURCES

This review of the history and surviving evidence of human associations with the Victorian coast is largely based on a report on the 'Prehistoric and Historic Resources on the Victorian coast' commissioned by the Land Conservation Council. The fully referenced report is available for consultation at the libraries of the Departments of Planning and Development, and Conservation and Natural Resources.

Historic Background

Aborigines have occupied Australia for at least 40 000 years. For much of this period, however, sea levels were lower than they are today because of the expansion of the polar ice caps during the last glacial period, or ice age, and Victoria was linked to Tasmania by a land bridge. Stories of the traditions of the Wathawurrung, Woiwurrung, and Boonwurrung tribes of Port Phillip and Westernport tell of the time when their ancestors hunted in Port Phillip Bay. Similar stories of hunting grounds where there is now sea have been recorded among the Ganai (or Kurnai) of Gippsland (Campbell 1967). Evidence of this early period of human occupation is generally rare in Victoria and of course rising sea levels must have destroyed many sites.

The sea reached its present level some 6000 years ago. Extensive archaeological records reflect Aborigines' use of the coast and its resources since then, particularly after about 4000 years ago. Their economy was based on hunting and gathering and focused mainly on the coastal wetlands rather than the shoreline or marine resources.

Historical records show that the Victorian coast was divided between nine language groups or tribes. Each comprised local groups or clans, many of which were based along the coast. For example, the Barath gundidj were centred on the mouth of Curdies River in Girai wurrung country; the Mallun gundidj belonged to Mallun (Griffiths Island) off Port Fairy, and appear to be the only Victorian clan centred on an island along the open coast. Incidentally, Mallun means 'island' in the local Dhauwurd wurrung dialect.

In the case of Dhauwurd wurrung, a language spoken at Portland, Port Fairy, and Warrnambool, clans were differentiated on the basis of their association with the coast. Coastal clans often had the label 'ngarmut' (meaning sea/ocean, sea water, wave) added to their names; whereas inland clans were identified by adding 'marayn' (which means stringy-bark tree and suggests an inland location).

European occupation and settlement proceeded sporadically from 1803 until permanent colonial settlement began at Portland in 1828 and then in 1836 at Melbourne. It severely disrupted Aboriginal society, and rapidly excluded the Aborigines from their coastal territories. By the late 1860s, most of the survivors were forcibly placed in missions. The coastal strip has since become one of the most developed and settled areas of Victoria.

Box 5.1: Cultural Resources

As well as documentary records and oral traditions, many traces of the history of human association with the coast survive, including archaeological sites and standing buildings. Archaeological sites are any places where material evidence of past human activity survives. This evidence can range from a scatter of stone tools or shells, indicating an Aboriginal camp, to the remains of structures associated with European coastal settlement and industry. Archaeological sites provide not only tangible reminders of past societies, but also important information for understanding human history.

THE PRE-CONTACT PERIOD

COASTAL RESOURCES

Hunter—gatherer societies live by directly utilising the plant and animal resources in their territories. Seasonal movements are highly organised to make effective use of available food, water, fuel, and shelter. Women and children normally collect plant foods and shellfish and hunt small animals, while the men generally hunt larger game.

Coastal wetlands were, for hunter—gatherer societies, the most productive parts of the

coastal strip. They were especially rich in plant foods, such as *Cumbungi* (bulrush), and supported a wide variety of bird life (hunted with nets and snares). Fishing and eeling were also important. Open woodlands along the coastal strip produced animals for hunting, such as kangaroos, emus, and wallabies, and provided a wide variety of plant foods as well. While sand dunes were generally much less productive, fruits such as kangaroo apple were certainly important on a seasonal basis.

Coastal waters and the shoreline were generally low in productivity, although this depended very much on the type of coastline. Rock platforms, sandy beaches, and estuaries provided different varieties of shellfish. Seal colonies and muttonbird rookeries occurred in some areas, and stranded whales contributed an occasional 'windfall' for Aborigines along the western coast. Along the western and central coasts, nodules of marine chert washed onto beaches made a good source of raw material for making stone tools. Along the Gippsland coast, where marine chert was not available, silcrete and quartz, mostly from the hinterland, were the most commonly used raw materials.

Historical sources suggest that Aborigines along the Victorian coast at the time of invasion exploited mainly the resources of the coastal wetlands and open woodlands of the hinterland rather than those of the shoreline and sea. Water-craft were mainly used for fishing on rivers, lakes, and lagoons. There are few accounts of visits to off-shore islands along the eastern and central coasts and none along the western. Archaeological evidence of past occupation on the islands is very sparse. At the time of contact, for example, Lady Julia Percy Island was regarded as a 'spirit-place'.

It is important to remember that the coastal environment is not static. Even since sea levels stabilised around 6000 years ago, erosion and deposition have caused substantial changes, such as development of the barrier system and formation of the Gippsland Lakes. The Ninety Mile Beach is a relatively unproductive environment, but the formation of the lake system improved the productivity of the region as a whole. Fishing on the lakes and rivers was particularly important for the Ganai of Gippsland. By contrast the western coast is probably the most productive. Here many different habitats occur close together - wetlands are close to the shoreline, for example - and this seems to have allowed the Aborigines to lead relatively settled lives.

COASTAL ARCHAEOLOGICAL SITES

Not all human activities leave material traces that will survive natural processes of decay. Only the most durable items, such as stone artefacts, survive for long periods. Bone and shell survive in favourable conditions, while other organic materials such as skin, wood, and other plant materials are rarely preserved. Natural processes of erosion and deposition determine whether sites survive and how they are exposed on the surface. In coastal dunes, for example, wind erosion may expose buried ones. Only a small fraction of the surviving Aboriginal sites have actually been recorded.

Sites are classified largely on the basis of their contents. Bones, shells, and preserved plant remains may indicate foods eaten and environments exploited. The raw materials and technology used to make stone tools may indicate territorial or ranging areas, or contacts with other areas and peoples, as well as the tasks performed. Organic remains such as wood, charcoal, bone, and shell may be used for radiocarbon dating. The distribution of sites in relation to landforms can provide an understanding of settlement patterns and human adaptations to the environment.

Nearly one-fifth of all Aboriginal archaeological sites recorded in Victoria (2547 sites) are found within a kilometre of the coast. This relatively large number may seem surprising, since wetland resources were far more important to coastal Aborigines than those of the shoreline. But it partly reflects the amount of archaeological survey undertaken along the coast and the good visibility that often exists there as a result of devegetation and erosion. Shell middens - by far the most common sites, at 77% of the total - are also often well preserved and easily recognised. Surface artefact scatters and isolated artefacts are the next most common site types, while all the rest (rock shelters, scarred trees, quarries, etc.) are very rare.

Shell middens are accumulations of shells, the refuse from meals. They range from hundreds of metres across, indicating repeated visits to the same spot, to very small scatters, which perhaps represent just a single meal or 'dinner-time camp'. Some middens also contain other types of cultural material such as the bones from land and sea mammals, fish, and crustaceans, and perhaps hearths and stone artefacts. Deeply layered midden deposits rarely occur here. Sometimes it can be

difficult to distinguish middens from natural shell deposits, especially when they have been reworked by erosion or storm surges.

Most shell middens are located in ecologically varied environments with access to a wide range of terrestrial and marine resources. Midden sites are found more frequently on coasts with a range of coastal forms - well-fissured and developed rock platforms, sandy bays, and fresh water in creeks or rivers, particularly swamps, lagoons and estuaries. The species of shellfish found tend to reflect the local environment.

Along the south-western coast, midden densities are high in the Discovery Bay, Portland, and Warrnambool area, where survey coverage has been comparatively high. Densities are lower further east, with more intermittent coverage, and very variable along the central coast. Few middens occur, for example, along the western arm of Port Phillip Bay, despite excellent survey coverage, and most sites cluster close to the major waterways. By contrast, middens are common in the Sorrento area. These variations probably reflect greater productivity in the Sorrento area and its hinterland. More rapid erosion may also be uncovering middens more rapidly. Along the eastern coast, densities are generally low, particularly along the Ninety Mile beach. Some dense clusters do occur - for example, at Mallacoota, Jack Smith Lake, Lake Tyers, and Point Hicks. These reflect the richness of the adjacent hinterland and, in the case of Point Hicks, the occurrence of rock platforms.



Midden near Mueller River

Stone artefact scatters and **isolated artefacts** are also found along the coast. They comprise mostly the waste products from making a range of cutting, scraping, and piercing tools, although the finished tools are some times found as well. Some of these sites are probably the last surviving remnants of heavily eroded middens. Others may indicate camps, either long-term or overnight stops, or specific activities such as hunting or plant processing. Like shell middens, stone artefact scatters occur mainly close to resource-rich environments. Along the western coast, the Aborigines would remove the outer weathered crust of the marine chert nodules close to the beach to inspect the quality of the stone inside, in order to reduce the bulk of stone carried to inland camps for making into a range of tools. These workshop sites are especially common around Discovery Bay. Isolated artefacts (that is, sites with three or fewer artefacts) are found all along the coast. The particularly high density around wetlands in the Portland area is most likely due to the intensive survey for the Portland aluminium smelter site.

Other site types, such as hearths, scarred trees, mounds, and quarries, occur very rarely along the coast. Several **rock wells** have been recorded on the eastern coast of Port Phillip Bay, where fresh water is scarce. These natural cavities in the rock are difficult to identify as Aboriginal sites where there is no historical evidence of their use.

Scarred trees, from which bark has been removed for building shelters, canoes, or other artefacts, are rare along the coast, except in the Gippsland Lakes area. Generally trees with usable bark either are not found along the coast or have not survived European development.

Burials have also been recorded in coastal dunes and midden sites. These sites are particularly important to Koori people.

Chronology of coastal sites

Most Victorian coastal sites are younger than the stabilisation of sea levels about 6000 years ago. The combination of rising sea levels and more recent coastal erosion has destroyed most earlier evidence, although older middens at Discovery Bay show that marine shellfish were exploited from about 8000 B.P., (before present). Surface artefact sites with tools similar to those from sites dated to 10 000—8000 B.P. are also found at Discovery Bay, while Bridgewater Cave was first occupied around 11 000 B.P. However, most sites are much younger than this and date some time within the last 3000—4000 years. Some researchers have suggested that the increased numbers of sites may reflect increased population or changes in settlement patterns. But they may simply mean that younger sites

are better preserved. Other evidence, at least near Discovery Bay, suggests a period of coastal erosion about 4000 B.P., which would probably have destroyed older sites.

Coastal Aboriginal sites in Victoria are fragile and constantly under threat from human activity and natural processes. Coastal development, especially in urban areas, has already destroyed many. In rural areas, tourism and recreation provide the major human impacts. Sites occurring along many stretches of the Victorian coast, such as sandy beaches and low-lying wetlands, are also constantly under threat from processes of erosion and redeposition.

POST-CONTACT PERIOD

The coast played a key role during a new period of colonisation of Victoria during the nineteenth and twentieth centuries. Initially, most migrants were of European ancestry, mainly from Britain, but later a diversity of nationalities became involved. The first

Table 5.1: POST-CONTACT SITES AND THEMES

Discovery
- Plaque at Point Hicks

Early settlement
- Woodbine Cottage, Port Fairy
- Captain Mills' Cottage, Port Fairy
- Sorrento, Mornington Peninsula
- Corinella, Westernport

Port development, communications and transport
- Lighthouse, North Bluff—Portland
- Lighthouse keepers cottage, Whale Crescent, Portland
- Lighthouse, Whalers Point, Portland.
- Customs house, Portland
- Complex of warehouses, wharfs, and surrounds, including the customs house, Moyne River, Port Fairy
- Lighthouse, Griffith Island
- Lighthouse and store, Lady Bay, Warrnambool
- Lighthouse, Cape Otway
- Submarine cable station, Apollo Bay
- Lighthouse, Point Lonsdale
- Signal station, Queenscliff
- Lighthouse, Shortlands Bluff, Queenscliff
- Pilot cottages, Gellibrand Street, Queenscliff
- Telegraph station, Ryrie Street, Geelong
- Former wool stores and warehouses, Geelong
- Geelong Wool Exchange, Corio Street, Geelong
- Customs house, Botanic Gardens, Geelong
- Customs house, Williamstown
- Tide-gauge house, Nelson Place, Williamstown
- Time ball tower, Williamstown
- Station platform, Williamstown
- Alfred Graving dock, Williamstown Dockyard, Williamstown
- South Wharf and buildings, South Melbourne
- Lighthouse, Nepean Highway, McRae
- South Channel Pile Light, Port Phillip Bay
- West Channel Pile Light, Port Phillip Bay
- New works complex, Lakes Entrance
- Lighthouse, Gabo Island

Aboriginal and European relations
- Lake Tyers Mission

Changing patterns of immigration
- Convict graveyard, Williamstown
- Immigrant waiting areas, Station Pier, Port Melbourne
- Quarantine building, Point Nepean
- Immigration depot, Port Albert

Coastal defence
- Guns and emplacements, Battery Hill, Port Fairy
- Powder magazine, Port Fairy
- Queenscliff forts
- Fort Gellibrand and barracks, Queenscliff
- Point Cook RAAF base
- Merricks rifle range, Williamstown
- South Channel Fort, Port Phillip Bay
- Point Nepean complex
- RAAF operations area, Mallacoota

Coastal and maritime industries
- Sealing/whaling sites, Lady Julia Percy Island
- Lime kilns, Limeburners Point, Geelong
- Cheetham saltworks, Port Phillip Bay
- Gasworks, Albert Park
- Fossil Beach cement works
- Sullivans kiln, Mornington Peninsula
- Chickory kilns, Phillip and French Islands
- Lime kilns, Walkerville
- Mason tramway remains, Port Welshpool
- Government tramway remains, Port Welshpool
- Glass factory, Lake Tyers

Tourism and recreation
- Former lifeboat shed, Port Fairy
- Proudfoots boathouse, Warrnambool
- Waiting room and lifeboat shed, South Pier, Queenscliff
- Eastern beach, Geelong
- Kerford Road pier, Albert Park
- Catani Gardens, St Kilda
- Pavilion, St Kilda Pier
- Brighton baths
- Bathing boxes, Brighton
- Various ferry terminals, Westernport
- Great Ocean Road

Landscape
- Great Ocean Road
- French Island
- Churchill Island
- Wilsons Promontory
- Port Albert

colonial settlements took advantage of the few natural harbours in Bass Strait and spread inland from them. For Aborigines, those along the coast often first encountered the invading Europeans. Growth of the rural hinterland supported these early settlements through the export of primary products. The difficulties of sustaining communication and trade also influenced Victoria's development. Despite the dangers of Bass Strait, shipping provided faster and more economic internal movement of cargoes than any other available means until the growth of a rail network in the 1850s. The exploitation of coastal and maritime resources, together with access to shipping and harbours, stimulated the early development of industry along the coast, and access to port facilities has continued to be a crucial factor in the siting of industrial developments. For many of the immigrants who survived the hazards of the voyage, Victorian ports were the gateway to Australia. The coast has formed the first line of defence since early settlement.

Many of these themes are illustrated by surviving standing buildings and other structures and artefacts (see Table 5.1) and by the numerous shipwrecks such as those listed in Box 5.2 and shown on Map 3. For convenience these themes are generally discussed separately, although it must be recognised that they are interwoven.

To date, no systematic identification and assessment of post-contact sites along the coast has taken place, nor have those studies carried out always used the themes described here. Because of the socio-economic conditions that created them, many sites lie on private land (for example, those that illustrate the 'early settlement' theme) or within cities such as port facilities illustrating the 'coastal and maritime industries' theme. Both cities and private land lie outside the study area. However, coastal shipwrecks, which relate to several of the themes - lie predominantly within the study area, despite some notable exceptions such as the *Freedom*, which now lies on land in the City of Warrnambool.

Box 5.2: Shipwrecks

The early history of European settlement in Victoria is very much a maritime one. Shipwrecks are thus an important part of the State's heritage and reflect many aspects of its history. About 700 wrecks are thought to have occurred in Victorian coastal waters; approximately 80 have so far been located and a number of these are shown on Map 3. The earliest known is that of the longboat from the *Sydney Cove* (itself wrecked in the Furneaux Islands), which was wrecked near Point Hicks in 1797.

Although shipwrecks occur along the entire coastline, they tend to cluster in certain particularly hazardous areas. These include:

- the western entrance to Bass Strait - where the combination of south-westerly swells, a narrow funnel-shaped entrance, no prior landfall, and the reefs off the Otways and King Island combined to make its navigation perilous before the advent of lighthouses
- the narrow entrance to and shallows of Port Phillip Bay
- the granite shoals off Wilsons Promontory and the fog resulting from the mixture of warm and cool currents just east of the Promontory
- the shallow waters off the approach to Port Albert
- the shifting and shallow entrance to Lakes Entrance

About 60 wrecks are known to have occurred along the west coast. Although ships were wrecked for many reasons, this was a dangerous place to make landfall and the colonial government was slow to establish adequate aids to navigation. Most wrecks were smaller wooden coastal and interstate traders, and the ships and their cargoes broadly reflect local trade. The Otway coast suffered several significant wrecks, including the *Loch Ard* and the *Schomberg*. The *Loch Ard* was wrecked in 1878, on a voyage from Gravesend to Melbourne, with a large loss of life and only two survivors.

The port of Melbourne occupies a pivotal position in trading and shipping patterns along the Victorian coast. Both intercolonial and international vessels used it, while many smaller vessels plied local routes within the bay. About 136 wrecks have occurred within 10 nautical miles of the entrance to Port Phillip Bay, the wide range of vessels lost reflecting the diverse traffic entering and within it. By contrast, most of the losses at the northern end of the bay were small local and coastal traders. Two wrecks in the bay have been studied in detail: the *William Salthouse* wrecked in 1841 and the *Clarence*, an Australian-built schooner wrecked in 1850. Excavation of the *William Salthouse* allowed detailed study of its very varied cargo, while the *Clarence* provided information about early Australian ship building techniques, which are poorly documented in historical sources.

(continued)

Box 5.2 (continued)

In the east, many ships lost at Port Albert and Corner Inlet were Tasmanian, reflecting the domination of this trade route, although several Newcastle coal ships also foundered here. The steamship *Clonmel* was the first wreck in the area and its loss in 1841 led to the settlement of Port Albert; only brought to Australia in 1840, it was used for interstate passenger transport and at the time represented a 'new age of luxury, speed, and regularity'. Built in 1850 in Maryland, U.S.A., to a luxurious standard, the *Monumental City* subsequently had a chequered history due to unreliable engines. It was the first steamship to cross the Pacific, ran aground off Mallacoota in 1853 on its first voyage in Australian waters, carrying passengers bound for the gold diggings.

Shipwrecks are a tangible reminder of the maritime dependence of colonial Victoria. They are celebrated in story and have become one theme - the Shipwreck Trail - that travellers along the Great Ocean Road can explore. Here they can see the coastal waters where the ships came to grief and learn their history. The more adventurous can dive on a number of wrecks, 21 of which have recently been identified to form an Underwater Shipwreck Trail. As of 1 April 1993 protection was extended to all shipwrecks aged 75 years or more and younger wrecks when they become 75, lying off the open coast under the Commonwealth *Historic Shipwrecks Act* (1976). Within the larger bays and inlets 21 shipwrecks are protected under the Victorian *Historic Shipwrecks Act* (1981)[1], and these are listed below.

Aneiura - Point Lillias: 1652-ton 3-masted American-built wooden sailing ship that was sold off and later burnt.

Briton - off Point Henry: 452-ton wooden 3-masted barque converted to a lighter, which sank at its moorings during a heavy gale (1864–1890)

City of Melbourne - near Point Henry: 1828-ton, 3-masted ship converted to a hulk following a fire off Williamstown (1853–90)

City of Launceston*2 - near the middle of the Bay: 318-ton iron-screw steamer that sank en route to Hobart from Melbourne

Clarence*3 - near Coles Channel: 67-ton wooden schooner that sank en route to Melbourne from Hobart (1841–50)

Countess of Hopetown - Swan Bay: 75-ton steel-hulled torpedo boat built for the Victorian colonial Navy; sold off and later abandoned (1891–1924)

Eliza Ramsden - South Channel: Scottish-built 415-ton iron sailing ship outward bound from Melbourne when it struck Corsair Rock and sank (1874–75)

Empress of the Sea - Point Nepean Bay: 2200-ton masted wooden ship en route to London from Melbourne (1853–61)

Gambier - near Popes Eye: 1577-ton Scottish-built iron steamer wrecked following a collision with the S.S. Easby (1874–91)

Hurricane - Capel Sound: 1198-ton 3-masted iron ship en route from Liverpool to Melbourne (1853–69)

Joanna*3 - West Channel: 34-ton 2-masted wooden schooner en route from Port Phillip heads to Melbourne (1856–57)

Medea - off Swan Island beacon: 423-ton Canadian-built wooden 3-masted barque that ran ashore near Swan Island following a heavy gale (1858–80)

Monarch - West Sands: 269-ton English-built wooden barque, wrecked during heavy weather while on a voyage from Melbourne to Newcastle (1836–67)

Mountain Maid - between Coles and West Channel: 160-ton 2-masted wooden brig en route from Manilla to Melbourne (1841–56)

Omega - William Sands: Australian-built 72-ton wooden schooner wrecked on William Sands while on a voyage from Melbourne to Devonport (1893–97)

Seabird - near West Channel pile: American-built 353-ton 3-masted barquentine, wrecked after parting from its anchor cables (1844–67)

S.F. Hersey - north end of Swan Island: American-built 961-ton 3-masted ship later converted into a hulk (1865–1923)

Swallow - West Channel: Australian-built 24-ton wooden ketch wrecked while on a voyage from Melbourne to Apollo Bay (1860–1922)

Time - north side of Nepean Reef: English-built 3322-ton steel-screw steamer, wrecked while entering the heads, en route from Sydney to Melbourne (1913–49)

Wauchope - Sorrento: 209-ton wooden-screw steamer that caught fire and exploded while on a voyage from Melbourne to King Island (1905–19)

William Salthouse*2 - north of Popes Eye: 254-ton 2-masted wooden sailing brig en route from Canada to Port Phillip Bay (1824–1841)

Will O'the Wisp*4 - Swan Point, Swan Island: English-built, 101-ton, wooden schooner designed for the opium trade but engaged as an intercolonial trader when wrecked (1840–53)

1. All coastal shipwrecks declared under this Act lie within Port Phillip Bay - list current at 30 March 1993.
* 2 Includes historic shipwreck and protected zone of 250 m radius; 3 Includes historic shipwreck and protected zone of 100 m radius; and 4 Includes historic shipwreck and protected zone of 50 m radius.

Source: Maritime Archaeology Unit - Aboriginal Affairs Victoria



Artifacts from the 'Loch Ard'.

COLONIAL DISCOVERY AND EARLY SETTLEMENT

Although the Victorian coast was 'first seen' by Lt. Zachary Hicks in 1770, from Captain Cook's ship *Endeavour*, it was the testimony of survivors from the wreck of the *Sydney Cove* in the Furneaux group of islands in 1797 that kindled interest in the possible existence of a strait between Van Diemans Land and the colony of New South Wales. Colonial administration and then sealers moved quickly to investigate. In 1797 Governor Hunter sent George Bass to explore the strait in a whale-boat. Bass initially explored as far west as Western Port, later exploring the whole strait with Matthew Flinders in the *Norfolk*. Charles Bishop, a British mariner who joined the *Norfolk* in another ship, landed 15 men on Cape Barren Island to exploit the seal colonies. They obtained 5000 seal-skins that year and 350 gallons of oil.

The strategic implications of a strait separating Tasmania and the rest of Australia were quickly realised. It therefore became imperative to establish a British presence on its shores. The visit of a French scientific expedition led by Nicolas Baudin alarmed the colonial government and the activities of sealers provided further incentive to found a colony. Accordingly, two surveys were conducted in 1801 which located Western Port and Port Phillip Bay. The following year Governor King sent the *Cumberland* to demonstrate a British naval presence and to scout out a favourable place for a colony.

There were two official attempts at settlement. The first, at Sorrento in 1803, lasted only 7 months. No attempt was made to find a suitable site. It was during this time that the convict William Buckley escaped, living for the next 32 years with the Wathawurrung tribe in the Geelong area. The second official settlement was at Corinella in 1826. This, being rather better organised, lasted just over a year. However, with the recognition of the purely scientific intent of French exploration and contradictory reports on the suitability of the area for long-term settlement, it was abandoned in January 1828. No traces of either settlement survive above ground, although archaeological excavations have found traces of Corinella below the surface.

Apart from the 'official' settlements, sealing gangs were operating throughout Bass Strait and no doubt established semi-permanent settlements near the main seal colonies. When the Corinella settlers sailed into Western Port they were greeted by sealers based on Phillip Island, whose boat they hired.

Sealing was succeeded by the whaling industry, which established more permanent settlements along the Victorian coast. William Dutton, a whaler based at Portland, had established a house and garden there by 1828. Launceston businessmen such as the Hentys and Griffiths who ran the whaling industry showed considerable interest in Victoria and, by 1834, Henty and Griffith had each established farms inland of the Victorian coast. Portland and Port Fairy were established and settled about the same time. Both towns retain standing buildings from this early phase of settlement, while archaeological traces remain of others. Port Fairy is particularly rich in early buildings. Woodbine Cottage, Captain Mills Cottage, the Merrijig Inn, and the Stag Hotel all survive from the 1840s.

In 1834 news of the rich pastoral lands of western Victoria, and the successful settlement at Portland, attracted settlers once again to the Victorian coast. John Batman and 15 others formed the Port Phillip Association in order to explore the possibilities of land in the Port

Phillip area. In 1835 Batman landed at Port Phillip Bay, explored around the Yarra, and found good land and water. He subsequently claimed to have signed a treaty with the Aborigines, local to the Yarra and Geelong areas, ceding 600 000 acres of land around the bay for a few blankets and axes. Within a few weeks another group arrived under John Fawkner and settled on the banks of the Yarra where Batman had explored. Batman returned later in the year and settled with his group, who had moved from their camp on the Bellarine Peninsula to near Fawkner's.

The Port Phillip settlement, like Portland, quickly became a commercial success and other settlers soon followed. The initial composition of the groups led by Fawkner and Batman favoured success, with a happy combination of agriculturalists, businessmen, tradesmen, and mechanics. The colonial government regarded the settlement and the settlers as illegal, but the situation was so remote from administrative control that, in 1836, Governor Bourke was forced to recognise the *fait accompli* and allow the settlement to go ahead. Western Port was settled at about the same time (1835) by the Anderson brothers from northern Tasmania. Further along the coast, districts such as Tarwin Lower were settled after Port Albert was established in 1841.

In East Gippsland, Mallacoota followed a different settlement pattern from that of the west coast towns; it lacked rich agricultural lands, the hinterland offered fewer possibilities for development, and travel was difficult. Attempts to settle there from the late 1830s onwards, mainly to run cattle, were thwarted by Aboriginal defence of their traditional lands. Runs inland at Genoa had been settled from the north as early as 1834. Captain John Stevenson, a whaler, was the first European to settle at Mallacoota after Aborigines drove him out of a run on the Cann River. He had abandoned the Mallacoota run by 1847, but William Baird reoccupied it in 1850. Although by the late 1840s settlers occupied most of the land between Tambo and the Latrobe River, far East Gippsland continued to be sparsely settled until the 1890s.

ABORIGINE–SETTLER RELATIONS ON THE COAST

The Aboriginal way of life was fundamentally changed within a few years of colonial settlement. The history of Aborigine and settler relations during the frontier period is generally a depressing tale that begins before the first permanent colonial settlement of Victoria. It is thought that smallpox epidemics had spread from New South Wales even before permanent settlement in Victoria, although the extent to which coastal populations in western Victoria and Gippsland were affected is unclear. Sealers, who commonly took Aboriginal women, possibly had more impact on coastal communities.

Relations between Aborigines and settlers took many forms. In some places, they were friendly: both parties were curious about each other's customs. But, more often, prejudice, misunderstanding, and conflict were the rule. Batman's 1835 'treaties' with clan leaders in the Melbourne area are a good example of cultural misunderstanding. Batman believed that the clan leaders were agreeing to his 'purchase' of their land. However, Aboriginal land-owners commonly granted permission for temporary access to land in ceremonies involving ritual exchange of gifts and tokens symbolising hospitality to guests (Barwick 1984). For the Aborigines, the colonists were the source of new goods, such as flour, sugar, and tea, and tobacco and metal axes, but they were also an invasion force seeking exclusive use of the land. The colonists, by and large, saw the Aborigines as 'primitive savages' and as obstacles to be removed before the land could be properly 'tamed'.

The spread of pastoral settlement of the coastal hinterland quickly led to conflict between settlers and Aborigines.

One of the most notorious incidents associated with the south-west coast occurred in either 1833 or 1834, at the site known as the 'Convincing Ground' between the Surrey River and Portland. This was the country of the Kilkarer gundidj. Here, apparently, a whale that had been harpooned by whalers from a nearby station had managed to release itself, only to beach itself on the shore. The Kilkarer people, who like other coastal peoples fed on whale carcass, claimed the beached animal. This angered the whalers, who considered it their property; they determined to convince the Aborigines otherwise and a massacre ensued.

The Aborigines were also denied the use of their land for hunting and gathering and turned instead to hunting sheep. The squatters retaliated and in many areas a bitter struggle ensued as the Aborigines sought to defend their traditional territories. But it was an unequal fight and, despite government attempts



Coastal communications - the steam tram, Back Beach, Sorrento.

to curb the excesses of the settlers, effective Aboriginal resistance in Victoria ended by about 1850.

Settlement had a devastating impact for the Aboriginal population. Estimating pre-contact population numbers is difficult, but where reasonably accurate estimates can be made it is clear that populations declined dramatically within a few years. William Thomas estimated that the Bunurong and Woiwurrung from the Melbourne area numbered about 350 in 1836. By 1863, only 33 survived. Similarly, in 1836, about 300 Wathaurung lived in the Geelong area. Within 17 years, there were only 30 to 40 survivors. Introduced infectious diseases were major killers, while many died from the effects of malnutrition and alcohol as well as violence. Venereal diseases were particularly serious, as they affected fertility. In the Geelong area, for example, only 24 children were born between 1837 and 1853. The first accurate census, in 1863, counted 1920 Victorian Aborigines; by 1877, only 1067 survivors remained in the whole of Victoria (Barwick 1971).

Most of the surviving Victorian Aborigines were 'resettled' by the 1860s on reserves supervised by the Board for the Protection of the Aborigines. Six stations were established - four run by missions and two by the government. Lake Tyers Mission on the East Gippsland coast was one of them.

The Lake Tyers mission was founded in 1861 and a few buildings still remain. In 1863, 2000 acres were used as a temporary reserve and a further 2000 acres were added in 1879. In 1870 a church was built and the settlement had grown to a number of buildings. From 1886, only 'full-blood' Aborigines and others over 34 were allowed to remain on the stations. This caused great hardship to those forced to try to find homes and jobs in a hostile white community and, by removing the main workforce, destroyed the economic viability of the stations. Between 1904 and 1924, five of the stations closed and many of their residents were moved to Lake Tyers. By 1925, the reservation was home to 300 Aborigines. Following World War II, there was a move to close the settlement, but considerable protest erupted, and in 1965 it became a permanent reserve. In 1986, the deeds to the 4000 acres were handed over to the 92 Koori adults and children still living there.

PORT DEVELOPMENT, COMMUNICATIONS, AND TRANSPORT

The development of Victorian ports has largely shaped the pattern of settlement and the road and rail network we see today. The establishment of safe shipping routes in the hazardous Bass Strait was crucial not only to external trade but to local communications before adequate roads and later the rail network were built. The problems of

providing adequate port facilities and maintaining a safe harbour as the volume of traffic increased were common to all the Victorian ports. The pre-eminence of the Port Phillip Bay ports, Williamstown, Sandridge (later Port Melbourne), and Geelong, was intimately connected with Melbourne's growth as a major import/export centre and its central placement on the coast. By contrast, local trade generally sustained other ports on the coast.

Discovery of the new route through Bass Strait saved 700 miles of travel, but it also had its hazards. King Island splits the Strait's western entrance in two, with the southern channel particularly hazardous as it has many reefs. The northern channel between King Island and Victoria was the safer route and many vessels chose to sail close to the mainland coast rather than that of King Island. However, this route posed its own particular problems. The main intercolonial trade route, the 'Great Circle', exploited the circularity of the earth and the strong winds around 50^{0} latitude; thus ships approached Bass Strait from the south-west and had much less 'gap' to aim for than they would if approaching directly from the west.

With increasing migration and traffic in the Strait, the number of shipwrecks also rose. By 1830, ships urgently needed accurate charts of the Strait, particularly of the reef area around Cape Otway. Lights were required at both Cape Otway and Cape Wickham, on the west coast of King Island. The Cape Otway lighthouse was finally completed in 1848, while the Cape Wickham lighthouse was not finished until 1861. Confusion between the two lights, however, meant that accidents continued.

By 1859 a number of measures had been carried out to improve the situation. There were now lighthouses at Cape Otway, Shortlands Bluff, Gellibrand Point, Cape Schanck, and Wilsons Promontory. The Admiralty issued new lighting instructions and Victoria brought out similar ones for its own waters. By 1860, new accurate charts were available for the Port Phillip Bay Heads. The lighthouse on Gabo Island near Mallacoota was one of the last to be constructed and then only after the disastrous wreck of the *Monumental City* in 1853. That year a temporary lamp went up with a permanent one coming into service in 1862. Many of these lighthouses, such as Cape Otway, are still in service. Other buildings relating to the problems of navigation in Bass Strait also survive: the telegraph station at Cape Otway; the pilots' cottages at Queenscliff; and the Time Ball Tower at Williamstown, which allowed ships in the northern part of Port Phillip Bay to regulate their chronometers.

At Melbourne, goods were originally landed directly onto the riverside mudflats. As both the volume and type of traffic in the bay grew, the ports and their facilities came under increasing pressure, until by 1847 the facilities of Melbourne and its satellites were completely inadequate. Facilities were slowly improved, but increasing traffic meant continual pressure for more. Port Phillip Bay and its entrance were notoriously difficult to navigate, too. By 1840 the harbour was becoming congested and accidents began to occur regularly. Sometimes as many as 20 vessels rode at anchor in Hobsons Bay. Intensive work in the bay and harbour resulted in a much improved situation by 1853. Pilots now boarded boats well outside the heads, tidal stations and new marker buoys were in place, and signals from the Point Lonsdale flagstaff advised on the four stages of the incoming and outgoing tides. The formation of the Harbour Trust in 1876 led to further improvements to navigation on the Yarra River.

By the late 1890s, substantial changes had occurred in shipping practices, including the development of larger ships. These tended not to berth at the smaller ports servicing intracolonial trade, although the growing intercolonial trade partly offset this. Australian ports were ill-equipped for the even larger ships of the early twentieth century despite further upgrading of port facilities such as the Victoria Doçk. The 1930s depression affected ship-building and the cargo trade but World War II stimulated improvements in cargo handling and security. This continued into the post-war years, when the Swanson and Webb docks were constructed and docking facilities were built at Williamstown for the tank farm at Altona. The 1960s saw the growth of container ships and the development of special cargo-handling machinery and storage docks.

Geelong was settled shortly after Melbourne. During the 1840s the port of Geelong exported a variety of products, including stone, leather, malt, and wool to Van Dieman's Land. A sand-bar across the harbour mouth hampered productivity until the 1850s; even so, by 1848 it was declared a free port and was exporting more than Melbourne. In the 1850s its population grew rapidly due to the gold-rush,

but like many other areas it suffered a subsequent period of stagnation in its local economy until industries such as the wool mills, tanneries, and fellmongeries developed on the Barwon. The opening of the railway to Melbourne in 1862 destroyed any chance that Geelong might have had of becoming the premier port on the Victorian coast. Industrialisation began on a larger scale in Geelong in the 1890s and early years of the 20th century.

Queenscliff was settled initially to service navigation requirements through the heads to Port Phillip Bay. Pilots operated from the area from 1839 and the lighthouse was erected at Shortlands Bluff in 1841. By the 1860s it had diversified and developed into a small fishing port and became a summer resort for the Port Phillip residents.

The early development of the west coast ports was closely linked to the whaling industry. Both Port Fairy and Portland were originally whaling centres that later became regional centres. Whalers such as the Hentys in Portland and the Griffiths at Port Fairy invested the substantial profits from whale products in land and stock. By 1840, a steady stream of agricultural products was exported from Portland. When the whaling industry crashed in the late 1840s as the whale population succumbed to over-exploitation, the initial investment in agriculture sustained the viability of the ports.

From the early 1850s they started to decline. The Portland Whaling Company was disbanded in 1859 and the pastoral and fishing industries gradually replaced whaling. Warrnambool, which had been established in 1845 as little more than a landing point on Lady Bay, primarily to service local rural industry, became more prominent. By 1861, the facilities were no longer adequate for the volume of shipping and a second jetty was built in 1874. Silting was a continual problem both here and at Portland. Portland was rejuvenated by the completion of a railway connecting it to Hamilton and Melbourne in 1878. This established communications with inland agricultural centres such as Horsham. The railway to Horsham and the Wimmera was completed in 1920, partly to relieve congestion in the Port of Melbourne. Warrnambool was linked to Melbourne by rail only in 1890.

Gippsland was first explored during the years 1839—40 and settled extensively from the north, east, and south within a few years. The east coast ports developed to service the region, and they also carried much of the Van Diemans Land trade. Port Albert was established in the early 1840s, but within 20 years was overtaken in importance by Lakes Entrance, despite problems of access through the natural entrance. Although 1870 saw the first attempts to cut a permanent entrance to the lakes, opposite Lakes Entrance, the entrance was finally breached during a storm in 1889.

With time, ports and harbours along the coast were gradually transformed to meet the demands of a growing population, the export of primary produce, and the establishment of new industries such as the offshore oil and gas industry. Entrance channels were widened and deepened; breakwaters, slipways, and dry docks were installed, and warehouses, chandlers, and shipping offices were established. Customs houses were associated with the early ports, railways were extended to piers and wharves, and huge wool stores were built at coastal centres including Geelong and Portland.

Victoria's major ports underwent a massive re-shaping in the period after World War II. By 1952 the Port of Melbourne contained 106 berths located on the Yarra banks, with pipelines installed to fuel storage tanks. Cranes and cargo-handling equipment grew correspondingly in terms of size and technology. Ongoing development of the major ports has led to the over-printing of many early structures; however, some - such as the South Wharf and wharf buildings in South Melbourne, which date to the 1880s - remain. Other coastal ports have structures that survive from most phases of their development. Many jetties, piers, and slipways remain along the coast, including a pier and slipway on the Mornington Peninsula dating to the 1850s.

CHANGING PATTERNS OF IMMIGRATION

Immigration in Victoria has come primarily from Europe, although other groups have always been represented. Unlike Van Diemans Land and New South Wales, the region never had convicts forming a large part of its labour force. Thus settlement of Melbourne differed in many respects from that of Sydney and Hobart. Free settlers created a different environment and climate of opinion. Nevertheless, tension arose in Port Phillip between those who wanted access to cheap labour and those who wanted to keep wages

high and the colony free from moral corruption.

The rapid spread of settlement and the growth of the ports at Portland, Melbourne, Geelong, and Port Albert created a strong demand for labour within a short period, primarily on the coast. On October 1st 1838 Sir George Gipps wrote to Lord Glenelg.

> 'I beg leave to recommend to Your Lordship that a Government Emigrant ship should as soon as possible be sent to Port Phillip, and that another should follow after a lapse of four or five months. A mixed Company of Emigrants, partly Mechanics and partly farm labourers, would be most acceptable, and the Mechanics should consist principally of Carpenters, Bricklayers (not Masons) and Smiths.'

Early immigration and land purchase had the assistance of such bodies as the Australian Emigration Association, who purchased land in the Port Phillip region. The first group of government immigrants arrived in 1839 via Sydney on the *Hope*. In 1839 a total of 7792 adults and 3569 children immigrated to the Port Phillip area. Usually immigrants were quickly employed and at good wages, and immigration increased rapidly. The increase in the maritime traffic and the combination of a dangerous strait and a lack of navigation aids meant that shipwrecks claimed the lives of many immigrants.

Gold was found in Victoria by the end of September 1851. This resulted in a massive exodus of available men to the goldfields leaving a labour vacuum in the coastal cities. The effects were widespread and business in the coastal towns virtually ceased temporarily. Initially, land sales fell and the price of labour and provisions rose, but soon after, the streets of Melbourne at least were filled once more by a steady stream of migrants. By 1852 gold-rush immigrants were living in a canvas town on the west side of St Kilda Road and many others camped on the Williamstown or Yarra River wharves. The 1851 census shows that Melbourne had a population of 77 345, which had risen to 538 628 ten years later. The great influx of people and the wealth generated by the gold-rush had its material expression in land acquisition. Just as whale profits had initially been re-invested in land, so gold was converted into land, both directly and indirectly. As investment took place, building and land prices in Melbourne and Geelong rose considerably.

By the mid 1850s the rush was virtually over and labour shortages in Melbourne gave way to unemployment and recession. Migrants still arrived, but 12 000 left the State in 1858, 10 000 in 1859, and 50 000 between 1860 and 1863. Assisted immigration was introduced once more in 1861 only to be phased out after 1873. Between 1860 and 1890, more than two million people emigrated to Victoria from interstate and overseas. Many of these left during the economic downturns of the 1870s and 1890s leaving a net gain in all that time of only 27 800 people.

After 1900, labour again became scarce and assisted passages were introduced. The government intended to settle migrants on the land in the north of the State, but this failed miserably, most preferring the urban environment. The outbreak of World War I brought a temporary halt to immigration. Post-war immigration had most impact on the coast and stimulated the growth of urban Melbourne.

In 1922 a rebuilding program at Station Pier was launched, enabling the Port of Melbourne to service the new, larger passenger liners. When Australia opened its doors to the huge influx of post-war refugees and displaced persons from Europe, and assisted immigrants from Great Britain, Station Pier was the point of arrival for many thousands of people. Throughout the 1950s and 1960s, they poured through the processing areas and waiting rooms at the Pier, for many their first taste of the immigration bureaucracy in Victoria.

The immigration building at Port Albert, dating from 1857, and the quarantine station at Point Nepean, first established in 1852, are tangible reminders of this aspect of Victoria's heritage. The quarantine station comprises a number of permanent buildings built between 1857 and the early 1900s. After 1957 it was used infrequently, as migrants increasingly arrived by air rather than by sea, and was finally closed in 1980.

COASTAL DEFENCES

Both the French and the Russians were believed to pose a significant threat to British interests in the Australian colonies during the nineteenth century. The perceived French threat was one factor in early attempts to settle Victoria and, although Britain and France formed an alliance in 1854, the French occupation of New Caledonia renewed British suspicions. During the 1850s, the Crimean War between Russia and Turkey and Russian

occupation of Chinese territories also alarmed the colonial government.

In 1854, as part of a general review of defences, the Secretary of State advised the Australian colonies to put their harbours in a state of defence. The first defence constructions - built shortly afterwards - consisted of earthworks, batteries, and gun emplacements around Hobsons Bay and a battery and guns at the entrance to Port Phillip Bay, at Shortlands Bluff.

Australia's first warship, the screw sloop *Victoria*, was acquired by the State government in 1856. It had an active life undertaking survey work, replenishing lighthouses, laying telegraph cables, undertaking general police duties in Port Phillip, and going to the land wars in New Zealand in 1860. The latter occurrence resulted in a technical act of piracy, as *Victoria* was not a commissioned warship in the British Navy.

Port Phillip's defences were staffed when, in January 1865, the CSS *Shenandoah* arrived at Melbourne. *Shenandoah*'s arrival caused greater controversy, especially when the Government slip was used to repair her damaged propeller-shaft and when its Captain undertook clandestine recruiting of crew. After the war, an international court awarded restitution of $3 875 000 to the United States for this breach of British neutrality.

In 1867, the Victorian government acquired HMS *Nelson*, which had been converted from a wooden triple-decked warship into a 74-gun steamship. *Nelson* arrived in Victoria in 1868 and remained in service until 1898. Relics of *Nelson*, including its figurehead and numerous guns, are to be found at the National Maritime Museum.

During this period funds were also provided towards the construction of an armour plated ship, the *Cerberus*. The *Cerberus* was used specifically to guard Port Phillip Bay, ending its days as a breakwater at Sandringham in 1926. It was one of the most technologically advanced warships of the day. The remains of the Cerberus are of world significance, being physical evidence of the transformation of capital ships from the three-decked ship (such as HMS *Victory*) into the battleship era of the early twentieth century.

From the 1870s, a number of 'scares' including Russian offensives against Turkey in 1877, the European crisis of 1882, and Russian threats to



Defence facilities Point Nepean.

Afghanistan in 1885 - stimulated the construction of defences. Further modifications to the Port Phillip Bay installations were made during these years and the first line of defence was centred on the heads, with the old Hobsons Bay defences being of secondary importance.

By the end of the 1880s a further phase of building had resulted in the installation of modern hydro-pneumatic guns at Queenscliff, Point Nepean, and South Channel forts as well as the development of fixed torpedo tubes, electric contact mines, and searchlight installations. Victoria also acquired several small torpedo boats.

After federation, defence became the responsibility of the Commonwealth. During World War I, coast watchers were deployed all along the coast. In both world wars, the garrison at Point Nepean was increased and coastal waters were mined. During World War II, air warfare became more important. Air bases, such as the one at Mallacoota, were established and anti-aircraft defences were constructed at Point Nepean. Wilsons Promontory was closed to visitors and used as a training centre for commandos, while aircraft used the shipwrecks off the Prom as practice targets.

Many remnants of Victoria's defences survive. The extensive fortifications at Point Nepean, Queenscliff, and South Channel Island are open for inspection, while the Victorian Navy is represented by the remains of *Cerberus* at Half Moon Bay and *Childers* and the *Countess of Hopetown* at Swan Island; the *Lonsdale* is buried at the rear of the Queenscliff Maritime Museum. Smaller fortifications at Port Fairy, Warrnambool, and Portland have also been restored.

COASTAL AND MARITIME INDUSTRIES

In general, little evidence of early industry survives close to the coast. Some industries were relatively short-lived and seem to have left few traces, while others, such as fishing, have continued to the present day. Modern development has also undoubtedly obliterated early sites.

Sealing and whaling were the earliest industries in Victoria. Sealing began on Cape Barren Island in 1798 and by 1800 there were several sealing ships in Bass Strait. Sealing craft were small and gangs were left on the islands for many months. To ameliorate the harsh conditions, they built crude huts, planted vegetables, and took Aboriginal women from the coasts of Van Diemans Land. Sealing began later on the western side of Bass Strait, when seal colonies in the Bass Strait Islands began to show signs of over-exploitation, but on Lady Julia Percy Island it could have commenced as early as 1811. Sealers operated on the Victorian coast at Port Fairy, Portland, Lady Julia Percy Island, Phillip Island, Wilsons Promontory, and Gabo Island.

By 1825 the industry was in decline, although some seal-hunting continued until the 1850s, and whaling became commercially important. Victorian whaling centres included Portland, Port Fairy, Wilsons Promontory, and Mallacoota. The profits made a significant contribution to the exports of the early colony. But, like sealing before it, whaling on the Victorian coast was doomed by over-exploitation, and had virtually ceased by the 1850s.

Very little evidence of whaling and sealing survives in Victoria. Only four sites are known - two on Lady Julia Percy Island and two at Sealers Cove.



A hard hat diver.

Bark cutting was another early industry and sealers often cut bark as an extra source of income. The tanning industry provided a large market for wattle-bark in Europe and the colonies. Export of bark from Western Port began in 1833 and continued throughout the century.

The lime-burning industry developed as the rapid growth of the settlements and ports created a continuous demand for building materials. Initially, demand was met by burning sea shells, both from natural shell-beds and from Aboriginal middens, but deposits of lime were quickly located and mined in Port Phillip Bay.

By the 1860s, small communities of lime-burners, woodcutters, and their families occupied the Mornington Peninsula at Sorrento, Tootgarook, and Schnapper Point. The isolated settlement at Walkerville, to exploit the Waratah Bay limestone, was established later and was entirely supplied by sea; it operated large kilns and employed at least 80 men. Substantial structures survive there. Other examples of early lime kilns are Sullivans Kiln and the Fossil Beach cement works on the Mornington Peninsula, and at Limeburners Point near Geelong.

Shipbuilding has never been a major industry in Victoria. British-built vessels dominated international shipping, but a small local shipbuilding industry developed in several coastal ports, primarily to service local trade, fishing, and recreation. The first steamship built in Melbourne, in 1841, was the P.S. *Fairy Queen*, while the first screw ship built in Australia was the S.S. *City of Melbourne*, built in Melbourne in 1851. During the 1860s, several engineering works associated with the shipbuilding industry were established in Melbourne and dry dock facilities were improved. The dockyard was renovated in 1913 and became a naval dockyard in 1942. It has since built 20 ships for the navy and launched 50 ships altogether, the largest being 10 000 tonnes.

Timber production built up around some coastal areas during the nineteenth century. Wilsons Promontory was an important source of timber for the goldmining industry in the Gippsland region during the 1850s. Small-scale timber-cutting was also important in the establishment of settlements such as Apollo Bay along the Otway coast.

Commercial fishing

Although not large by world standards, Victoria's fishing industry has played an important role in the State's development. As a decentralised industry, fishing is an essential component of the economy of many of our coastal towns. As the industry grew, strategic centres along the coast responded with the development of wharves, jetties, sheds, breakwaters, iceworks, drying racks, and fish-processing plants. Marine animals in south-eastern Australia were the first of our natural resources to be exploited by colonists and fishing, along with whaling and sealing, was among the first industries to be established.

The first European visitors to the southern shores of Victoria commented on the abundance of oysters and other shellfish to be found in the bays. When Flinders sailed into Port Phillip in the *Investigator* in 1802, he noted that 'quantities of fine oysters were lying upon the beaches between high and low water marks and appeared to have been washed up by the surf; circumstances which I do not recollect to have observed in any other part of the country'.

In 1801 Lieutenant John Murray in the *Lady Nelson* visited Western Port, and fish and shellfish featured in the crew's diet. Large quantities of oysters, mussels, and other shellfish were gathered at Elizabeth Cove and this caused Murray to write that 'a company of 6 to 8 men would not run any risk or hazard of being starved here for several months due to the vast quantity of shellfish to be found at low water'.

It is interesting to note that oysters were exploited for commercial purposes from the earliest days of settlement. Western Port at one stage supported a fleet of 21 boats engaged in oyster-dredging and Port Albert shipped local oysters to the Melbourne market as early as 1843.

The first significant attempt by Europeans to fish for food in Victoria occurred in 1803. In the early 1800s encouraging reports of the abundance of sea mammals of south-eastern Australia had generated considerable interest in Britain, France, and America. In 1803, fear of a French claim to the lands of Port Phillip led to the Collins settlement at Sullivan Bay at Sorrento. The possibility of establishing a fishing industry in the area was also in the minds of the proponents of the settlement. Five of the convicts in the Collins party were reputed to be fishermen and two of the free settlers had emigrated with the express purpose of developing the industry. Although the settlers were able to eke out their rations with fish, they were poorly equipped with gear and were soon restricted to one hauling net and some lines and hooks. It was clear that with the provision of sufficient fishing gear and better expertise, the settlers should have been able to meet much of their food requirements from the sea.

After the abandonment of the Sorrento settlement little activity occurred around the Victorian coast apart from whaling and occasional visits from sealers and bark-strippers from Launceston.

With the settlement of Melbourne, fishing commenced in order to provide the colony with a varied diet. The Yarra River abounded with bream, perch, mullet, and blackfish and angling became a favourite pastime. Many of the early settlers used nets and often the netting operation was a social occasion as well as a means of supplementing the diet. Liardet, the founder of Port Melbourne was reported to have had a large hauling net and when he intended to use it he would go out with his guitar and play a particular tune, which was a call for all the neighbours to come and see the net drawn and the great variety of fish caught.

Fish-marketing in the early days relied mostly on fish-hawkers who carted the catch around Melbourne in barrows or in shoulder baskets. In 1841 the Western Market opened for trading and its south-east part was reserved for the sale of meat, poultry, and fish. From all accounts it was a most unsanitary place and was described by the press of the day as, 'a collection of temporary hovels'.

The fishing industry in Victoria developed close to settled areas where rail transport or regular shipping services to Melbourne were available. The bulk of the catch was, and still is, sent to Melbourne.

Discovery of gold in 1851 resulted in the addition of 290 000 migrants in the next 10 years, which naturally led to a greatly increased demand for food. This gave a boost to the infant fishing industry as fishermen based close to Melbourne moved further afield to localities at the southern end of Port Phillip Bay and at Western Port.

In the early 1860s Queenscliff came into prominence as a fishing port as fishers moved

in from other areas, with migrants swelling their numbers. By 1865 the Geelong Advertiser was able to report that 130 fishers of various nationalities were working from that port. Some idea of the extent of the early fishing from Queenscliff can be gained by evidence given to the 1892 Parliamentary Inquiry into the fishing industry, which indicated that the region sent a weekly average of 1000 to 1500 baskets of fish, each weighing 56 lb (25.4 kg), to Melbourne, Geelong, and Ballarat. Queenscliff was also a significant port for the early rock lobster fishery, with local boats working the grounds around and adjacent to Port Phillip Heads.

Barracouta-fishing commenced very early in the settlement of Victoria and Queenscliff and played an important part in the development of that fishery. At the height of the barracouta season Queenscliff fishers would sail out of the heads at 4 a.m. and travel up to 16 miles off-shore to fish, returning to the port the same day in time to send the catch to Melbourne on the 5 p.m. train.

During 1969/70 some 2500 tonnes of barracouta was landed in Victoria and this represented 26% of the total Victorian landings of finned fish. Since that time the barracouta fishery has declined to a point where it is no longer significant in the Victorian catch. In 1983/84 only 55 tonnes were landed in this State. Despite its importance in the early days of the fishing industry, the species lost its place in the market to shark and the more desirable varieties of trawl fish that became available after World War II.

Commercial fishing in the Gippsland Lakes and the other eastern inlets became a significant industry after a rail link was established between Sale and Oakleigh in 1878. In June 1878 the Gippsland paper, the Mercury, reported: 'The opening of the railway has extended fishing operations in the Gippsland Lakes to an extent never contemplated. The steamer *Tangil* on its last two trips conveyed no fewer than 663 baskets of fish to the Latrobe wharf which equals 15 tons of fish for the two days'. By 1892, 100 boats and 200 men fished the Gippsland Lakes.

Fishing had little commercial importance in the Port Albert area until the Gippsland Steam Navigation Company commenced operating regular steamship services to Melbourne. As the Gippsland Guardian of 7 February 1862 reported, regular quick communication by steamer enabled Port Albert to supply fresh fish to the metropolitan market. In 1866 2- or 3-ton hauls were common, half the quantity being forwarded to Melbourne packed in wicker baskets and the remainder kept and dried - often by Chinese. By the late 1800s Port Franklin, at that time called Bowen, supported a large number of fishers who worked mainly in the area known as Shallow Inlet.

Fishing in the Port Fairy area received a boost when a rail link between Melbourne and Port Fairy was established in 1889. Portland also supported a sizeable fishing fleet and was an important port in the development of the rock lobster fishery, being one of the main ports in the early 1900s with Queenscliff and Port Fairy. Stony Point later came into prominence as a rock lobster port, as boats fishing Tasmanian grounds regularly unloaded there, taking advantage of the rail link with Melbourne.

The infant fishing industry benefited greatly from advances in technology with the development of refrigeration and the invention of the internal combustion engine, especially the perfection of the diesel in the late 1930s and '40s.

Most of Victoria's high-value, high-volume fisheries are of comparatively recent origin. The old established net fisheries that sustained the industry in the 1880's and early 1900s were located in the bays and estuaries and ocean beaches around the coast. Utilisation of fish resources in ocean waters was restricted to the inshore grounds, where species such as barracouta and rock lobster could be fished from boats under sail and with the limited fishing gear available at that time. The shark fishery, for example, which became a major provider of product to the cooked fish and chip trade, only developed in the 1930s. In 1930 only 1 ton of shark was marketed in Victoria; however, by 1939 the shark catch had risen to 500 tons.

The Victorian-based Danish seine fishery can trace its origins to 1947, when there was mass movement of trawlers from New South Wales ports to Lakes Entrance. The trawl fishery comprises Danish seine vessels and inshore and off-shore trawlers, and is now a major provider of fish to the Melbourne and Sydney markets.

Until 1963 the Australian scallop fishery had been based in Tasmania, where fishing has been carried out in the D'Entrecasteaux Channel since early this century. In 1963, scallop-fishing commenced in Port Phillip Bay

and in a few short years developed to a stage where it involved more than 200 boats. Since that time the Bay scallop fishery has experienced a series of production peaks and troughs. The uncertainty of catch size, combined with a policy of licence limitation, has resulted in a significant decline in the number of vessels licensed to dredge for scallops in the Bay.

In the early 1970s productive scallop-beds were discovered in ocean waters near Lakes Entrance and further exploratory fishing revealed viable scallop-grounds in many areas of eastern Bass Strait. The history of the scallop fishery in both Port Phillip Bay and Bass Strait reflects the volatile nature of the fishery, with production highs and lows.

The abalone fishery is also of recent origin. Early records indicate that the Chinese gathered abalone, known to the locals as mutton fish, mainly for their own use. This did not find favour with the authorities of that time, who introduced a regulation prohibiting the collection of abalone. The modern abalone industry commenced in the early 1960s and has developed to a stage where it is now Victoria's most valuable fishery. Abalone are gathered by divers, who harvest inshore reefs from Mallacoota in the east to Portland in the west.

Other industries

Several other sub-themes of coastal and marine industries are evident along the coast.

Even from early settlement, the coast has been important for tourism and recreation. Tourism has long been important for the economy of many coastal centres. Queenscliff, for example, had became an important holiday centre by 1855 and was serviced by a number of paddle steamers that called at other bayside towns and settlements. By the late 1880s increasing prosperity meant tourism became more fashionable and popular holiday destinations grew close to Melbourne - around the bay. These developments have continued into this century.

The material culture of coastal tourism is as varied as the many attractions of the coast, and the changing pastimes of tourists. On many popular beaches, particularly in Port Phillip Bay, the foreshores were extensively developed. Formal landscaping features were introduced, including promenades and retaining walls, steps and seating areas, pavilions, kiosks, and seaside gardens. The increasing popularity of sea bathing, surfing, surf lifesaving, and sailing resulted in the establishment of numerous clubrooms, changing rooms, life-boat sheds, seaside playgrounds, and foreshore camping areas. Sea baths, bathing boxes, and the infrastructure associated with tourist ferries and bay steamers are all reminders of this enduring attraction. Along the open coast are other features, such as the Great Ocean Road, which not only linked coastal towns but was also promoted for its tourism potential. This promotion has endured and has become part of the tourism identity of coastal towns such as Lorne.

Industrial sites demonstrating early 20th century salt harvesting, are the Cheetham salt works and those at Laverton, Point Wilson and French Island.

The offshore oil and gas industry has been a recent, post-1960s, development in Victoria. The development of off-shore drilling technology to exploit oil and gas in Bass Strait has made a substantial contribution to Australia's energy needs and is described in Chapter 8.

ISSUES

* Protection of sites and landscapes of cultural significance and the promotion and use of cultural resources.

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6. LANDSCAPE AND VISUAL RESOURCES

Owing to a lack of information, this chapter does not provide a description or assessment of the landscape and visual resources of the Victorian coast and off-shore areas. Rather, it addresses the importance of conducting such a landscape assessment. It also describes past studies, and possible methodologies or procedures for future assessment of these resources as they relate to the coast.

The nature of landscape and visual resources

Its very diverse sights and sounds make the coast a source of pleasure, relaxation and inspiration. It includes rocky headlands with pounding surf, the call of birds, and distant vistas of long sandy beaches to the quiet waters of estuaries, where in the early morning glass-like surfaces reflect surrounding views. Changing patterns of light from sunrise to sunset and the moods produced by approaching storm clouds and then beating rain provide striking contrasts.

The coast is also an underwater world. For many the first visit by snorkel or scuba is a source of amazement as rich three-dimensional patterns of colour, forms, and textures unfold. The underwater scenery of the Wilsons Promontory coast with its diverse bottom types, flora and fauna and shipwrecks is of note and documented (O'Toole and Turner, 1990).

Our total visual environment includes both above-and below-water landscapes. The landscape is a physical and visual resource, just as soil, water, and vegetation are other important land resources, and all resources should be taken into account in determining the use and management of Victoria's coastline.

This coastline has a diversity resulting from unique combinations of landform, waterform, vegetation, and cultural components in the various settings. Each combination gives rise to the local landscape character or 'sense of place', which is important in determining individuals' decisions regarding where they live and recreate, how they relate to the environment, and even how they guide themselves through the landscape.

The coastal landscape is a product of the forces of Nature (winds, currents, tides, and waves) and of human-induced change. Its visual sensitivity derives partly from its natural characteristics - coastal terrestrial vegetation often exhibits low visual absorption capabilities (i.e., its sparseness, fragility, and low height give it little ability to screen or absorb any introduced change) - and partly because of the large numbers of visitors and their expectations of what they will see and experience.

The diversity, dynamism, and sensitivity of the coastal landscape do not make it an easy resource to plan for and manage, but highlight the need for consideration of landscape and visual resources in determining the use of our marine and coastal areas.



Dramatic coastal scenery at Wilsons Promontory

Landscape management

Coastal landscape management is important because all land uses and land management activities occur within the context of a particular landscape setting and have ramifications (including visual ones) of varying degrees. For example, tourist developments, roading, housing subdivision, construction of communication and other facilities, forestry, and mining uses or activities all have impacts.

Sensitive landscape management should determine whether significant land- or sea-use changes and management actions are acceptable and, if so, how they can be integrated within appropriate design constraints. Careful planning is required to integrate them without creating scars, visual intrusions, or discordant forms, lines, colours, and textures and without

damaging ecological systems. Thorough planning and careful management of proposals can often minimise the need for subsequent extensive and costly measures to reduce unexpected impacts. For this reason, landscape planning and assessment should be incorporated in the early stages of major projects or operations.

In order to integrate human-induced change into the coastal landscape in a responsible manner it is necessary to understand the resource and the nature of the changes being introduced. Landscape planning seeks to:

* identify, describe, and systematically analyse the landscape
* evaluate the significance of the resource (in terms of public perceptions, rarity, etc.) and proposals for change
* make land-or sea-use and management decisions about acceptable levels of change to visual characteristics, quality, and diversity of the landscape, its features, and visual resources (this should lead to a broad strategy plan for the area)
* sensitively integrate the change using appropriate techniques, which may include community awareness, information, plans, recommendations, and detailed visual guidelines.

Appropriate techniques will vary from one section of the coast to another, ensuring that significant bio-physical features and local landscape character or 'sense of place' are maintained or enhanced.

Because of the difficulty of rehabilitating many landscape resources, and the possible loss of unique landscape settings for all time, landscape analysis and effective planning mechanisms and guidelines should be given a much higher priority than at present.

Landscape planning

The approach adopted by the Council in its past regionally based studies along the coast has been that landscape has rarely been separated as a concept or treated in its own right. Instead it has been an integral part of many recommendations. When making these recommendations, Council has not followed a particular methodology for considering this resource. Accordingly, landscape assessment has varied between regional studies. As these have focused on the terrestrial component, submarine landscapes have seldom been considered.



Still evening sea and Howe Range - Croajingolong National Park.

Landscape assessment has been undertaken in Victoria at least since the late 1970s and several methodologies have been developed and applied in particular terrestrial landscapes. While approaches may differ, this is not unique to landscape assessment and should not hinder the adoption of a suitable methodology. The great value in most landscape methodologies is that they offer a framework to handle a difficult and apparently uncertain issue, and they are repeatable by others and transferable in site and application. However, no method has been identified that has been applied to submarine landscapes.

A systematic assessment of coastal and marine landscapes in Victoria is needed, and the problem relates to resourcing rather than a failure to recognise its importance. In fact, the importance of visual resources is emphasised in numerous pieces of State and Commonwealth legislation and in established policies and strategies.

LANDSCAPE METHODOLOGIES

This section briefly describes a number of approaches that have been adopted in the past for assessing and managing sub-aerial coastal landscape resources in Victoria. It is not comprehensive, but provides a basis for a possible scenic assessment.

Council's scenic coast

As a result of its regionally based studies, Council has previously recommended, a category 'scenic coast'. Council has derived its 'scenic coast' recommendations primarily from natural attributes, which may be supplemented or enhanced by features such as

Box 6.1 Coastline - Landscape Character Type

The 'coastline' landscape character type comprises a zone of varying width, including the shore, and extends to the landward limit of marine influences. It includes all of Wilsons Promontory, the numerous off-shore islands along the coast, and the major bays and islands therein.

Its landward border conforms with the occurrence of vegetation types that can withstand the effects of winds carrying salt, or with other distinctive features such as sand dunes or lagoons. From the inland border, it spreads seaward over cliffs or sand dunes, (or occasionally, in bays and inlets), over tidal mudflats. In addition, the zone from the breaker line to the shore is regarded as visually significant.

The character type is cut by numerous streams that originate inland and flow to the sea. Parts of the coastal strip, such as the section bordering the Otways, rise abruptly to mountains. In other sections marine terraces and rolling plains extend for long distances inland, where the transition to the adjacent landscape character type is much more diffuse.

Of prime visual importance throughout this landscape is the land-sea contrast, its openness, and its consequent vulnerability to negative visual impacts. A single incompatible structure, for example, can degrade a view over a great distance, just as a relevant feature such as a lighthouse can give a coastal vista a focus and distinctiveness it may otherwise lack. Fog and mist, and their ephemeral ability to enclose and distort the landscape, are frequently a significant feature of large sections of the coastal strip.

While all landscapes have some value and importance, some have more than others. Descriptive criteria called frames of reference define a range of scenic-quality components within a particular landscape character type, making three classes of relative scenic quality high, moderate and low. Those for the coast are described below, and in the table.

It is assumed that scenic quality increases with greater degrees of:

* uniqueness in rock outcropping, water, sub-alpine heathlands, and other natural features
* naturalness and lesser degrees of cultural alteration
* relative topographic relief and ruggedness
* vegetative diversity and general landscape variety
* vegetative diversity and green-crop patchwork effects in agricultural landscapes
* vegetative mixture and edge diversity in coniferous plantations

High scenic quality	Moderate scenic quality	Low scenic quality
Landforms		
• Irregular coast edges with rocky islands, rock stacks, steep cliffs, and sandy beaches • Hills, ridges, and peaks of distinctive form, which become focal points • Heavily dissected steep slopes and/or abruptly truncated ridges • Distinctive gorges or deep valleys with vertical or near-vertical walls and/or unusual configuration and colour	• Regular coast edges with little contrast in form and colour • Rounded hills, ridges, and peaks that are not visually dominant, but surrounded by more landforms of similar type • Broad slopes that may be steep but stable, broad valleys that are not dramatically defined by adjacent landforms	• Expanses of indistinctly dissected landform
Vegetation		
• Strongly defined patterns of such combination as eucalypt forest, scattered conifers, dune vegetation, tea-tree scrub, and/or barren rock • Unusual displays of seasonal colour • Wind-shaped, gnarled, or dwarfed vegetation that may create unusual form, colour, or texture in comparison with surrounding vegetation	• Predominantly forest, woodland or scrub cover, combined with natural openings and/or streamside vegetation in patterns that offer some visual relief • Some contrast caused by seasonal colour	• Extensive areas of similar vegetation such as tea-tree or dune grasses, and very limited variation in texture and colour
Waterforms (only those waterforms visible on aerial photographs of approximately 1:40,00 scale are considered)		
• Unusual ocean shoreline and motion characteristics • Fresh-water flow characteristics such as waterfalls, cascades, rapids, and/or still pools with reflecting qualities	• Common ocean, shoreline character, and motion characteristics	• No fresh-water present or with only intermittent flows

Source: Leonard and Hammond, 1984



San Remo to Kilcunda - part of Victoria's spectacular shoreline landscape.

lighthouses or pleasant rural landscape. Sections of the coast recommended as scenic coast are: Warrnambool to Lorne; Lorne to Point Roadknight; Point Nepean to West Head (Flinders); Griffith Point (San Remo) to Black Head (Kilcunda); Cape Paterson to Entrance Point; Lake Corringle to Pearl Point; Tamboon Inlet to Mallacoota Inlet; and Lake Barracoota to Cape Howe. However, identification of this category has lacked the benefit of systematic assessment of the coast.

Landscape character types of Victoria

The former Forests Commission Victoria undertook a study of the State's landscape character types and their scenic quality. The Commission identified nine such broad-scale areas of land with common distinguishing visual characteristics (Leonard and Hammond 1984). This report describes the coast in various geographic sections according to distinguishing features largely associated with geology, but also covering climate, vegetation, and land use. Frames of reference - associated with landforms, waterforms, and vegetation - are provided to distinguish high, moderate, or low scenic quality in coastal landscapes, (see the box). They have been established on the basis that the greater the degree of naturalness the greater the scenic quality will be, which may not always be the case. This approach is broad-scale, but could be used to define sub-units of coastal landscape character and to measure scenic quality.

Visual management system mapping

The former Department of Conservation Forests and Lands (DCFL) undertook extensive visual management system mapping for public land areas along the coast. The maps cover about 50% of the coastline, but are not complete. The system (VMS), developed by the former Forests Commission Victoria, established a method to describe and inventory the physical landscape and assess the view. It identifies landscape management zones of relative management concern for the landscape and visual resources. Visual quality objectives, written for each landscape management zone, describe the minimum acceptable standard or extent of visual change to the landscape. This approach, originally developed to apply to forest landscapes, has some limitations regarding the measurement of public sensitivity of the landscape resource.

In the 1980s, the Landscape Management Section, DCFL, developed a proposal to undertake a coastal visual resource assessment from Point Lonsdale to Princeton. Its purpose was to systematically identify, describe and assess the visual resources of a section of

Victoria's coastline. The proposal drew on the VMS methodology and identified new components, but was not implemented.

In the late 1980s, the DCFL, Landscape and Architectural Services, and the Ministry for Planning and Environment produced three brochures as part of a planning and managing series. This series focuses on some of the specific guidelines for protecting the coastal landscape without addressing the assessment and evaluation of the resource.

SCENIC ASSESSMENT STUDY OF VICTORIA'S COAST

The VMS - the most highly developed and broadly applied of the methodologies or approaches outlined above - has considerable scope for review and adaptation to the requirements of scenic assessment and the development of management guidelines for the Victorian coast, as proposed by the Landscape Management Section, above. Conducting such a study offers several advantages.

* A methodology for scenic assessment and for the development of management guidelines specific to the Victorian coast could be developed.
* A study by one individual or group of qualified professionals across the entire coastline would have the advantages of consistency and timeliness.
* The Council would have an assessment and guidelines that would fill a gap in its resource inventory and contribute to its recommendations.

Important components of the methodology would include: the delineation of sub-character types within the coastline landscape; public-perception testing to establish relevant frames of reference for the evaluation of scenic quality; and validation of the results via aerial observation along the coast and the recording of features.

ISSUES

* the development and use of an appropriate coastal landscape assessment methodology
* the need to conduct systematic studies

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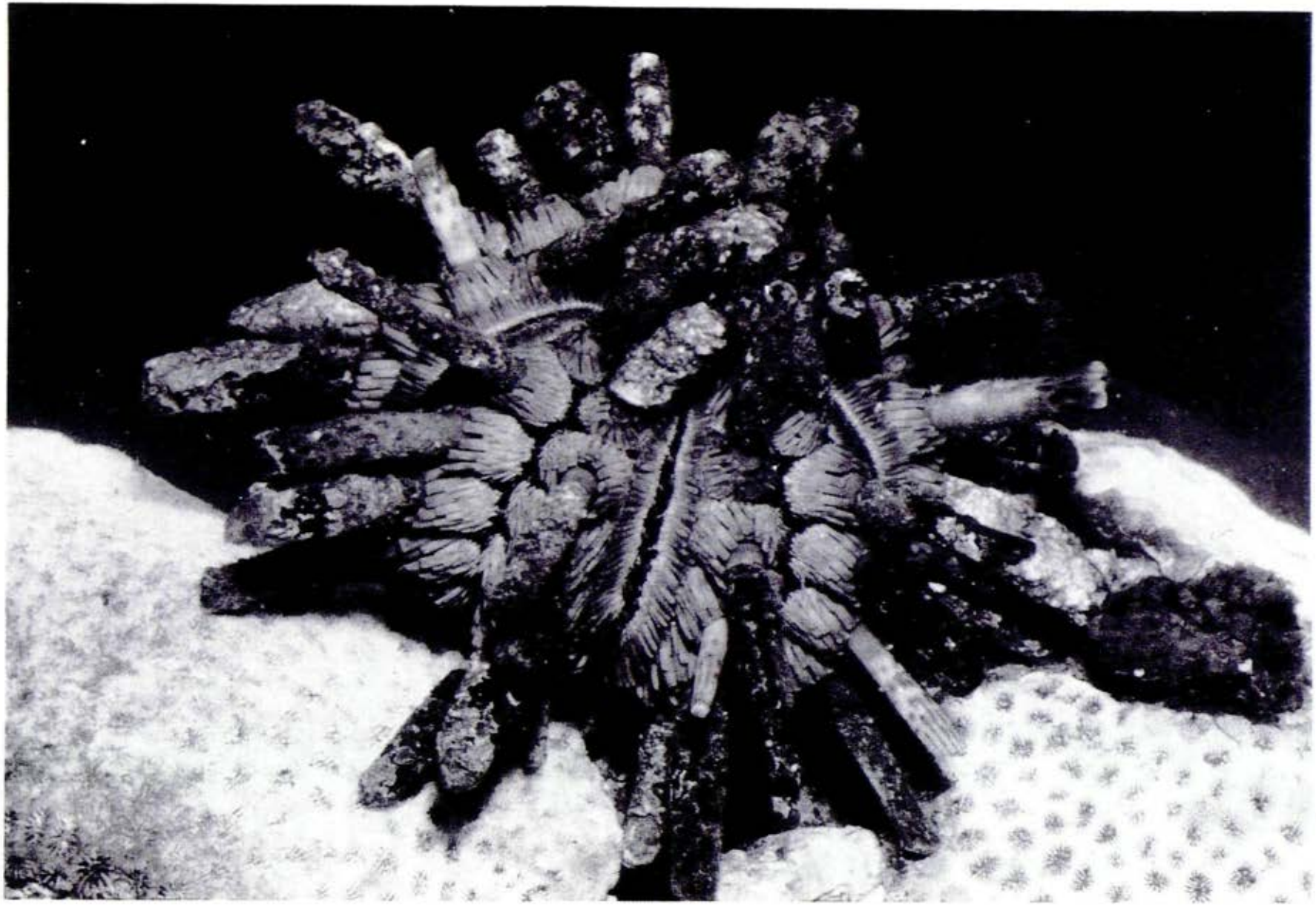
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Slate pencil urchin.



PART III

USES - CURRENT AND POTENTIAL

7. MARINE AND ESTUARINE FISH RESOURCES

More than 500 fish species and hundreds of crustaceans, molluscs, and other life forms are found along the Victorian coast. Marine and estuarine living resources support substantial commercial and recreational fishing and bait-fishing. Subsistence fishing for food and collection of live specimens for aquariums also take place.

Average consumption of fish products in Australia is estimated to be 17.3 kg per person per year (liveweight equivalent) with 6.7% of all weekday meals and 5.2% of weekend meals containing fish product (Australian Fisheries Service 1991; Kitson 1992).

The catching sector of the Victorian commercial fishing industry directly employs 1890 licensed fishers (master fishermen and crew) on a fleet of about 1004 Victorian registered fishing vessels. Some 64 persons are also licensed to take bait. In addition to State fishing licences and entitlements, the fleet carries a number of Commonwealth licence endorsements in the South East Trawl (SET), shark, and Bass Strait scallop fisheries.

The fleet is diverse in character and ranges in size from small open inshore vessels of 4 m to large multi-million dollar ocean-going vessels up to 45 m. The table below gives an indication of the fleet composition (information supplied by the Marine Board of Victoria relates to 818 boats registered in 1992 for survey by the Board).

Length (m)	Number of vessels
0 - 5	80
5 - 10	424
10 - 15	165
15 - 20	128
20 - 25	15
>25	6

Recreational fishing involves an estimated 28% (over 1.2 million) of Victorians each year, with about half fishing mainly in marine and/or estuarine waters. Port Phillip Bay is the most heavily fished salt-water area; more than one-quarter of all Victorian anglers fish there at some time during the year (Morgan 1987). Anglers mainly seek snapper, whiting, bream, Australian salmon and flathead. Recreational fishing also includes bait collection. The subject is further discussed in Chapter 9.

'Subsistence' fishing - a term with a range of meanings - often refers to fishing practised as part of a traditional lifestyle, most commonly by indigenous peoples. In these circumstances, the taking of particular marine species or the use of particular fishing techniques may have spanned hundreds or thousands of years. Aspects of Aboriginal fishing practices, known from archaeological or ethnographic records, are described later in this chapter and in Chapter 5.

The social dimension of the definition, however, becomes blurred when the fishers now live in areas or use waters with which they have no direct traditional association. With their diverse cultural base, migrants to Australia over the past 200 years brought expectations of harvesting a wide range of fish and shellfish. Some of these expectations led to growth in the range of commercially available species. In some circumstances, such as lack of a particular species on the commercial market or for social reasons, people may still wish to harvest select species directly - a form of subsistence fishing. There is also anecdotal evidence that during periods of economic hardship people will fish to provide themselves with a source of protein, which could be deemed another form.

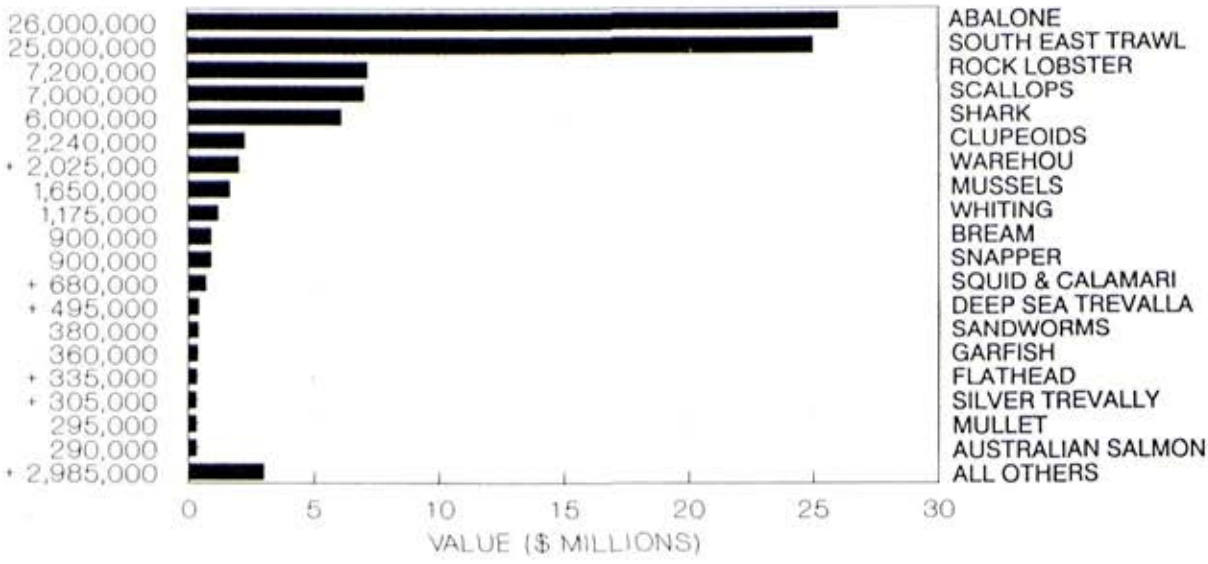
While the impacts of such harvesting of shellfish along the shoreline have been documented, descriptions of subsistence fishing in Victoria are, as for much of the rest of Australia, fragmentary and poorly documented.

COMMERCIAL MARKET VALUE

Victorian marine and coastal commercial fish production has a landed (first-sale) value around $86 million.

Processor and distributor networks, which encompass over 1000 Victorian small businesses in the wholesale, retail, and export sectors, add further value. These businesses also add value to fish bought into Victoria from other States. No detailed economic study has ever been made of Victorian fisheries-related businesses operating in areas other than the primary catching sector.

Figure 7.1: Victorian Marine and Coastal Commercial Fishery Values (first sale price) - 1990/1



Notes:
1. Fresh-water species excluded.
2. The SET aggregated value applies to a large number of species landed in Victoria from a Commonwealth-managed fishery. Further figures for the SET fishery are included later in the report.
3. The scallop value is not based on actual landings for 1990/91 which were abnormally low, but is derived from the average of 25 years of landings valued at current prices paid to fishers.
4. Species marked with an asterisk are valued on the basis of reported landings excluding the SET fishery. Full valuation of these fisheries should also take into account the SET component.

It should be noted that different techniques have been used to provide dollar values for the economic activity associated with commercial and recreational fishing. There is therefore no common basis for their comparison.

Jurisdiction

Since the 1983 Off-shore Constitutional Settlement (OCS) agreements, management of the new Australian Fishing Zone has been shared between the States and the Commonwealth. Fish resources are now managed under four possible management categories.

Status quo management. In fisheries where no OCS management arrangements have been agreed, this provides for State control over fishing in territorial waters (up to 3 nautical miles from the shore) and Commonwealth control over fishing in proclaimed waters (3 to 200 nautical miles from the shore).

State management. Arrangements have been made for some fisheries in Commonwealth-proclaimed waters to be managed under the laws of the adjacent State.

Commonwealth management. Where a fishery adjoins more than one State, it can, by agreement, be managed by the Commonwealth.

Joint authority management. The Commonwealth and one or more States can form a single entity that manages a fishery or fisheries under a single law, either Commonwealth or State.

Major fisheries in waters off Victoria that fall into one of the above categories include the abalone, rock lobster, Bass Strait scallop, south-east trawl and southern shark fisheries.

Abalone and Rock Lobster fisheries are managed as State fisheries, by agreement between the Commonwealth and States. Victoria manages waters contiguous with its territorial waters. East of 143^{O} 40', control extends as far as 39^{O} 12' South. To the west Victorian control extends to 40^{O} South and includes the entire continental shelf area. The seaward boundary between Victoria and South Australia has recently been redefined by the Surveyor-General as 140^{O} 57'52.4891" East (formerly 141^{O} East). Figure 7.1 shows the abalone and rock lobster zones managed by Victoria.

Bass Strait scallops come under Victorian management to 20 nautical miles from the coastline (except around Wilsons Promontory, where Tasmanian waters are closer than 20 nautical miles from the Victorian shore).

South East Trawl and southern shark fisheries are 'status quo' ones in which a large number of Victorian vessels operate, with Commonwealth management, outside 3 nautical miles from the shore.

Legislation and regulations

The Victorian legislation and regulations related to fisheries management are diverse. The principle legislation is the *Fisheries Act* 1968. This Act and Regulations made under it together provide the legal basis for all aspects of fisheries management in Victoria. In 1992, the then Minister recognised the need for a review and updating of the Act as a priority to be completed by 1995.

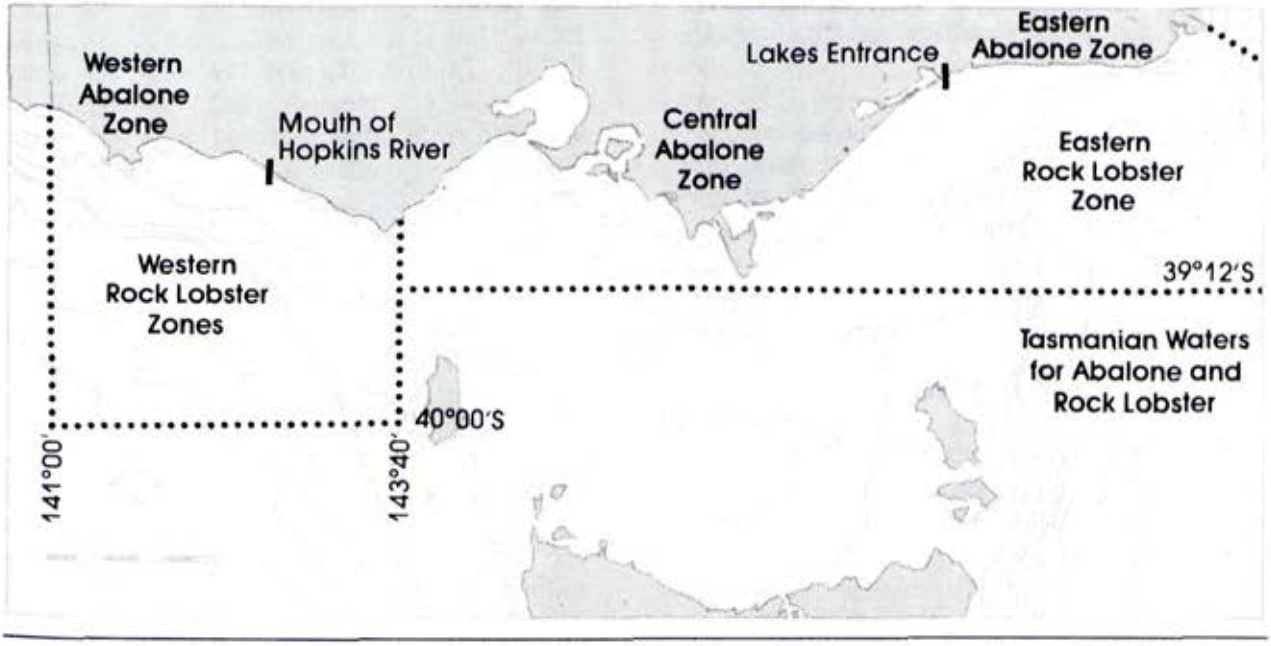
Following a recent review of the Fishing (General) Regulations 1981 and the Commercial Fishing Licences Regulations 1982, the legislation was rationalised and replaced by the Fisheries (Commercial) Regulations 1992, Fisheries (Fees) Regulations 1992, Fisheries (Eel) Regulations 1992 and the Fisheries (Recreational) Regulations 1992.

Fisheries Act 1968: Under the Act, responsibility for Victorian fisheries management resides with the Minister for Conservation and Natural Resources who delegates his authority through the Secretary, Department of Conservation and Natural Resources and the Director of Fisheries.

The Act enables:

* establishment of agencies through which fisheries management activities may be conducted (e.g., Commercial Fisheries Licensing Panel and a Licensing Appeals Tribunal)
* arrangements to be made for Commonwealth—State fisheries management agreements
* issue of commercial and amateur fishing licences, aquaculture permits, and special permits for experimental or research fishing
* setting of licence fees or penalties for infringements of regulations made under the Act
* management of noxious fish species and fish diseases
* establishment and management of marine protected areas (marine reserves) for conservation, scientific, educational, or recreational purposes
* management and control of fisheries by regulations including
  - setting of minimum legal sizes and/or bag limits for various fish species
  - restriction or prohibition of certain types of fishing equipment
  - proclamation of seasonal or permanent closures to fishing in certain areas
  - prohibition of the taking of particular species
  - limited licence entry and quota management
* establishment a Fisheries Management Committee (FMC) to advise the Minister on commercial fishery licensing and management and on any other matter referred to it by the Minister or the Secretary.

Figure 7.2: Victorian Abalone and Rock Lobster Zones



Related legislation - the *National Parks Act* 1975, *Flora and Fauna Guarantee Act* 1988 and *Environment Protection Act* 1970.

Fisheries Notices Under the *Fisheries Act* 1968 the Minister may, in consultation with the Victorian Fishing Industry Federation (the peak industry body), manage commercial fishing activities by issue of Fisheries Notices for a period of up to 3 months. Fisheries Notice provisions were introduced to enable effective management of short-term fisheries issues that cannot be addressed quickly enough through the normal regulatory process. Notices have been used in recent times to manage the scallop, shark, and wild mussel fisheries.

Licensing All commercial fishers in Victorian are licensed to take fish for sale and most commercial fisheries have limited entry management rules. Recreational or amateur fishers (other than those in exempt categories) require an Amateur Fishing Licence to fish 'inland waters' (including some estuaries), but do not require any licence to fish in marine waters unless fishing for rock lobster or using a bait hauling net where permitted.

Inland waters and marine waters Under the Act and Regulations 'inland waters' are defined as all Victorian waters to the coast, including estuarine areas other than Gippsland Lakes, Lake Tyers, the Lower Lake of Mallacoota Inlet, and Wingan and Curdies Inlets, where the boundaries are precisely defined in the Regulations. Precise boundaries are also defined in regulations in relation to the mouths of the Barwon River, Boggy Creek, Curdies River, Ironstone Creek, Merri River, Stony Creek, and Yarra, but all other waters change from 'inland waters' to marine waters at the 'mouth'. Inland waters does not, however, include any waters which are on private property.

Marine parks and reserves can be included under Schedule 4 of the *National Parks Act* 1975 and managed under Section 19B of that Act. The Park Regulations 1992 generally provide for angling to be permitted, but contain provisions to enable the protection of indigenous fish, including molluscs and crustaceans, by excluding some forms of fishing from specified areas.

In addition to these provisions, additional rules may also apply to marine parks and reserves under Section 79A of the *Fisheries Act* 1968. Current 79A management arrangements are as follows.

In the Harold Holt Marine Reserves no commercial or recreational fishing is permitted at Popes Eye Marine Reserve; spear fishing is permitted only at Mud Islands Marine Reserve; while anglers may line fish at Mud Island, Swan Bay, Point Lonsdale, and Point Nepean Marine Reserves.

In Point Cook Marine Reserve, spear fishing is prohibited, but line fishing is permitted beyond 200 m from the shore.

South Gippsland Marine and Coastal Parks includes Shallow Inlet, Corner Inlet, and Nooramunga Marine Coastal Parks, Wilsons Promontory Marine Park, and Wilsons Promontory Marine Reserve. Amateur line fishing is permitted in all but the last-named. Proposals to also prohibit commercial fishing there have not yet been implemented.

In Bunurong Marine Park fishing is prohibited in the sanctuary zone, which extends between The Oaks and the bluff east of Eagles Nest.

Recreational spear fishing and the taking of abalone and rock lobster are not permitted, except that: spear fishing is permitted in Shallow Inlet and Nooramunga Marine and Coastal Parks, and in Wilsons Promontory Marine Park, General Use Zone A, spear fishing and taking of abalone are permitted by skin-diving only (no scuba or hookah). For rock lobster there is a bag limit of one per person per day; normal seasonal closure and size limits apply.

Fisheries Statistics In Victoria, licensed fishers are required to complete Commercial Fishing Returns, recording daily catches and other information such as effort and depth. The returns are processed by the Catch and Effort Unit at the Marine Science Laboratories (MSL), Queenscliff, and the data are being progressively updated and independently validated from other sources. It is considered that recorded catches currently, on average, underestimate the actual catch by about 20%, although this varies with species.

A modern database holds a complete dataset from 1978 to 1991, plus historical records preceding 1978, providing crucial information in assisting with management and decision-making in relation to specific fisheries. Figures for specific fisheries included in this chapter have been compiled (unless stated otherwise) from MSL records. Yearly data are for the period 1 July to 30 June of the following year.

PRINCIPAL FISHERIES OF VICTORIA

The five largest commercial fisheries of Victoria are the abalone, south-east trawl, shark, scallop, and rock lobster fisheries. Between them they account for around 80% of the value of all Victorian commercial fish landings from marine and coastal areas.

ABALONE

Blacklip abalone	(*Haliotis ruber*)
Greenlip abalone	(*H. laevigata*)

Blacklip abalone, the most abundant species in Victoria, are found in reef areas from the low-tide zone to depths of about 30 m. Their range includes Tasmania, South Australia, and southern New South Wales as well as Victoria, with small numbers also being found in Western Australia. Blacklip abalone tend to favour heavy reef areas with more highly turbulent waters, particularly those that support brown kelp growths, and to colonise vertical faces on heavy reef ledges and crevasses.

Greenlip abalone are less common in Victoria and are more commonly found in the lee of sheltering headlands among low-profile reefs and seagrasses in strong currents. They also occur in waters off Tasmania, South Australia, and Western Australia.

Biology

Abalone are gastropod molluscs (marine snails) that inhabit inshore reef areas of most temperate oceans. Adults have flattened dish-like shells with a shallow spiral pattern. The body of the abalone is protected by shell and attaches firmly to rocks with a muscular 'foot'.

Of the six species known to inhabit Victorian waters, only blacklip abalone and, to a much lesser degree, greenlip abalone support commercial and recreational fisheries.

Abalone have separate sexes, and reproduction occurs when sperm and eggs are released into the water mass, generally (but not always) in summer. Fertilisation takes place in the water and larvae are initially planktonic for 5—10 days. Although larvae can survive dispersal over long distances, subsequent survival depends on finding suitable habitat on which to settle. Some evidence indicates that abalone released from reefs exposed to currents are flushed away from suitable habitat whereas those released from more sheltered reefs are likely to complete their larval life near the parent stock. The dense growths of seaweed and complex topography typical of many abalone reefs may create water movement patterns that cause localised larval dispersal and settlement. Other research indicates that the presence and activity of existing abalone (slime trails, etc.) provide the stimulus for settlement of juveniles. Of abalone that do settle, few survive the first few months.

Growth rates differ from site to site according to environmental factors such as water flow. Abalone in sheltered waters grow more slowly than those in exposed reef areas, where higher water exchange provides more food in the form of drifting seaweed. Fastest-growing individuals may reach 120 mm in 4 years, but individuals from some sheltered reefs take many more years to reach this size (if at all). They reach maturity at 4 years of age, and breeding takes place annually. Individuals, from age 6 onwards can produce more than a million eggs. Consequently, harvestable individuals from fast-growing populations may be reproductively immature whereas individuals from slow-growing (stunted) populations may produce eggs for many years before reaching legally harvestable size.

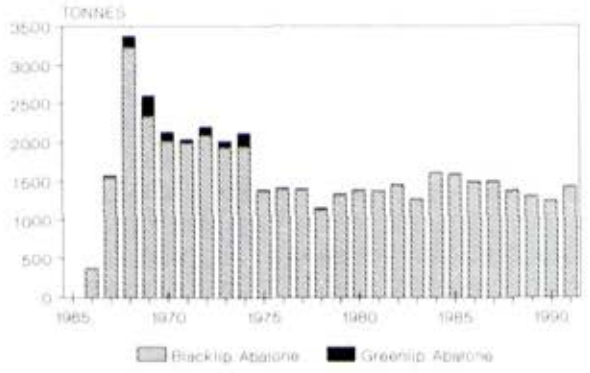
Tagging studies show that abalone move only metres within their lifetime, often returning to the same 'home-sites' after short nocturnal forays.

Commercial fishery

The abalone resource is Victoria's most valuable commercial fishery, currently worth about $26 million per year to licensed commercial fishermen. Processors add further value to the product by processing for export markets, which are mostly located in Asia. In the early years of the fishery, blacklip abalone accounted for around 90% of the landed Victorian catch. In recent years this proportion has increased to 99%. Greenlip abalone make up the remainder. The modern fishery commenced in the early 1960s and production and effort in the fishery increased rapidly.

Abalone are taken by divers supplied with air from a compressor mounted in a boat, who work in depths generally less than 20 m. After removing abalone from the reef with the aid of a metal bar or scraper, they place them in a net bag supported by an air parachute. Regulations require that abalone be landed

Figure 7.3: Abalone Landings



Note: Commercial Fishing only began in 1966.
Source: 1976–78 South Eastern Fisheries Committee (1982).

unshucked (whole in the shell) and passed to licensed processors.

An estimated total of 121 sq. km of reef support the abalone populations currently exploited by the commercial fishery. Most of the commercial catch comes from a few 'major' reefs located around large headlands (McShane *et al.* 1986). Other reefs that provide habitat for abalone populations may be commercially insignificant or generally unsafe for diver access .

Some abalone are exported live to Asian markets, but most of the Victorian catch is currently canned. Meat yield per shell varies seasonally, with yield being up to 20% higher in winter months.

Recreational fishery

Abalone are collected by recreational fishers who dive or wade in search of them in nearshore localities. As well as using these for food, they often retain the highly ornamental shells as curio items. No quantitative data related to recreational taking of abalone are available.

Evidence from shell middens along the coast indicates that the Aborigines have used abalone as a food source for many thousands of years, but currently use them only minimally.

Current management

Management zones and licensing /The commercial fishery in Victoria has been a limited-entry one since 1968 and is divided into three separate areas, see Figure 7.1. The eastern zone comprises all Victorian waters east of longitude 148^{O} East. The western zone includes all Victorian waters west of longitude 142^{O} 31' East. The central zone covers waters between these longitudes. There are currently 23 licensees in the east zone, 14 in the west zone, and 34 in the central zone. Licences are transferable.

Total allowable catch and quotas The fishery is currently (since 1988) managed by setting a total allowable annual catch (TAC) for each zone. The TACs for the eastern, western, and central, zones are 460, 280, and 700 and tonnes respectively. This translates into the allocation of an annual quota to individual licensees. Each eastern and western zone licensee has a 20-tonne quota and each central zone licensee a 20.58-tonne quota. Quotas are for unshucked abalone of either species. Quotas may be transferred from one licensee to another.

Commercial catch docket system To help in administration of the TAC and quota system a commercial catch docket system has been introduced. Licensees are issued with annual sets of 'abalone dockets', which they use to accompany all commercial catches. It is an offence for persons other than holders of a processor's licence or abalone licence to possess, transport, or control more than 10 abalone without a legal accompanying docket.

Minimum legal size for abalone apply to both commercial and amateur users of the resource. Abalone are measured at the widest part of the shell and legal size limits are:

Greenlip abalone (all Victorian waters)	13 cm
All other species:	
West of Lorne	12 cm
East of Lakes Entrance	12 cm
Between Lorne and Lakes Entrance (except Port Phillip Bay)	11 cm
Port Phillip Bay	10 cm

Varying size limits were introduced because abalone grow at different rates in different localities. Recent research (McShane 1989) indicates, however, that current size limits may not be the most appropriate for optimum management of the fishery. Some stunted populations could be managed to permit taking of smaller abalone and some faster-growing populations would be better managed by increasing the minimum size limit to 12.5 cm.

Bag limits (amateur) A daily bag limit of 10 abalone per person applies.

Resource issues

Greenlip abalone The catch of greenlip abalone has declined from around 10% of the total catch to less than 1% in recent years. They are at the edge of their geographic range in Victoria, so the combination of the market preference for them and their less cryptic occurrence on reefs has resulted in the small stocks being reduced to remnant stocks.

Measures such as species-specific bag limits, commercial fishery bans, and significant increases in minimum legal lengths have been considered as ways to arrest further declines of this species in Victorian waters, but the lack of knowledge of the biology of local greenlips has impeded progress on the issue.

Blacklip abalone stock protection Stocks are extremely vulnerable to overfishing and respond very slowly to changes in fisheries management or pressures, so the existence of an illegal fishery - reported to be of similar magnitude to the licensed commercial fishery - is a major concern.

Commercial aquaculture Interest in commercial aquaculture of abalone is increasing around the world, and several Pacific nations (Japan, Taiwan, United States) have already established operational abalone farms. Australia now has pilot abalone farms and, if abalone prices remain relatively high, commercial farms will probably develop, with resultant impacts on established coastal usage.

Sources: (Fallu 1991; Parry *et al* 1990; Fisheries and Wildlife Division 1976; Department of Conservation and Environment 1991; Bureau of Rural Resources 1991)



Abalone trailers at Mallacoota Inlet

ROCK LOBSTERS

southern rock lobster	*(Jasus edwardsii)*
eastern rock lobster	*(J. verreauxi)*

Rock lobster found in Victoria are predominantly southern rock lobster. Distribution of this species extends from the southern waters of Western Australia to the central New South Wales coast. Principle exploited populations (in order of commercial importance) are in South Australia, Tasmania, and western Victoria.

Small numbers of eastern rock lobster are found in far eastern Victorian waters, which represents the southernmost extent of their natural range.

Biology

Southern rock lobster adults inhabit reef areas from near-shore coastal areas to depths of 180 m. They are carnivorous and mainly feed on molluscs, small crustaceans, and bottom-dwelling invertebrates, chiefly during the evening. Rock lobsters grow by a series of moults, which occur less frequently with increased age, and reproductive and moult cycles affect feeding behaviour.

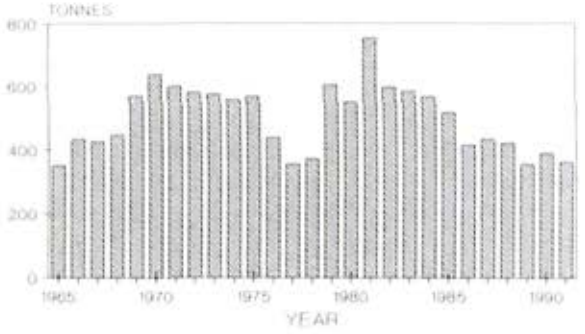
Females take 4 years or more to mature to a size with approximately 75 mm carapace length. In eastern Victorian waters they usually moult and mate in April and May. After producing up to half a million eggs, (berried) females carry these beneath the tail until hatching takes place in September—October. In western Victorian waters these events occur later, with moulting and mating in June—July and hatching in October—November. Most males moult in October—November.

After hatching, the larvae spend 8—10 months in a planktonic state and may be dispersed hundreds of kilometres by ocean currents. Metamorphosis occurs from June to August, when puerulus (transparent miniature rock lobster) settle to the bottom and seek shelter.

Rock lobsters are preyed on throughout their life cycle. Larvae fall prey to pelagic fish and planktonic predators, small juveniles to many benthic fish, and adults to octopus, gummy sharks, and other bottom-dwelling predators. Few rock lobster live beyond 10 years.

Eastern rock lobster do not reach reproductive maturity until much larger than southern rock

Figure 7.4: Rock Lobster Landings



Note: Data for 1976–78 may have doubtful validity.
Source: Bureau of Rural Resources (1991).

lobster (167 mm carapace length). Mature individuals are only known to occur in off-shore waters to the north of Port Stephens. Juveniles settle on inshore reefs near the coast and migrate to off-shore spawning grounds when mature.

Commercial fishery

The southern rock lobster catch is currently worth around $7 million dollars annually to commercial fishers.

Beehive-type pots are baited with fish (heads) and set on reefs, located with the use of echo-sounders. Most boats are equipped with mechanical pot-haulers and tippers to make the retrieval of pots easier.

A large part of the Victorian catch is sold locally with the balance being exported. (Exports are shifting away from frozen product to live product destined for Asian markets). Most (70—75%) of it comes from the west zone (west of 143^{O} 40'E), with negligible commercial capture of eastern rock lobster.



Southern rock lobster.

By-catch species of the southern rock lobster fishery include giant king crabs *(Pseudocarcinus gigas)* from deeper waters and velvet crabs from shallow inshore areas.

Recreational fishery

Amateurs may take rock lobster in Victorian waters but only by hand or with hoop nets, and require an amateur fishing licence (unless persons are exempt). There are currently no available data on the extent of rock lobster exploitation by amateurs, but it is believed that most are taken by hand (by divers). Amateur activity is generally confined to near-shore reefs.

Current management

Management zones and licensing The commercial fishery in Victoria has been a limited-entry one since 1967 and is divided into two areas, an east zone and a west zone (east and west of 143^{O} 40'East).

Of the 178 current licensees, 80 work in the east and 98 in the west, although 14 of the boats have dual rock lobster licences for the Victorian and Tasmanian fisheries and 12 boats have dual Victorian—South Australian licences.

The number of pots that may be used on each commercial rock lobster boat are noted on Boat Registration and Boat Licence certificates. 8281 pots are allocated to Victorian licensees, with 2644 pots allocated to the east zone and 5637 pots to the west. The total number of pots in the fishery is currently subject to gradual reduction measures that are applied when transfers of pots take place between licensees.

Commercial gear requirements All pots must be fitted with escape gaps to allow exit of undersized lobsters. All pots and coffs (underwater storage pens) used in the fishery must be visibly marked with the identifying mark of the boat employed in the setting or using of the equipment.

Minimum legal lengths (carapace) of 11 cm for males and 10.5 cm for females apply to all rock lobster taken from Victorian waters by amateur and commercial fishers.

Bag limits (amateur) in Victorian waters restrict amateurs to a maximum of four lobster on any one day, except from specified waters adjacent to Wilsons Promontory where a bag limit of one lobster per day is applicable.

Closed Seasons apply for taking or possession of rock lobster. Females may not be taken from 1 June to 15 November. Males may not be taken from 1 September to 15 November. Pots and hoop nets may not be used in marine waters from 1 September to 15 November.

Protection of breeding females and soft-shelled lobster Females with eggs or bearing young (in berry) are totally protected, as are moulting (soft-shell) rock lobster.

Resource issues

Decline in landings and catch per unit effort is evident in both zones. Total landings of rock lobster from Victorian waters have declined steadily since a peak catch of 737 tonnes in 1980—81.

Catch per unit effort has also shown a steady downward trend, from 2.5 kg per potlift in 1950 to 400 g per potlift in 1990—91. This is despite the advent of new echo-sounder and satellite navigation technology that enables fishers to locate and define fishing grounds more accurately.

A new program reviewing the rock lobster fishery commenced in 1992.

Adjoining State management issues Legal size limits differ between Victoria and South Australia, which has a smaller limit. This has caused problems near the border area, as a number of operators are licensed to fish in the waters of both States.

Sources: Fisheries and Wildlife Division, 1976

SCALLOPS *(Pecten fumata)*

Scallops live on sand or mud substrate in depths from 5 m to about 100 m. Commercial quantities have been found in Western Australia, South Australia, Victoria, Tasmania, and New South Wales (Bureau of Rural Resources, 1991). They are also found in New Zealand.

Local distribution varies from year to year, with population success being dependent on a number of environmental variables, such as available nutrients.

The relatively nutrient-rich waters of Port Phillip Bay (compared with open coastal waters of Bass Strait) maintain a significant but variable population of scallops. Open coastal waters outside the Bay also support scallops, but with greater variation in location and size of populations.

Biology

Scallops are bivalve molluscs (that is, they have two shells hinged on one side). Between the two shells, the muscle and gonad tissues are surrounded by a curtain-like mantle that is used to filter planktonic and detrital food from the water. The mantle has well-developed eyes, which can detect movement and changes in light intensity.

Adult scallops live sedentary lives on mud or sand substrate. They can move short distances (< 4 m) by opening and closing their shells in a series of rapid movements that jet water out behind.

Scallops are hermaphrodites, having both male and female reproductive elements within each individual. The red portion of the reproductive organ (gonad) is female, while the white portion is male.

Scallops spawn for the first time in their second year, and spawning appears to be triggered by rising water temperature (August to November). Each adult scallop can produce millions of eggs and sperm during its life-span. After spawning, scallops lose condition, and mortality rates are often high.

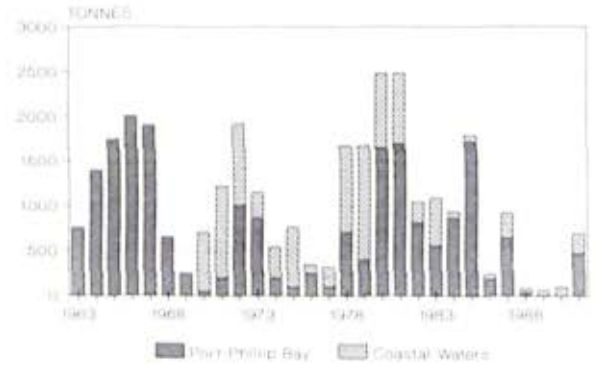
During spawning, eggs and sperm are released into the water column. Fertilised eggs initially sink to the bottom before developing into pelagic planktonic larvae for about 6 weeks. Juvenile scallops then again settle to the seabed for a short period of attachment to solid objects, after which they live the rest of their lives free on the seabed.

Commercial scallops grow quite rapidly, and can reach a harvestable size (about 75 mm) in their second year if environmental conditions are favourable. They have been known to live up to 12 years of age and can grow to larger than 150 mm.

Adult scallops are preyed on by sea stars, whelks, and globefish.

Scallop populations throughout the world fluctuate quite dramatically in response to variable environmental conditions. Relatively high populations occur in some years. These can be followed by relative scarcity, but

Figure 7.5: Scallop Landings



Note: The fishery in waters outside Port Phillip Bay did not commence until 1970.

populations can quickly rebound to large numbers provided enough adult scallops remain for successful breeding recruitment.

Commercial fishery

A commercial fishery for scallops commenced in Port Phillip Bay in 1963. Further scallop beds were discovered in coastal waters off Lakes Entrance in 1970. Based on a current meat-weight value of approximately $7.00 per kg (paid to fishers), scallop landings over the past 25 years have an average annual value of over $7 million.

Vessels tow dredges along the seabed for 5—15 minutes before tipping the contents aboard for sorting. Scallops are separated from empty shells and other bottom debris, which is returned to the sea. Boats normally work together, dredging up and down in the one locality until catches from that area decline. It has been observed that catches from boats working together on a 'patch' generally exceed those made by single boats working in similar areas.



Scallop fishing.

When landed ashore, scallops are split (opened) to remove the muscle, normally with the roe attached. The meat yield averages about 15% of the whole shell weight. Much of the catch is exported, traditionally to France.

Scallop-fishing is renowned for successions of 'boom and bust' periods, which make the fishery difficult to manage. Current estimates of scallop numbers in Port Phillip Bay are very high (greater than 2000 million). However, the small size of newly recruited scallops delayed the 1992 opening of fishery until later than normal.

Recreational fishery

Amateur divers are permitted to take up to 100 scallops per person per day, but no data related to the quantity of the amateur catch are available.

Current management

Management zones and licensing The Victorian commercial scallop fishery is currently divided into two zones: the 'Port Phillip Bay Zone' and 'Victorian Ocean Waters' (which extends to 20 nautical miles from the coast). The 113 licensees in the fishery hold one of three types of licence: 'Port Phillip Bay Only' (currently 19), 'All Victorian Waters' (currently 65), and 'Victorian Coastal Waters' (currently 29). The scallop fishery is a limited-licence one, and no new licences have been issued since 1970.

Commercial gear restrictions The dredge has a maximum allowable width of 336 cm, and must be covered with mesh with openings of not less than 68 mm in length by 44 mm in width. Dredging is not permitted in water less than 10 m deep in Port Phillip Bay with the exception of the Geelong Arm, where it is prohibited in water less than 5 m deep.

Assessment information is regularly gathered to assist management decision-making. This includes:

* collection of fisher's monthly catch-and-effort returns
* annual surveys of the distribution, abundance, and size structure of scallops in Port Phillip Bay
* spatfall monitoring in the Bay
* surveys of ocean grounds by scallop boats under special permits

The Scallop Advisory Committee (SAC) was established following the last comprehensive review of the scallop fishery (Arnold 1986), to assist the Fisheries Management Committee to make management recommendations to the Minister.

Minimum legal size There is no minimum legal size for scallops. Previous size restrictions were removed after research indicated that the restriction afforded little benefit.

Bag limits (commercial) The commercial catch is limited (via Fisheries Notice) to a daily number of specified-size crates or containers, which may be caught from Port Phillip Bay or coastal waters. The catch must be landed with processors as whole (in-the-shell) scallops. Fishers are issued with special tags that must be attached to each container.

Season Scallop-fishing has no set closed seasons in Victorian waters. Commercial fishing seasons are determined annually based on the abundance, size, and condition of scallops. Past management practice has set seasons that optimise the meat yield by targeting fishing operations to the times when scallops are relatively large with roe. Fishing thus seldom takes place from early December to April.

Residual stocks The Port Phillip Bay fishery is managed with the aim of maintaining a residual breeding stock of at least 70 million adults at the end of each season.

Fisheries Notices Management and regulation of the scallop fishery has in recent years relied on the issue of Fisheries Notices, which can apply for up to 3 months. This enables the fishery to be under constant review, and management measures to be changed quickly in response to the changing status of the resource.

Resource issues

Boom—bust cycles in resource availability create a number of management problems, particularly when scallops have been sufficiently abundant to permit fishing in one management zone but not another, excluding those who are not licensed for that particular area. Economic studies and reviews have repeatedly concluded there are too many licences. Licence-reduction strategies have been suggested but not implemented (Department of Conservation and Environment 1989).

Assessment of environmental impacts of dredging is currently being conducted by CNR. The project is due to be completed in December 1993. Preliminary findings, from an internal report of the Marine Science Laboratories, indicate that changes caused to the environment have not proved large enough to be measured easily and further analysis is required to determine the ecological impacts of observed changes and the recovery rate of dredged areas. Alternative dredge types are also being trialed in independent studies carried out by industry and the Tasmanian authorities in conjunction with the CSIRO.

Sources: Ministry for Conservation (1976); Department of Conservation and Environment (1989,1991*a*).

SOUTHERN SHARK

Gummy shark	*(Mustelus antarcticus)*
School shark	*(Galeorhinus australis)*
Saw shark	*(Pristiphorus* spp.*)*
Elephant shark	*(Callorhynchus milii)*

Commercial shark-fishing in Victoria targets species with principally demersal (bottom-dwelling) habits. Main commercially important species are gummy, school, and saw sharks. The first two of these dominate landings and currently account for about 80% of the total catch.

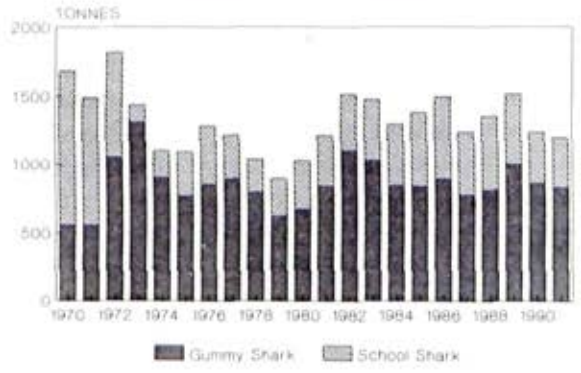
A number of other sharks (including pelagic species such as white pointer, blue whaler, mako, thresher sharks, etc.) are also found in Victorian waters. These are taken as incidental catch by commercial fishers and also by anglers, but are prohibited from being consumed or marketed due to their high mercury content.

Distribution

School shark are found in inshore and off-shore waters of less than 550 m - mainly in depths less than 200 m. Preferred feeding habitat is heavy reef and rough bottom. Gummy shark occur at all depths to 500 m, but mostly at less than 75 m. They prefer sandy substrates or low-profile reefs, particularly in areas with sponge or bryozoan growths. Both species adopt pelagic behaviour at times.

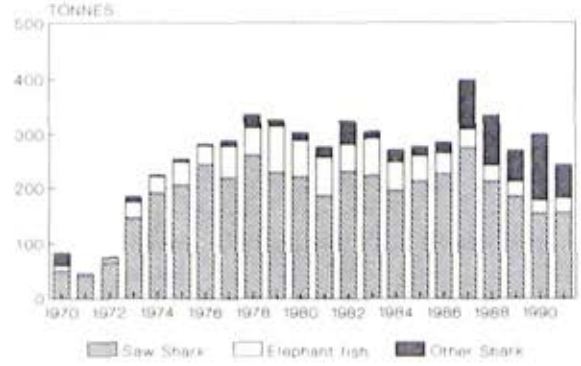
During winter many Victorian school sharks migrate to warmer waters off South Australia and New South Wales. A return migration takes place in late spring. School shark tagged

Figure 7.6: Gummy and School Shark Landings (carcass weight)



Note: Shark bycatch of South-East Trawl fishery and Victoria's bay and inlet fisheries is not included.
Source: MSL Southern Shark Monitoring Fishery Database.

Figure 7.7: Saw, Elephant, and other Shark Landings (carcass weight)



Note: Shark by-catch of South-East Trawl fishery and Victoria's bay and inlet fisheries is not included.
Source: MSL Southern Shark Monitoring Fishery Database.

off New Zealand have been re-caught in Australian waters. Gummy sharks move between the waters of Victoria, Tasmania, South Australia, and Western Australia, but do not exhibit any well-defined migration pattern.

Biology

Sharks are slow-growing and long-lived species with a relatively low fecundity. Female school and gummy sharks produce small numbers (1—45) of live-born offspring from about 8 years of age, generally from October to December. School sharks give birth in protected inshore 'nursery' areas, but no such nurseries have been identified for gummy sharks, which are born over a wider area.

Gummy shark feed on a wide variety of epibenthic crustaceans and cephalopods, with most important food in waters off Victoria being octopus, hermit crabs, goulds squid, and sand crabs. The diets of small juveniles and adults differ little. School shark feed mainly on fish and cephalopods, particularly barracouta, octopus, and squid. Juveniles found in 'nursery' areas also feed on bottom-dwelling molluscs, polychaetes, and crustaceans typical of nursery environments.

While gummy sharks live to a maximum of 16 years, school sharks may live more than 50 years. Neither species has any known predators, other than large shark species and humans.

Commercial fishery

The southern shark fishery extends through waters adjacent to Victoria, Tasmania, and South Australia. Of the 134 vessels with current licences in the fishery, 58 are Victorian. The principal method of capture is bottom-set monofilament mesh nets, but there is also some use of baited long-lines.

The Marine Science Laboratories estimate that the total annual catch - currently around 5000 tonnes (liveweight) - is worth more than $15 million. About 40% of it is landed by Victorian vessels, but it should be noted that virtually all the catch from other State vessels is marketed in Victoria for use as 'flake' in the fish and chip trade.

Recreational fishery

Anglers are known to target and take school and gummy sharks found in inshore areas, during the breeding season, but the catch cannot be quantified. Recreational anglers also target pelagic sharks.

Legislation and management

Victorian management Victorian coastal waters inside the 3 nautical mile limit (other than the waters of Port Phillip Bay, Western Port and Corner Inlet) are currently closed to shark gill-netting and shark long-lining.

Commercial licences No specific shark licence or endorsement is required (other than a Master Fisherman's Licence) to take shark commercially in Victorian coastal waters, but an endorsement by the Commonwealth to take shark is required for Commonwealth waters.

Size limits are 45 cm (legal minimum) for gummy sharks and 40 cm for school shark.

This refers to the length from the rearmost gill-slit to base of the caudal fin. Landing shark in Victoria except in the form of whole carcasses is prohibited.

Prohibited species Due to health concerns related to consumption of flesh with high mercury levels, a prohibition is placed on many of the shark species found in Victorian waters. Except for the purpose of measuring and weighing (by sports anglers), it is not legal to keep in possession any species of shark other than school, gummy, saw, angel, elephant, and northern school black spot, New Zealand rig, New Zealand ghost and New Zealand pale ghost sharks.

Resource issues

A steady decrease in the catch per unit effort and a decrease in average size have indicated that stocks of commercial species of sharks are over-exploited and that the total catch must be reduced. Interim and long-term options being considered to achieve this include further substantial reductions in effort or the introduction of catch quotas. In addition, the mortality of small sharks due to fishing pressure in identified nursery areas causes some concern (Williams 1991).

Sources: Parry *et al* (1990); Department of Conservation and Environment (1991*a*); Ministry for Conservation (1976); Walker (1992); Bishop (1992); Campbell *et al*. (1992)

THE SOUTH-EAST TRAWL and INSHORE TRAWL FISHERIES

Orange roughy	*(Hoplostethus atlanticus)*
Gemfish	*(Rexea solandri)*
Tiger flathead	*(Neoplatycephalus richardsoni)*
Blue grenadier	*(Macruronus novaezelandiae)*
Redfish	*(Centroberyx affinis)*
School whiting	*(Sillago bassensis flindersi)*
Sea bream (Morwong)	*(Nemadactylus macropterus)*
Blue warehou	*(Seriolella brama)*
Spotted warehou	*(S. punctata)*
Blue eye trevalla	*(Hyperoglyphe antarcticus)*
Ling	*(Genypterus blacodes)*
John dory	*(Zeus faber)*
Mirror dory	*(Zenopsis nebulosus)*
Silver trevally	*(Pseudocaranx dentex)*
Ocean perch	*(Helicolenus percoides)*
Royal red prawn	*(Haliporoides sibogae)*

The SET fishery is managed by the Commonwealth outside 3 nautical miles from Barrenjoey Point, north of Sydney, around Tasmania, and west to Cape Willoughby in South Australia. It overlaps the Victorian inshore trawl fishery, which has 60 licensees entitled to fish inside 3 nautical miles. Most licensees maintain dual entitlements for both Commonwealth and State waters, but other licensees have single entitlements for State only or Commonwealth only waters. The bulk of the catch comes from the SET fishery.

The main catching method is demersal trawling using otter boards, but Danish seine fishing also takes place, particularly in waters of eastern Bass Strait.

Fishers from the SET have reported catches to the Commonwealth since 1985, whereas the inshore catch is reported to Victorian fishery managers. In 1991 the value of the SET fishery was about $88 million, of which the component landed in Victoria was worth an estimated $25 million. The Victorian inshore fishery is, by comparison, relatively small. More than 70 species are harvested from these fisheries, but 16 main species account for more than 80% of the catch. These (listed above) are subject to quota management.

There are some problems in obtaining species breakdown of the Victorian component of the SET catch because many of the larger vessels travel extensively and may undertake fishing operations in waters adjacent to a different State from that in which the catch is landed. It can be said, however, that most school whiting and tiger flathead are caught adjacent to Victoria and are landed here.

Species - biology, distribution, and fishery

Species caught in the SET and Victorian inshore trawl fisheries can be broadly categorised as 'near-shore', 'mid continental shelf', and 'off-shore' species (Parry *et al* 1990). Although assigned to one of these categories, some species can be found at times in areas associated with another category.

In general, the 'off-shore' species do not venture into Victorian waters, but most mid continental shelf and near-shore species are caught both within and beyond 3 nautical miles of the coast.

Some species found in near-shore waters (such as sand crabs, school prawns) are not caught

Table 7.1: Total Catch in the SET Fishery (tonnes)

Species	1986	1987	1988	1989	1990
Orange roughy	3 353	6 737	6 762	26 689	41 958
Gemfish	3 663	4 554	3 409	1 497	825
Tiger flathead	1 935	2 394	2 399	2 055	1 631
Blue grenadier	1 472	2 002	1 806	1 699	1 683
Redfish	1 648	1 256	1 134	443	571
School whiting	1 286	997	1 274	902	1 759
Morwong	1 007	1 016	1 423	1 359	718
Spotted warehou	1 168	734	1 595	791	1 079
Pink ling	700	743	550	566	429
Squid	401	569	287	237	346
Mirror dory	400	451	328	439	204
Silver trevally	534	195	284	239	310
Royal red prawn	263	359	334	245	202
Barracouta	249	374	229	99	159
Blue warehou	211	363	530	609	719
Jack mackerel	491	124	1 201	11	13
Shark	324	245	105	349	324
Ocean perch	279	192	180	167	96
John dory	230	204	179	143	130
Other	2	1 624	1 922	1 761	2 067
TOTAL	21 742	25 133	25 930	40 300	55 223

Note: Figures for 1990 may be incomplete.

Source: Industry Commission (1991).

outside State waters and are targeted exclusively by Victorian inshore trawlers. These are described elsewhere in the chapter.

Near-shore species

Tiger flathead are distributed from southern New South Wales into Victoria and Tasmania in waters 20—300 m deep, but the bulk of the catch comes from soft seabed areas 40—200 m. Commercial catches are mainly adjacent to New South Wales and eastern Victoria. Maximum age is 12 years and spawning extends from October to May, with mature females producing up to 2.5 million eggs. Large tiger flathead feed mainly on fish and move off the bottom into the water column to feed on pelagic species at night. Some migration of adults into coastal bays occurs in spring.

Recreational fishers catch tiger flathead, along with other flathead species, but in insignificant quantities compared with the commercial catch.

Sustainable yield for tiger flathead taken in the SET and Victorian inshore trawl fisheries is estimated at 2500 tonnes, within a total sustainable yield of 3000 tonnes for all flathead species combined. Catches of more than 5000 tonnes in the 1930s proved to be severe over-fishing. In recent years, some recovery of the stock has occurred, with catches to 3000 tonnes being maintained under managed fishing levels and use of minimum mesh sizes.

School whiting are distributed from southern Queensland to south-eastern South Australia at depths of 5—80 m. Most commercial landings are from waters adjacent to Lakes Entrance. Four separate stocks have been identified, three of which are in the SET zone. The annual catch of school whiting over the past several years has ranged from 1000 to 1400 tonnes and is valued at from $2 to $3 million. Most of the catch is exported to Japan.

School whiting live to a maximum of 7 years and reach reproductive maturity at about 2 years, spawning between October and March. They can feed on a variety of food items ranging from zooplankton to bottom-dwelling invertebrates. Large numbers are taken from time to time by recreational fishers in inshore areas.

John dory are distributed from southern Queensland to central Western Australia at

depths of 30—100 m, although abundance is greater north of Victoria and the fish is seldom encountered in Victorian waters west of Wilsons Promontory. It is currently assumed that a single stock exists in the SET area.

Sources: Bureau of Rural Resources (1991); Tilzey (1992); Parry *et al* (1990); DPFRG (1991a); Last *et al*. (1983)

Mid continental shelf species

Morwong (sea bream) are distributed from New South Wales to southern Western Australia, mostly at depths of 70—360 m. The species also occurs off New Zealand, South Africa, and South America. Recent studies indicate that there may be several distinct stocks, but further study is needed. Spawning occurs in late summer—early autumn and maximum reported ages for males and females are 11 and 16 years respectively.

Resource estimates indicate that the current catch is sustainable and increased catches are possible.

Blue warehou and spotted warehou are distributed throughout south-eastern Australia from New South Wales to South Australia. Blue warehou, a near-shore species, occupies shallower waters at 10—180 m, whereas spotted warehou is a mid continental shelf species found at depths of 300—600 m. Blue warehou distribution is associated with reef. Most trawl catches are from late winter through spring. Warehous are also taken in significant quantities by (shark) gill nets. Juveniles of both species are pelagic and are associated with drifting jellyfish.

Redfish are found along the east coast of Australia from Queensland to Tasmania at depths of 10—450 m. They form schools over rocky reefs and muddy substrates and are known to be long-lived (16 years) and slow-growing. Spawning occurs in late summer—autumn. Commercial catches are mainly off New South Wales. Declines in catch per unit effort and mean size of fish landed indicate a significant decline in the redfish resource. Maximum sustainable yield is estimated to be between 500 and 1100 tonnes per annum.

Silver trevally are distributed around southern Australia from north-east Queensland to north-western Western Australia. Juveniles are found in near-shore coastal areas, but fish move into deeper waters as they grow. Catches in the SET are mainly from New South Wales. The species is more fully described later in this report.

Sources: Parry *et al*. (1991); Grant (1987); DPFRG (1991*a*); Tilzey (1992).

Off-shore species

(Note: almost exclusively found outside Victorian territorial waters)

Orange roughy, a deep-water off-shore species, are found from 800 to 1000 m in deep waters of the temperate oceans around the world. Currently the most important commercial species in the SET fishery, catches have risen dramatically over the past few years. This is due to a fishdown of virgin stocks, but catches are unsustainable at current levels
over the longer term. The species is extremely long-lived, with a maximum age in excess of 120 years and age 20—25 years at reproductive maturity. Spawning grounds have been identified off St Helens on the east coast of Tasmania. Knowledge of stocks is incomplete.

Gemfish are caught generally in water depths 150—600 m; stocks found off the east coast of Australia are generally considered to be separate from those found to the west of Bass Strait. The eastern stock has been fished by boats that target the spawning aggregation off the New South Wales coast and serious over-fishing is widely acknowledged. Management is now directed at enabling stock recovery. The western fishery does not target aggregations and there is no evidence of a spawning run comparable to that off the east coast.

Blue grenadier are distributed from New South Wales to southern Western Australia in depths greater than 300 m. Studies indicate that Australian waters contain a single stock. The majority of catches are taken by targeted demersal trawls in the south-west sector of the SET, with up to 33% by weight being taken in some years from a winter-spawning aggregation west of Tasmania.

Blue eye trevalla are distributed widely on the outer shelf and continental slope of major land masses in temperate waters of the Southern Hemisphere, and are found from mid New South Wales to southern Western Australia in depths of 100—900 m, particularly near reef drop-offs. Juveniles are found associated with

large drifting jellyfish. The commercial catch is predominantly taken by drop-lining, but trawlers and (shark) mesh nets also taken part of it. The resource may be fully exploited and there is a need for further information to assess stock conservation requirements.

Pink ling are distributed widely in temperate oceans of the Southern Hemisphere and are found in Australia from Crowdy Head, N.S.W., to southern Western Australia in depths of 60—600 m. Research indicates that they may comprise two sub stocks, one on the shelf (<200 m) and one in deeper slope waters. Spawning occurs from April to October. A related species, rock ling (*Genypterus tigerinus*) is found in shallower water at 5—60 m, particularly around caves and ledges.

Mirror dory occur from northern New South Wales to central Western Australia in depths of 200—600 m, but most of the commercial catch is taken off New South Wales in conjunction with the gemfish fishery.

Ocean perch have an unclear status: at least two distinct forms occur off new South Wales and possibly a further form off Tasmania. Most of the SET catch comes from the eastern sector in depths 300—600 m.

Royal red prawns are caught in depths ranging from 275 m to 820 m. Most SET landings are from off New South Wales with little of the catch being taken adjacent to Victoria.

Sources: Bureau of Rural Resources (1992*a*, 1992*b*); DPFRG (1991*a*); Parry *et al.* (1990); Tilzey (1992); Grant (1987); Last *et al.* (1986)

Management

The SET fishery is currently being managed by a management plan based primarily on implementation of output controls (total allowable catch) for 16 main species. Quotas for these species have been issued to licensees in the fishery, and may be transferred between licensees. The management plan is currently being reviewed and changes were expected to be incorporated into a revised plan that would take effect in January 1993 (AFMA 1992).

Resource issues

Biological and population dynamics assessment information in relation to many of the species in the SET fishery is incomplete, particularly stock size, structure, and recruitment.

Over-quota landings and by-catch - implementation of quotas for SET fishery species requires updated enforcement systems and additional commitment of fisheries management resources. However, dealing with non-targeted catches and over-quota landings of species (such as gemfish) that are over-exploited, and for which strict maximum catch limits need to be applied, presents practical problems also. The only effective way to prevent over-quota landings is to terminate fishing operations once quotas have been filled. This is not generally considered to be a viable option for the multi-species SET fishery, despite general agreement that it is difficult to prevent some level of over-quota by-catch, even if effort is largely targeted away from the over-quota species. A program of on-board monitoring is being implemented to address this problem.

Discarding and upgrading in the process of legitimately filling agreed quotas, trawlers often catch quantities of under-sized or lesser-valued small fish. It does not 'pay' fishers to fill their quota with relatively low-valued small fish, and they often dump this part of the catch at sea. The result is a hidden and unquantified impact on future fishery stocks.

BAY, INLET, AND ESTUARINE FISHERIES

The management of commercial and recreational fin fisheries in Victorian bays and inlets was the subject of recent inquiry by the Parliamentary Natural Resources and Environment Committee (NREC 1991). The Committee brought forward some 51 recommendations, to which the State Government responded in 1992. The following table, updated from the NREC Report, gives a useful indication of the fisheries found there.

In the multi-method, multi-species commercial fisheries in Victorian bay, inlet, and estuarine areas, catches frequently reflect marketability of species rather than relative abundance. It is of interest to note that landing estimates for Port Phillip Bay in 1982/83 indicate that the total recreational catch for bays and inlets is possibly as large as if not larger than the total commercial catch (NREC 1991).

The following species descriptions deal firstly with those more commonly caught in bays and inlets before going on to those encountered more frequently in estuaries.

Table 7.1: Summary - Fisheries of Victorian Bays and Inlets

Commercial catch (tonnes/year)	Recreational catch (tonnes/year)	Mesh nets	Seines	Longlines	Spearfishing	Commercial restrictions	Number of commercial fishers*	Principal species taken
Port Phillip Bay 740 to 1907	1050 (1982-83)	yes	yes	yes	Swan Bay excluded	Numerous line, area and gear controls.	125 T 11 NT	Pilchards, Snapper, Whiting, Garfish, Salmon, Flathead, Anchovies, Flounder
Gippsland Lakes 557 to 1150	350 (1979-83)	yes	yes	no	banned in parts	Not within 400 m of rivers or north arm or Lake Reeve. 732 m seine length. Mesh nets noon Friday to sunset Sunday prohibited.	34 T 5 NT	Black Bream, Mullet, Carp, Anchovies, Flathead, Tailor, Trevally, Luderick, River Garfish
Corner Inlet 200	176 (1983-84)	yes	yes	some	banned in parts	Mesh net length 1300 m - 1650 m	35 T	Whiting, Flathead, Flounder, Mullett, Garfish,
Westernport 155	Not known	yes	yes	no	yes	No longlines 1 November to 25 February. Mesh nets 1100-1650 m 50 mm mesh. Seine nets 366 m. Noon Saturday to 10 pm Sunday prohibited.	125 T	Flathead, Whiting, Garfish, Salmon, Mullet
Mallacoota Inlet 26 to 98	27 (1981-84)	no	yes	no	no	Bottom Lake only 550 m length haul seine only.	8 T	Black Bream, Luderick, Mullet, Trevally, Salmon
Lake Tyers 2 to 28	15	yes	yes	no	no	May to August only; noon Friday to pm Sunday prohibited. 366 m seine length. 100 m mesh net length	12 NT	Black Bream, Luderick, Mullet
Shallow Inlet 1 to 14	Not known	no	yes	no	no	15 February to 15 Dember only. No mesh nets.	5 NT	Salmon, Mullet, Whiting, Garfish, Trevally, Flounder
Anderson Inlet 1 to 14	Not known	yes	no	no	no	March to November only. Part of bay closed.	4 NT	Salmon, Mullet, Trevally
Sydenham and Wingan Inlets *banned*							0	Black Bream
Tamboon Inlet 1 to 26	not known	no	yes	no	no	1 May to 14 October only. 550 m haul seine length. Noon Friday to pm Sunday prohibited	4 NT	Black Bream, Salmon, Mullet, Tailor, Trevally

Source: Natural Resources and Environment Committee 1991 (updated September 1992)

* T = transferable NT = not transferable

CLUPEOIDS

Pilchards (*Sardinops neopilchardus*)
Anchovies (*Engraulis australis antipodum*)
Sandy sprats (*Hyperlophus vittatus*)
Blue sprats (*Spratelloides robustus*)

Clupeoids are pelagic and are found in inshore coastal waters, bays, and inlets of Victoria and other southern Australian States. Principal fishing grounds are Port Phillip Bay and within 1 km of the open coastline adjacent to Lakes Entrance, although small quantities are taken from Western Port and other areas.

Pilchard distribution stretches from southern Queensland to Kalbari, W.A., but only includes the north and east coasts of Tasmania. They are found at depths of 0—200 m. Anchovy distribution extends around the southern coast of Australia, from Queensland

to Shark Bay, W.A., but is confined to inshore waters adjacent to favourable breeding areas. Distribution of sprats and less commercially valuable clupeoids is not known.

Biology

Pilchards spawn in the open sea during spring and summer. Post-larval pilchards move inshore to bays and estuaries, where they spend 1 year before moving out to join adult stocks. They feed mainly on plankton, live to a maximum of 6 years, and reach 30 cm in length. After attaining reproductive maturity at 2—3 years of age, they produce 10 000 to 45 000 eggs annually.

Anchovies spawn in bays, inlets, and estuaries during summer where salinity exceeds 15 parts per thousand. Post-larval anchovies school separately from older ones until migrating to Bass Strait for the winter before returning to breed. Anchovies reach reproductive maturity at 1 year and live a maximum of 4.5 years.

Sandy sprats are mainly found in depths to 12 m immediately behind the surf zone. Large quantities are known to exist, but they are seldom fished due to the limited market for them. Little is known of their biology.

Commercial fishery

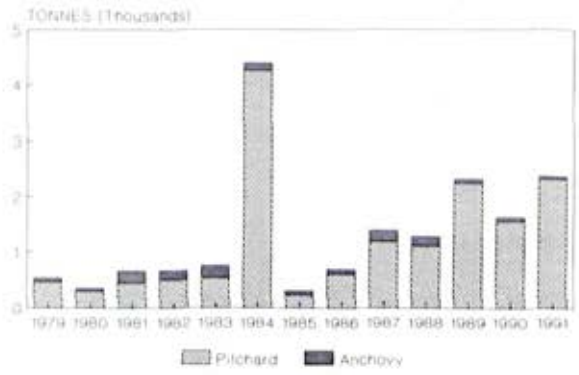
Commercial catches of clupeoids in Victoria vary from year due to large changes in abundance and/or in market demand. Greatest landings are of pilchards and anchovies, with sprats only infrequently taken.

Currently in Victoria, clupeoids are sold on the fresh-fish market, for bait and for pet food. In the past, a clupeoid fishery for production of fish-meal and fish-paste operated intermittently off Lakes Entrance, but was last active in 1983/84, when about 4000 tonnes of pilchards were taken for fish-meal.

The catch of pilchards from Port Phillip Bay in recent years has been 750—1400 tonnes and is generally rising. The catch of anchovies, however, has fallen from a peak of 150 tonnes in the 1970s to 16 tonnes in 1990. Although the Port Phillip Bay fishery is subject to an umbrella of limited-licence entry, no specific management limitations are applied to the fishery, which is possibly underexploited.

Most of the clupeoid catch is taken by a small number of vessels using purse seine or lampara nets, but small quantities are increasingly being taken by a number of fishers who are licensed to collect bait species.

Figure 7.8: Pilchard and Anchovy Landings



Note: Landings at Lakes Entrance are known to have been 2000–4000 tonnes for some years during this period, but have not been reported on fishing returns.
Source: (Parry *et al* 1990).

Recreational fishery

Clupeoids are a source of bait (mostly purchased) for recreational fishers. Bait drag-nets may, however, be used in specified waters. Users of bait drag-nets in all waters (including marine) require an amateur fishing licence unless exempt.

Resource issues

Impacts on clupeoid stocks There is concern that the recent increase in commercial landings of pilchards may not be sustainable.

Impacts on other fish Because clupeoids are low in the food chain, there is also concern that the increased catches from Port Phillip Bay may adversely affect stocks of other fish, which are of commercial and recreational fishery value.

Impacts on penguins may be of concern as a result of removing a food species of the little penguin, numbers of which have declined in their Phillip Island breeding colony over recent decades, according to the Phillip Island Penguin Reserve Committee of Management. These penguins spend their winters in Port Phillip Bay and are known to feed on clupeoids, particularly small pilchards. It is unclear whether starvation mortality in penguins is related to food shortage or to fishing difficulties caused by rough weather (Dann 1992).

Estuarine conditions for anchovies Anchovies depend on estuarine conditions for successful spawning and recruitment.

Deterioration of water quality in Hobsons Bay - the only significant area of estuarine waters in Port Phillip Bay - may be the major cause of reduced abundance of this species in the Bay (NREC 1991).

Sources: Parry *et al.* (1990); Grant (1987); Last *et al* (1986); Winstanley (1979); NREC (1991).

KING GEORGE WHITING
(Sillaginodes punctatus)

King George whiting are bottom-dwellers found in depths of 2—40 m around the southern coasts of Australia. Preferred habitats are seagrass and soft substrate areas, especially in the vicinity of low-profile broken reef or sandy gutters.

Biology

King George whiting grow to a maximum of 60 cm and are the largest whiting species found in Australia. Fish mature at 32—36 cm at 3 years of age and spawning takes place from autumn to early winter. Smaller adults produce around 100 000 eggs, but larger fish can produce up to half a million. Spawning in Victoria is believed to take place in open coastal waters (such as outside Port Phillip Heads), with eggs and larvae drifting until settlement in protected bay and inlet areas. Juveniles remain there in shallow seagrass areas up to 18 months of age. Fish tend to form schools when smaller, but the largest individuals are often solitary. Older fish move into more open waters and some fish tagged in South Australia have been re-captured as far as 300 km from point of release. Whiting feed on a variety of molluscs, crustaceans, and invertebrates found in inshore areas (Jones 1989).

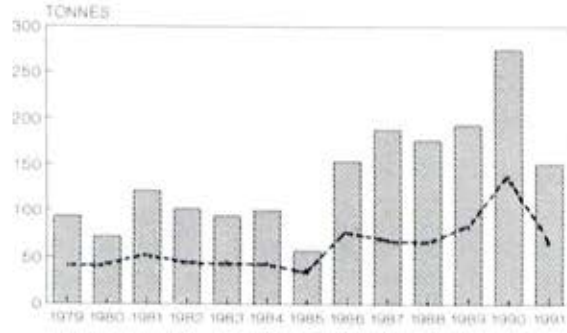
Commercial fishery

Victorian catches of King George whiting are mainly taken in Port Phillip Bay, Western Port, Corner Inlet, and Shallow Inlet, but small quantities also come from open coastal waters. Principal methods of capture are haul seine and mesh nets, although significant quantities are also taken by baited hand-line.

Recreational fishery

Whiting are a highly prized recreational species, targeted on known grounds by anglers line-fishing with bait.

Figure 7.9: Whiting Landings



Note: Broken line indicates catch from Port Phillip Bay.
Source: NREC (1991)

Current management

A minimum legal size of 27 cm and an amateur bag limit of 20 King George whiting per person per day apply.

Sources: Jones (1979); NREC (1991); Grant (1987); Parry *et al.* (1990)

SNAPPER *(Pagrus auratus)*

Snapper are found in coastal marine waters around southern Australia to the edge of the continental shelf in depths to about 200 m. Their range extends south from Gladstone, Qld, to Coral Bay, W.A., and includes waters of New South Wales, Victoria, and South Australia. They are only occasionally found in waters of northern Tasmania. Juveniles predominantly live in sheltered waters, marine embayments, and inshore coastal areas, with adults moving to deeper waters between annual migrations to inshore breeding grounds. (Some stocks, however, do not appear to always follow this general pattern.)

Biology

Specimens of this relatively long-lived and slow-growing species, grow to a maximum of around 16 kg over 35 years. The Australian population includes several discrete sub-populations that spawn at different times of the year in different localities, and there are thought to be two stocks in Victoria. Spawning in Victorian waters takes place from late spring to early summer, with larger fish breeding early in the season and small ones later. Males and females reach maturity at 3—5 years of age at length about 28 cm, and form aggregations for spawning, when they release eggs and sperm into the water column.

Snapper are highly fecund, with individual large fish producing up to 6 million eggs. Little is known of early behaviour, but it is believed that juveniles are pelagic, settling to the bottom in their first year when about 6 cm in length.

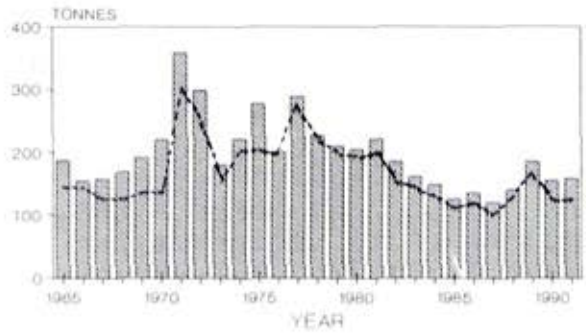
Snapper can be found in a variety of hard- and soft-bottom habitats, but fishers note they congregate near reef margins. They feed on a variety of crustaceans, molluscs, and benthic fauna. Tagged fish have undertaken migrations of up to 300 km before recapture, but many exhibited no migratory tendency, being recaptured at point of release after many months. They attain a maximum size of about 1.3 m and 20 kg.

Commercial fishery

Most of the Victorian catch (80—90%) comes from the waters of Port Phillip Bay. Snapper are caught all through the year, but most are taken between November and May from relatively shallow waters.

Commercial fishers use a number of methods, including hand-line, mesh nets, and seines, but the greatest commercial catch comes from baited long-lines. In waters outside Port Phillip Bay, small quantities of snapper are also taken incidentally by trawlers and in traps used by licensed rock-lobster fishers. The local catch does not satisfy Victorian demands, and annual imports of about 200 tonnes come from New Zealand and other Australian states.

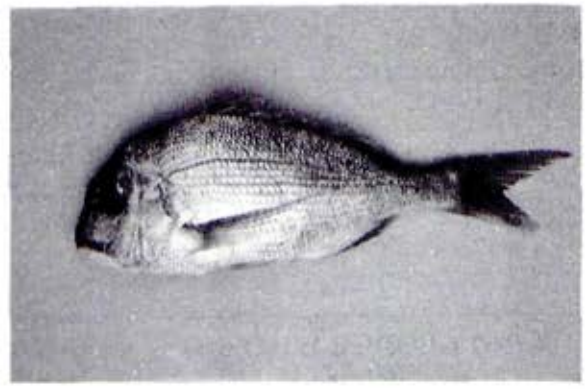
Figure 7.10: Snapper Landings



Note: Broken line indicates catch from Port Phillip Bay
Source: Port Phillip Bay - NREC (1991).

Recreational fishery

Most of the recreational snapper catch in Victoria is taken in Port Phillip Bay. Smaller catches come from Western Port, the mouth of Corner Inlet and along the open coastline. In Port Phillip Bay the species is the number one



Snapper.

angler-nominated target and the third-ranked species caught. Catches taken by recreational anglers using baited lines in the Bay are often at night and probably exceed commercial landings.

Management

Minimum legal size and amateur bag limits apply, with a minimum legal length of 27 cm. for commercial and recreational fishers, and a maximum recreational bag limit of 10 snapper of less than 40 cm per person per day. In addition, no more than five snapper of more than 40 cm may be taken.

Commercial gear restrictions Strict controls cover the type and amount of gear that may be used by commercial fishers in Port Phillip Bay.

Sources: MacDonald (1982); Bureau of Rural Resources (1992*a*); Jones (1979); NREC (1991).

FLATHEAD

Sand flathead	*(Platycephalus bassensis)*
Dusky flathead	*(P. fuscus)*
Rock flathead	*(P. laevigatus)*
Yank flathead	*(P. speculator)*

The several species found in Victoria have adapted to favour slightly different niches on the sea floor, but the territories of the five most commonly encountered species overlap.

Rock flathead are primarily restricted to weed-covered reef and seagrass of non-estuarine bay and inlet areas, but small populations are also found in protected areas of Bass Strait. Their range extends from southern New South Wales to southern Western Australia and includes Tasmania. Sand flathead - found from

southern New South Wales to South Australia, including Tasmania - are the main species found in Port Phillip Bay. They are most common in inshore bay and inlet areas although they are found to depths of 100 m in Bass Strait. The relatively less abundant yank flathead occupy inshore waters of Bass Strait, living on shallow sand patches and among seagrasses of bays and estuaries. Dusky flathead also live in inshore coastal areas and estuaries from Queensland to Victoria, but they are seldom found west of Wilsons Promontory and are unknown around Tasmania. They are found on clean sandy bottom as well as among dense seagrass beds.

Tiger flathead biology and distribution are described in the section dealing with the SET and Inshore Trawl fisheries.

Biology

A number of flathead species are found in Victorian waters. All are primarily adapted to life on the sea floor, with flattened bodies and heads helping them to remain hidden from prey and predator. Eyes placed on the top of the head look sideways and upward, but most species cannot look effectively downward. They are predators that opportunistically feed on a variety of small creatures encountered on the sea floor.

Each species is found in a range of colours and this leads to many cases of mistaken identity. Most particularly, sand flathead are confused with tiger flathead and yank with dusky flathead.

Sand flathead grow to about 45 cm and 3 kg; rock flathead grow to 50 cm and 2.5 kg; tiger flathead grow to 60 cm and 2.5 kg; yank flathead grow to 90 cm and 8 kg; while dusky flathead, the largest-growing species, reach more than 14 kg.

We have little information on the life cycle of flatheads, but the fact that no flathead species are found in New Zealand waters indicates that an absence of any extensive planktonic phase of eggs or larvae, and after hatching juveniles probably quickly take up residence on the near-by sea floor.

Commercial fishery

Tiger and sand flathead landings in Victoria come mainly from the trawl and Danish seine fleet, which operates in inshore waters of eastern Victoria and the South East Trawl fishery. These Victorian boats land 1200—2000 tonnes annually, with tiger flathead making up about 90% of the catch and the balance being mostly sand flathead. In recent years, 25-50 tonnes of sand flathead have come from Port Phillip Bay as a by-catch of mesh and seine net fisheries.

The bulk of commercial landings come from Gippsland Lakes, where the species is taken as a by-catch of the net fishery for bream. Total annual catches have ranged from 20 to 30 tonnes recently. Reported commercial landings of yank flathead are also relatively small, in the range 10—20 tonnes, mostly being derived as by-catch from Lakes Entrance trawl and Danish seine fisheries and also from Port Phillip Bay. Commercial landings of rock flathead have ranged from 40 to 60 tonnes over recent years. Most are taken by mesh nets and seines in Port Phillip Bay and Western Port.

Recreational fishery

Flathead species support a substantial recreational fishery, being readily taken by baits and artificial lures. The estimated recreational catch of flathead from Port Phillip Bay (approximately 450 tonnes) is nine times the commercial catch (NREC 1991). That from other Victorian waters has not been quantified, but flathead are among the most popular fish commonly taken by recreational anglers (Barnham and Tunbridge 1990).

Management

Minimum legal length for all species is 25 cm.

Sources: Last *et al* (1983); Grant (1986); Parry *et al*. (1990)

BLUE MUSSEL *(Mytilus edulis planulatus)*

Mussels are widely distributed in Victorian waters, particularly in marine embayments. Population size fluctuates markedly with seasonally variable environmental factors such as water salinity and nutrient levels etc.

Biology

These bivalve molluscs feed by filtering phytoplankton from the surrounding water.

Annual spawning is followed by a short planktonic larval stage. Juveniles then settle onto suitable hard-surface substrates, which must initially be covered with algae growths



Mussel farming.

that provide the necessary biological stimulus for successful settlement.

Mussels grow quickly, reaching maturity and a commercial size within 12 months. Maximum life span is several years.

Commercial fisheries

Blue mussels are commercially taken from three different areas in Victoria, and 21 mussel-farmers have permits to grow blue mussels on sites in Port Phillip and Westernport Bays. It is estimated that annual production of mussels from farms has been 500—800 tonnes in recent years.

Prior to a prohibition on dredging of mussels in Port Phillip Bay in 1987, annual mussel landings to 1500 tonnes were recorded. Mussel landings from scallop boats outside Port Phillip Bay are relatively small, averaging less than 20 tonnes annually. Since the prohibition, market demand has stimulated the further development of a dive fishery for wild mussels in the Gippsland Lakes, currently comprising 12 regular fishers and two who fish irregularly. This fishery landed 57 tonnes of blue mussels in the year ended 30 June 1991, but in more favourable years exceed 100 tonnes.

Australian production cannot fill the demand for mussels and some $4—5 million worth are imported annually, particularly from New Zealand.

Recreational fisheries

Mussels were traditionally widely collected by recreational and subsistence-food gathers, particularly from Port Phillip Bay, who used them for bait as well as for human consumption. In recent years, however, outbreaks of toxic algal blooms and the associated publicity have alerted the general public that consumption of wild mussels and other shellfish from certain areas can be harmful to health.

Management

Mussel aquaculture is confined to clean-water areas with least risk of mussels being contaminated by industrial pollutants. Two major aquaculture zones established in Port Phillip Bay (near Grassy Point and Clifton Springs) are now the focus for mussel-growing, together with four mussel-farm sites on the east side of Port Phillip Bay and one in Western Port. Mussel-growing activities are generally controlled by the fish culture section of the *Fisheries Act* 1968.

Dive fishery The Lakes Entrance dive fishery for mussels was initially subject to a voluntary code of practice by participants. This code has since been incorporated into Fisheries Notices, which restrict weekly fishing to Mondays only with a regularly reviewed maximum catch of 5—10 bins (30 kg per bin) per diver.

Dredge fishery Apart from a prohibition on the dredging of mussels from Port Phillip Bay, no restrictions cover dredging of mussels from any area where scallop-boats are permitted to fish.

Resource issues

Farmed mussels require considerable investment of capital and labour to produce. They must compete for sales in the open market with wild caught mussels. At times when production increases, it has been claimed that the wholesale floor price of mussels can fall to levels that make farmed production uneconomic. The sustainability of a potentially large mussel-culture industry may, it is claimed, be threatened by sporadic production from minor wild mussel fisheries.

Sources: Winstanley (1982); Australian Fisheries Service (1991); Smith *et al.* (1991); Hickman (1983); Johnstone (1985)

GARFISH
Southern garfish *(Hyporhamphus melanochir)*
River garfish *(H. regularis)*

Southern garfish occur in sheltered bays and marine estuaries from southern New South

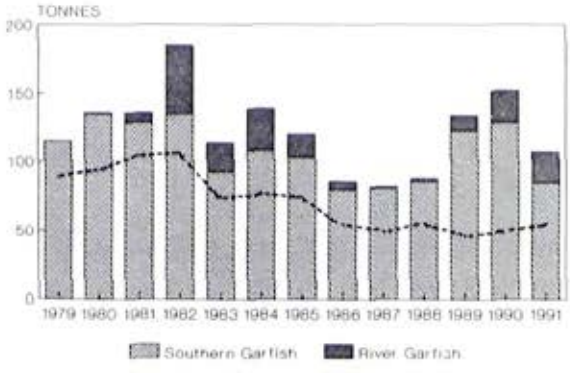
Wales to southern Western Australia. River garfish occupy less-saline waters of shallow estuaries from central Queensland to eastern Victoria (around Lakes Entrance). Both species are usually found associated with seagrass beds, on which they depend for spawning and feeding.

Biology

Garfish feed on seagrass and algae by using their jaws to nibble and scrape seagrass and fine weed to remove the thin film of diatom growth that coats this vegetation. In the process they consume large quantities of filamentous algae (hair-like strands of edible green vegetable matter) together with small organisms disturbed in this feeding process. Garfish excrement floats at the surface and during calm weather skilled fishers use it to locate schools of the fish.

Southern garfish mature at about 27 cm, and breeding first takes place at 3 years of age during late spring to summer. They lay about 10 000 eggs among seagrasses, to which these adhere. Detailed reproductive information for river garfish is not known.

Figure 7.11: Garfish Landings



Note: Dotted line is the catch from Port Phillip Bay
Source: Port Phillip Bay - NREC (1991).

Commercial fishery

Southern garfish are mainly caught in the fisheries of Port Phillip and Western Port and Corner, and Shallow Inlets. Small quantities are also taken from open coastal waters. Principal method of capture is seine nets. River garfish are taken mainly from the Gippsland Lakes.

Recreational fishery

Recreational anglers target garfish by line-fishing with floated bait near seagrass areas and by dip-netting from boats at night with a spotlight. The recreational catch is probably as great as if not greater than the commercial catch, particularly from Port Phillip Bay (NREC 1991).

Management

There is no minimum legal length for garfish taken by recreational fishers but the minimum for all garfish taken by commercial fishers is 20 cm.

Sources: Jones (1979); Parry *et al* (1990); NREC (1991)

SOUTHERN CALAMARI
(Sepioteuthis australis)

Widely distributed in shallow marine coastal waters of southern Australia, southern calamari are mainly found near the bottom in association with weed- or seagrass-covered substrates. They occur down to depths of 85 m, but are most common in less than 20 m.

Biology

Southern calamari are a neritic species of coastal waters and marine embayments. They feed mainly on fish and grow to a maximum weight of about 4 kg, with a body length of 50 cm. Breeding takes place from late winter to spring, when clusters of eggs are attached to marine plants on the sea floor at depths of 3—20 m.

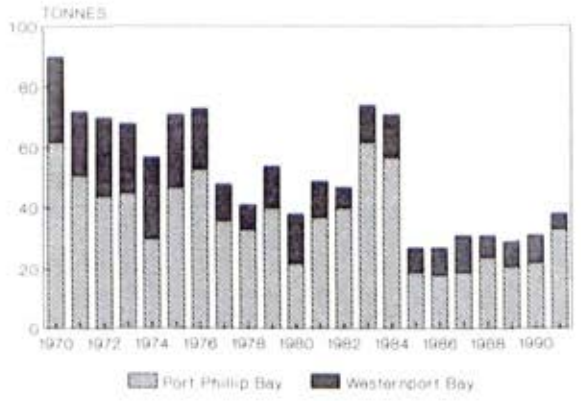
Commercial fishery

Most (up to about 75%) commercial catches are derived from Port Phillip Bay by seining and jigging. Most of the balance comes from Western Port and Corner Inlet, but small incidental catches are also taken by trawlers and Danish seiners working inshore in Bass Strait. The high demand for calamari in the market-place made the fishery worth more than $600 000 in 1990—91.

Recreational fishery

A substantial recreational fishery for calamari has also developed, particularly since the war years when an influx of migrants from southern Europe brought with them the cultural appreciation of its culinary qualities. In 1982/83 the recreational catch in Port Phillip Bay was estimated to exceed the commercial catch.

Figure 7.12: Calamari Landings



Source: Years 1970–84 NREC (1991)

Management

A recreational bag limit of ten squid (all species) per day per person applies. Anglers may use up to four lines at once when fishing for squid, with a maximum of two squid jigs (lures) attached to each line.

Sources: NREC (1991); Parry *et al.* (1990).

FLOUNDER
Greenback flounder *(Rhombosolea tapirina)*
Long-snouted flounder *(Ammotretis rostratus)*

Flounders are widely distributed in Victorian inshore waters, but are most common in sheltered bays and inlets with extensive sandy shallow areas.

Biology

Several species of flat bottom-dwelling fish, collectively known as flounders and soles, inhabit Victorian waters. The most important of these in terms of commercial and recreational fisheries are the greenback and long-snouted flounders.

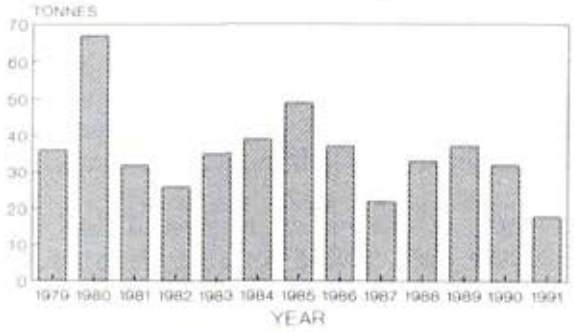
Each lays several hundred thousand eggs, which hatch to produce larvae that are symmetrical and upright-swimming like other fish species. Within several days, however, the initially planktonic larvae begin to lean to one side and the eye on that side begins to migrate to what eventually becomes the 'top' of the fish. After assuming a flattened form, they become demersal and lie in wait to ambush other small bottom-dwelling creatures.

They often bury themselves in the sand, leaving only their eyes uncovered, and can also camouflage themselves by changing colour to match the underlying substrate.

Commercial fishery

Flounders are commercial species, mostly taken in bay and inlet net fisheries. Most commercial landings come from Corner Inlet—Nooramunga, but it is noted that catches from this part of Victoria are in decline (NREC 1991). Commercial catches of sole in Victoria are negligible.

Figure 7.13: Flounder Landings



Recreational fishery

Recreational fishers take flounder mainly at night, by wading in sheltered beach areas and using a light and hand-held spear.

Management

Minimum legal length of 23 cm applies to all species of flounder, and a minimum of 20 cm applies to all species of sole.

Hand-Spear regulations Hand spears may not have more than two prongs and may not have any barbs attached. They may not be used within 30 m of any jetty or the mouth of any creek and may not be used in Curdies Inlet, Mallacoota Inlet, Swan Bay, Sydenham Inlet, Tamboon Inlet, Lake Tyers, Wingan Inlet, or the North Arm of the Gippsland Lakes. In Andersons Inlet and Corner Inlet hand spears may only be used in certain defined areas.

Sources: Last *et al.* (1983); Crawford (1984); NREC (1991)

SILVER TREVALLY
(Pseudocaranx dentex)

Silver trevally are widely distributed in southern Australian waters from north-central Queensland to northern Western Australia. They are also found in New Zealand.

Biology

These opportunistic carnivores can adopt both benthic and pelagic feeding patterns. They can live to 40 years of age and attain lengths of about 100 cm and weight of about 10 kg, although the majority of fish caught in Victorian waters weigh less than 2 kg. First maturity is reached at about 30 cm. No spawning grounds have been identified and adult fish in spawning condition have been found everywhere from estuaries to deep off-shore waters. Spawning occurs in summer, with eggs and larvae being planktonic until development into juveniles at about 12 mm. Juveniles move into inshore areas at about 3 months when they are about 40 mm long. From about 20 cm fish move steadily into open waters and off-shore. Largest specimens are seldom taken in inshore areas. Those found in large schools off-shore are generally pelagic whereas inshore fish in smaller groups are usually demersal.

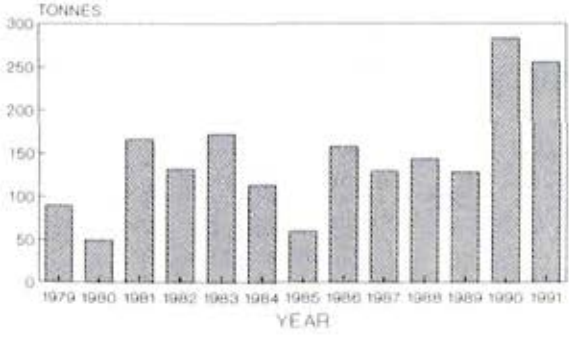
Commercial fishery

Most commercial catches of silver trevally in Victoria are of smaller fish taken in the mixed catch of bay and inlet fishers. Larger fish, however, feature in the by-catch of off-shore shark and trawl fisheries.

Recreational fishery

Although not rated very highly in angler preferences (Barnham and Tunbridge 1990), trevally feature more often in angler bags than some other more highly sought species. They are usually taken by generalist anglers fishing with floated or bottom bait rigs.

Figure 7.14: Silver Trevally Landings



Management

A minimum legal length of 20 cm applies.

Sources: Parry *et al.* (1990); Tilzey (1992); Grant (1987)

TAILOR *(Pomatomus saltatrix)*

Although, distributed around the southern waters from southern Queensland to central Western Australia, tailor are not common in Tasmania or South Australia. In Victoria they are mainly found east of Wilsons Promontory. They are also found in many warm temperate coastal areas of the world.

Biology

Tailor are opportunistic inshore pelagic predators that live to 9 years of age and grow to 120 cm and 14 kg in weight, although fish over 5 kg are considered large. They are voracious predators, mainly feeding on smaller fish.

Juvenile fish 35—70 mm long settle into estuarine areas, where they rapidly grow to about 200 mm before moving into open coastal waters after their first year.

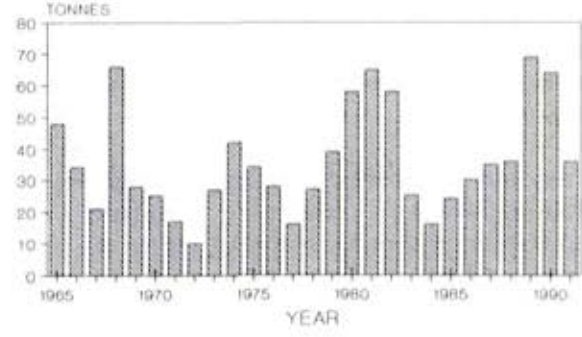
Fish mature in their second year and produce from 200 000 to 2 million eggs, depending on size. Annual spawning migrations to warm semitropical waters take place from late winter to spring. The only known spawning area in Australia adjoins

Fraser Island, Qld. Larvae drift on currents prior to later settlement in estuaries. Tailor in Australian waters are currently considered as one single stock.

Commercial fishery

The main commercial fishery for tailor lies north of Victoria where larger fish are netted from beaches. Locally, they are mainly taken as a by-catch by estuarine netters.

Figure 7.15: Tailor Landings



Note: Victorian landings generally contribute only 5–10% of the total Australian commercial catch.

Recreational fishery

Large tailor have a reputation for fighting and anglers prize them as light game fish. To the north of Victoria they are readily taken from beach gutters and surf zone areas, using fresh and artificial fish baits. Fish in Victoria - mainly immature youngsters found around estuaries prior to northward migration - are opportunistically taken by anglers, but are not targeted to the same extent as larger fish found to the north.

Management

The State minimum size of 23 cm permits the taking of sub-adult fish from estuarine areas. In Queensland a minimum legal size of 30 cm effectively prevents the taking of juveniles. Bag limits apply to recreational fishers in New South Wales and Western Australia but not in Victoria, where recreational pressure on the resource is not considered to be as great.

Sources: Bureau of Rural Resources (1992*a*); Last *et al.* (1983)

BLACK BREAM
(Acanthopagrus butcheri)

Living in estuarine waters of southern Australia from southern New South Wales to central Western Australia, black bream are abundant in Victorian estuaries. They occasionally enter the open sea when estuaries are flooded, and some limited movement between estuaries occurs.

Smaller numbers of closely related yellow-fin bream (*A. australis*) are found in eastern Victoria, which is the southern limit for this generally more northerly species.

Biology

Of these two closely related bream species, black bream is the most abundant and important.

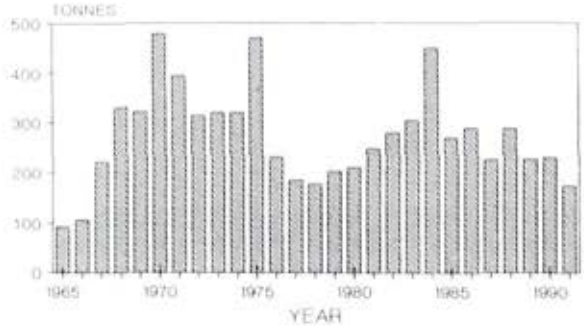
They are omnivorous, feeding on a variety of bottom-dwelling estuarine shellfish and invertebrates, but also consuming some plant matter (algae). They grow to a maximum length of about 60 cm and weight of about 4 kg.

Black bream mature at 3—4 years of age and the spawning season runs from August to January, with eastern populations spawning first and western ones later. Females release eggs several times during the spawning season, to a total of 1—3 million eggs. Recruitment success has been correlated with the amount of fresh water entering the estuarine area and subsequent habitat suitability (NREC 1991). For optimum survival, eggs and larvae require salinity levels of 15—25 parts per thousand (sea water = 35 parts per thousand) for 4—6 weeks after spawning.

Commercial fishery

Most landings of this important estuarine commercial species come from Gippsland Lakes net fisheries.

Figure 7.16: Bream Landings



Note: Landings for 1973 and 1974 are estimates only.
Source: Bureau of Rural Resources (1991); CNR.

Recreational fishery

As the most important recreational fish species of Victorian estuaries, black bream provide an estimated 75% of recreational landings in the Gippsland Lakes region (NREC 1991). Recreational fishing is mainly concentrated in river areas from which commercial fishing activity is excluded.

Management

A recreational minimum legal size of 24 cm applies; the commercial minimum is slightly larger at 25.5 cm.

Resource issues

Stocks of black bream are believed to have declined in some estuaries (such as those of the Genoa and Wallagaraugh Rivers) as a result of habitat degradation.

Sources: Hera-Singh (1992); Parry *et al* (1990); Cadwallader and Backhouse (1983).

MULLET
Yellow eye mullet *(Aldrichetta forsteri)*
Sea mullet *(Mugil cephalus)*

Yellow eye mullet are found throughout estuarine and inshore coastal waters of southern Australia from New South Wales to southern Western Australia. It is known that stocks include distinct 'east' and 'west' subspecies, with Wilsons Promontory separating them.

Sea mullet are found throughout tropical and temperate estuarine and coastal waters of the world from 42^{O}N to 42^{O}S, including those around Australia.

Biology

A number of mullet species occur in Victorian waters, but the most significant and abundant are the yellow eye mullet and sea mullet. Yellow eye mullet grow to a maximum of about 35 cm long with a weight of about 1 kg. Sea mullet live 9 years and grow to 76 cm and 8 kg. Both species mature in their third year, when the former are about 20 cm and sea mullet about 33 cm long.

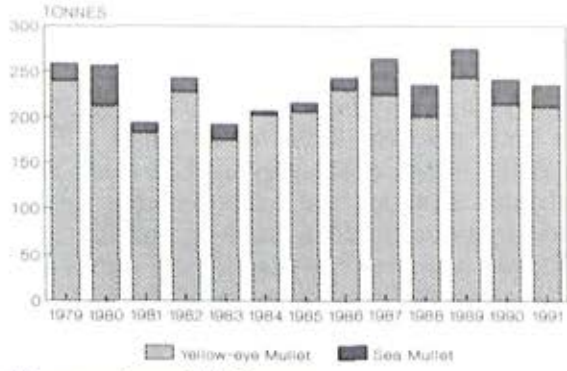
Yellow eye mullet feed mainly on algae and detritus, but also opportunistically prey on small aquatic organisms they may encounter. Juvenile sea mullet feed primarily on detritus, and microscopic plant and animal life of estuaries, but adults feed mostly on algae found further upstream in fresher reaches.

The eastern stock of yellow eye mullet spawns during summer and autumn while the western subspecies spawns in winter. Spawning probably takes place in estuaries, and at sea adjacent to estuaries, with females laying from 100 000 to over 600 000 eggs. In contrast, sea mullet migrate out of estuaries and move northward to spawn relatively large numbers of eggs (1—6 million) from February to July. Yellow-eye mullet larvae drift freely prior to making their way into nearby estuaries. Sea mullet larvae are dispersed by currents along the coast prior to settlement in estuaries at several months of age.

Commercial fishery

Although forming a component of Victorian bay and inlet net fishery landings, yellow eye mullet are not in high demand and generally fetch relatively low prices in the market place. Lesser numbers of sea mullet are taken, mainly from the Gippsland Lakes and Mallacoota. A much larger commercial catch of sea mullet is taken in States to the north, where migrating spawning stocks are netted, mostly for roe export markets

Figure 7.17: Mullet Landings



Recreational fishery

Yellow eye mullet are among the most frequently encountered species taken by recreational fishers in estuary and sheltered inshore coastal areas. They are mostly taken on small bait under a float, especially by anglers using berley. Sea mullet are often observed, but are only infrequently taken due to their mainly planktonic feeding habits.

Management

Minimum size limits applied to mullet taken by amateurs were recently reviewed and removed from regulations. The species do not appear to be over-exploited and recreational anglers currently have no inducement to take small fish in numbers that could affect populations. Minimum size limits, however, still apply for mullet taken by licensed commercial fishers. These are: 24 cm for yellow-eye mullet; 25 cm for sea mullet; and 22 cm for flat-tail and sand mullet.

Sources: Cadwallader and Backhouse (1983); Parry *et al* (1990); Bureau of Rural Resources (1992*a*).

LUDERICK *(Girella tricuspidata)*

This species is found on the eastern coast of Australia from southern Queensland to Victoria and northern Tasmania, and occasionally as far west as central South Australia. Luderick inhabit estuarine areas and inshore areas of the open coast (rarely more than 100 m from the shore platform).

Biology

Luderick are primarily herbivorous, feeding on filamentous algae and seagrass in estuarine areas while cabbage weed forms the basis of their diet along the open coast. They also opportunistically consume the worms, crustaceans, etc. found in association with these food plants.

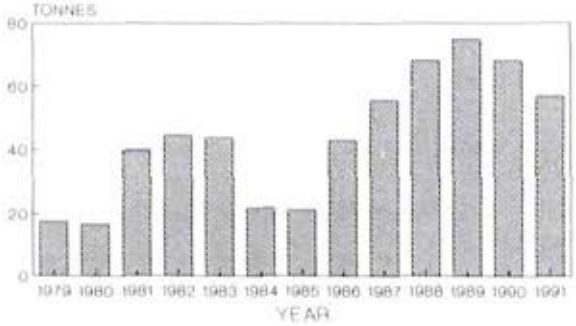
Fish move readily between estuaries, following the open coastline close to the shore. They generally form small groups that move into intertidal areas to feed when the tide floods. Maximum size is 60 cm and 4 kg, but fish over 1 kg are uncommon in Victoria. Fish mature at 2—3 years of age at a length of about 25 cm.

Spawning is believed to take place near estuary mouths, but no sites have been identified in Victoria. Some evidence suggests that luderick undertake a northerly migration prior to spawning, which takes place from late spring to late summer. Small juveniles are known to inhabit seagrass beds.

Commercial fishery

Luderick are primarily taken as a by-catch of the estuary net fishery for bream, being a relatively low-value commercial species and seldom targeted. Most landings in Victoria come from the Gippsland Lakes.

Figure 7.18: Luderick Landings



Recreational fishery

Luderick are a fighting sport fish much sought after by a dedicated band of specialist anglers. They are present in many estuarine and coastal areas of Victoria but are not often taken by generalist anglers. The tradition of fishing for luderick is more firmly established in New South Wales and Queensland than in Victoria, but luderick angling is on the increase, particularly east of Wilsons Promontory. Anglers generally fish with light tackle and use weed bait beneath a float.

Management

A minimum legal length of 22 cm applies.

Sources: Bureau of Rural Resources (1992*a*); Last *et al* (1983); Parry *et al* (1990).

MULLOWAY *(Argyrosomus hololepidotus)*

These fish are found in southern Australian waters from central Queensland to southern Western Australia, but are only rarely encountered in Tasmanian waters. They occur in estuaries, in gutters of surf zones, and near headlands, occasionally venturing out into coastal reef areas down to about 100 m depth. In Victoria mulloway are mainly associated with several of the larger estuaries (Glenelg, Hopkins, Barwon), but occasionally fish have been taken from other areas along the coast.

Biology

They grow to a maximum of about 1.8 m and about 50 kg, with juveniles to 7 kg mainly remaining in large estuaries. These are opportunistic bottom predators, prey on a large number of food items, including smaller mulloway, generally by lying in wait where currents and tide transport prey species.

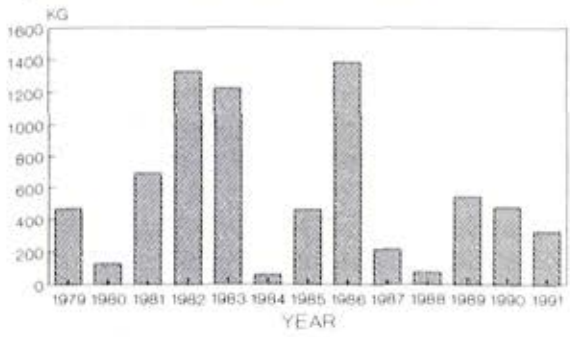
Mulloway do not mature until about 6 years old, 70—80 cm long and about 7 kg. Spawning takes place from late spring to early summer on the ocean side of river mouths and in surf zones near fresh outflows. Larvae and juveniles develop locally at sea before migrating into 'nursery' estuaries of larger river systems when about 10 cm long and 1 year old. Successful recruitment appears to be related to increased larval and juvenile survival during increased flows of fresh water into the sea.

Substantial coastal migrations are undertaken in association with the exit of maturing fish from estuaries and the return of adults to breeding grounds adjacent to nursery estuaries. Some evidence indicates that Australia has several discrete stocks with distinct breeding grounds.

Commercial fishery

Victorian commercial fishers take small numbers of mulloway each year, primarily as a by-catch, and with negligible value. But a substantial ($0.2—$1.2 million) commercial fishery for mulloway operates in south-east South Australian waters.

Figure 7.19: Mulloway Landings



Recreational fishery

Anglers prize mulloway for their size and the challenge involved in their capture and mainly take them by using live bait. Victorian anglers successfully land large adult specimens less commonly than in bygone years, and it is a prestigious event in the recreational fishing community. Most of the fish they take, however, are estuarine juveniles from the Glenelg.

Management

No specific management measures cover mulloway in Victoria. Other States have minimum legal lengths designed to prevent excessive exploitation of juveniles. These are: 33 cm (Qld), 33 cm (W.A.), 38 cm (N.S.W), 46 cm (S.A. - Coorong), and 75 cm (S.A - marine waters). Bag limits also apply in all other States except Queensland.

Resource status

Little is known about Victorian mulloway, but concern has been raised in relation to the apparent demise of catches over recent decades. Most fishing today targets juveniles in Glenelg estuary, recognised as the main nursery area, where large numbers of fish are taken prior to breeding age. The relationship between Glenelg fish and those found in other locations (Hopkins, Barwon, Yarra, Gippsland Lakes, Mallacoota, etc.) is not clear, but there may be several stocks in Victorian waters.

Sources: Bureau of Rural Resources (1992*a*); Grant (1987); Hall (1986).

ESTUARY PERCH *(Macquaria colonorum)* AUSTRALIAN BASS *(M. novemaculeata)*

Estuary perch inhabit estuaries and lower reaches of rivers from northern New South Wales to the mouth of the Murray in South Australia, and are also reported from northern Tasmania. They are relatively abundant in Victoria. By contrast, Australian bass, found in estuaries and lower reaches of rivers from southern Queensland to eastern Victoria, seldom occur west of Wilsons Promontory and are only present in small numbers in Victoria.

Biology

These two closely related and almost identical species are often confused when encountered. Bass prefer freshwater habitat immediately above the tidal influence of rivers; estuary perch prefer more saline habitat below the tidal influence. Both species are opportunistic predators, although estuary perch feed mostly near the bottom while bass frequently rise and feed at the surface.

Male and female estuary perch first mature at about 26 and 31 cm respectively. For Australian bass, the figures are 18 and 22 cm. Both species migrate downstream to spawn, with estuary perch spawning in late spring—early summer and bass in winter—early spring. Both species lay several hundred thousand eggs.

Commercial fishery

Commercial landings of these species primarily take place in estuaries in eastern Victoria, but total only several tonnes per year. The bulk of the catch is estuary perch, although neither species is targeted.

Recreational fishery

While both species are excellent sports fish, they are not intensively exploited in Victoria. They take live baits and artificial lures, but are seldom taken by estuarine anglers using 'lifeless' baits.

Management

A minimum legal length of 25 cm applies to both species, and Australian Bass have received preliminary listing under the *Flora and Fauna Guarantee Act* 1988.

Sources: Cadwallader and Backhouse (1983); Parry *et al* (1990); McCarraher & McKenzie (1986).

OTHER OPEN COASTAL AND MINOR FISHERIES OF VICTORIA

Victoria has more than 500 species of fish in marine and coastal areas, as well as hundreds of crustaceans, molluscs, and other varied life forms. Many of these are used to some extent by humans today. It is not possible to describe each fishery in detail here, and some value judgement has taken place in choosing the minor fisheries described below.

AUSTRALIAN SALMON
Eastern Australian salmon
(Arripis trutta)
Western Australian salmon
(A. truttaceus)

Eastern Australian salmon primarily inhabit waters from southern Queensland to Tasmania as far west as Cape Otway in Victoria and as far east as New Zealand. The Western Australian salmon range extends from southern waters of Western Australia to Bass Strait. In Victoria and Tasmania, schools often include a mixture of both species.

Biology

Studies have shown that eastern and western populations originally considered to be one species - are maintained as genetically separate due to isolated breeding areas. The former breed from November to February in waters from Lakes Entrance to Bermagui. Western Australian salmon breed from February to June in waters from Albany to Perth.

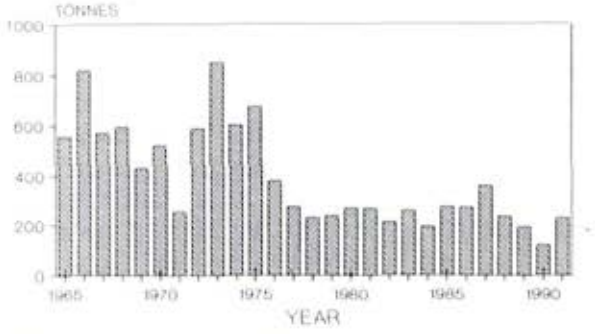
Australian salmon are serial spawners. Planktonic eggs and larvae are distributed in the direction of prevailing currents (the East Australian Current moves southwards, the Leeuwin Current flows eastwards from Western Australia. First-year juveniles of 4—8 cm appear in sheltered waters, bays, and estuaries and subsist initially on opportunistic diets of bottom-dwelling crustaceans and fish (western salmon) or zooplankton and epi-benthic species (eastern salmon).

As maturity approaches, salmon move from sheltered waters into open coastal areas from the surf zone to depths of about 80 m. Adult western salmon feed mainly on pelagic fish (pilchards, anchovies, etc.) whereas eastern salmon feed mainly on zooplankton (euphausiids).

Commercial fishery

The Victorian commercial catch is primarily taken in open coastal waters, and used for human consumption. Large catches of larger fish (originally obtained mainly from around Lakes Entrance) have not been maintained in more recent years. The large commercial catch taken in South Australia and Western Australia (2000—3000 tonnes annually) is mainly used for crayfish bait.

Figure 7.20: Australian Salmon Landings



Note: Figure for 1974 estimated only.

Recreational fishery

Australian salmon are popular target species for shore-based coastal fishers, although trolling from boats also takes place when pre-spawning schools are encountered. No quantitative data are available, but it is acknowledged that salmon provide the focus for a major Victorian recreational fishery: large numbers of anglers regularly congregate at well-known fishing beaches all along the coast. In South Australia anglers are believed to take hundreds of tonnes annually (Cappo 1987).

Management

A minimum legal length of 21 cm applies.

Sources: Bureau of Rural Resources (1992*a*); Parry *et al* (1990); Grant (1987); Last *et al* (1983); Stanley (1980)

BARRACOUTA *(Thyrsites atun)*

These fish inhabit southern Australian waters from Eden, N.S.W., to Albany W.A., and around Tasmania. They occur widely throughout the Southern Hemisphere, but distribution is generally confined to waters of temperature 13^{0}—18^{0}C.

Biology

Barracouta are pelagic marine predators that grow to 105 cm in length and can attain 5 kg or more at a maximum age of around 10 years. Principal food items include euphausids (krill or brit), various small fish species (pilchards, anchovy, jack mackerel, and small barracouta), and small squid. Feeding activity takes place at all hours, but increases at dawn and dusk.

Commercial catch information indicates that large dispersed schools may be found at various times in Victorian waters at depths ranging from surface waters to the bottom. Large schools, when present, form a major component of the marine biomass.

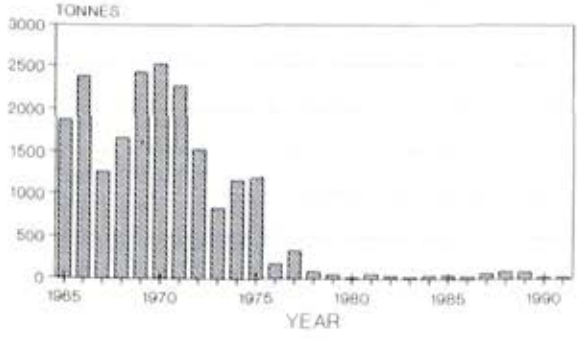
Biologists have previously described several distinct Australian stocks that spawn in different regions: during winter and spring off eastern Victoria; from late autumn to winter off Western Australia and South Australia; during both warm and cold months off western Victoria and eastern South Australia.

The species matures at about 3 years at 55—70 cm. Dolphins, seals, sharks and tunas are known to prey on large barracouta.

Commercial fishery

Prior to 1975 barracouta provided a reliable inshore commercial fishery that fluctuated but generally exceeded 1000 tonnes per year. The decline in catches from the main traditional commercial areas off Victoria (and eastern Tasmania) in the early 1970s is believed to have been caused by changed oceanographic conditions that altered the distribution of food species, with the result that barracouta ceased schooling at the surface close to shore. The quantity landed by seasonal trolling boats was estimated as only a small fraction of the available resource (Winstanley 1979).

Figure 7.21: Barracouta Landings



Recreational fishery

Large barracouta are voracious feeders easily caught by trolling or spinning and when available are sought after by amateur anglers using boats or fishing from jetties.

Sources: Winstanley (1979); Last *et al.* (1983); Grant 1982)

SQUID
Arrow squid *(Nototodarus gouldi)*

This species inhabits open waters from the surface to depths of about 500 to 1000 m where temperatures range between 13^{O} and 20^{O}C. Populations appear most dense around oceanic temperature fronts.

Biology

Fast-swimming pelagic predators, they feed on fish, crustaceans, and smaller squid. They attain a maximum of about 75 cm long and a weight of about 1 kg before spawning and then dying at about 1 year of age. The annual death of the squid population provides a food source bonanza for multiple species in the coastal ecosystem.

Commercial fishery

Commercial catches of squid have until recently been taken as a by-catch. The SET has provided the bulk of recent landings - of 200—500 tonnes annually. Annual (first-sale) value of the catch has been from $400 000 to $800 000.

Experimental targeted fishing conducted by foreign squid-fishing vessels in the late 1970s demonstrated that average catch rates of up to 1.5 tonnes per vessel per day are achievable in waters adjacent to Victoria (Ichikawa 1980). These vessels used automated jigging machines in conjunction with high-powered lights to attract squid (fishing can also take place during the day without the use of lights, but catches are lower).

Attempts by Victorian vessels to establish the fishery have met with mixed success. Apart from problems related to mobility of the resource, demand for squid is highly influenced by catch quality. Overseas vessels snap-freeze the catch immediately to preserve the life-like appearance of the product and attain premium prices on the international market. The

investment involved to do this is high in relation to potential returns for the comparatively small local boats, who currently rely on sales of fresh product on the domestic market. The Bureau of Rural Resources (1991) database information indicates that arrow squid catches (in waters adjacent to Victoria and Tasmania) by non-Australian vessels exceeded 6000 tonnes annually. The open-ocean vessels involved, however, are not only much larger than traditional Australian fishing boats, but also have access to home markets not readily accessed by Australian fishers.

Despite potential for a significant fishery for arrow squid, a careful economic analysis needs to be undertaken to ensure that the potential returns justify the costs of development. Access to the developing fishery for arrow squid is presently unrestricted, and a total allowable catch of 10,000 tonnes is recommended.

Recreational fishery

Most of the recreational fishing is directed at calamari squid, discussed earlier, but arrow squid are also targeted by use of special 'squid jigs' that hook the tentacles. Squid are used for human consumption and as bait for other types of fishing.

Management

A recreational bag limit of 10 squid (all species) per day per person applies. Anglers may use up to four lines at once when fishing for squid, with a maximum of two squid jigs (lures) attached to each line.

Sources: Ichikawa (1980); Winstanley *et al* (1983); Parry *et al* (1990).

PRAWNS
Eastern king prawn *(Penaeus plebejus)*
School prawn *(Metapenaeus macleayi)*

Both species inhabit estuaries and coastal waters along the east coast of Australia from Queensland to Victoria, but are seldom found west of Wilsons Promontory.

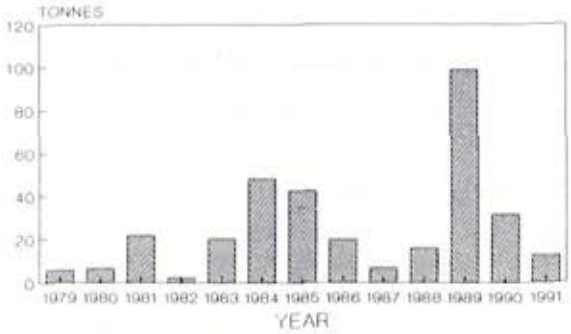
Biology

Both these prawns spawn in off-shore waters and planktonic larvae are carried southward by the East Australian Current prior to juveniles making their way into coastal estuarine areas. Here they grow to maturity before undertaking a spawning migration back out to sea.

Commercial fishery

The commercial fishery for prawns in Victoria is relatively small and mainly confined to stake-net fishing in eastern estuaries and irregular seasonal trawling along Lakes Entrance to Marlo. Average annual reported catches are 25 tonnes for school prawns and 4.6 tonnes for eastern king prawns, but catches vary considerably from one year to the next. Annual value averages about $300 000, but the catch in 1988/89 was worth around $700 000. Most years at least four boats trawl for prawns, but in years when they are plentiful up to 15 boats participate in the fishery between January and June.

Figure 7.22: Prawn Landings



Recreational fishery

Recreational fishers take prawns from coastal estuaries when they are migrating out to sea during nights on the dark phases of the moon from January to April. Fine-meshed dip or landing nets are used to catch prawns spotted by torchlight as they are swept out to sea on the outgoing tide.

Sources: Parry *et al* (1990); Montgomery & Winstanley (1982).

SEA URCHINS
Black sea urchin *(Centrostephanus rodgersi)*
White sea urchin *(Heliocidaris erythrogramma)*

White sea urchins are widespread in southern Australian waters from central New South Wales to central Western Australia, but are not abundant in eastern Victoria. The distribution of black sea urchins is not documented, but they appear to be the most abundant species in

Victorian waters. Both species predominantly live in depths of less than 10 m where reefs exist in sheltered areas of the coast.

Biology

Sea urchins found in Victorian waters are related to sea stars and sea cucumbers. They have five segmented spherical exoskeletons covered with outward-pointing spines that serve as tactile and taste organs. The urchin moves slowly, using muscles at the base of spines to operate these like stilts. Its mouth, which contains five-plated jaws, is on its under-side and the urchin grazes the rock surface as it moves along. As they graze, black sea urchins create 'urchin barrens', devoid of larger brown seaweeds and containing only encrusting coralline algae. White sea urchins feed on algae also, but do not create 'barrens'.

It is known that urchins provide a food source for rock lobsters and that in some way compete with abalone. Reefs experiencing a reduction in these predators and/or competitors have often become overrun with urchins, but the ecological principles involved are not yet clearly understood.

The life span of medium-sized urchins is believed to average 5—6 years.

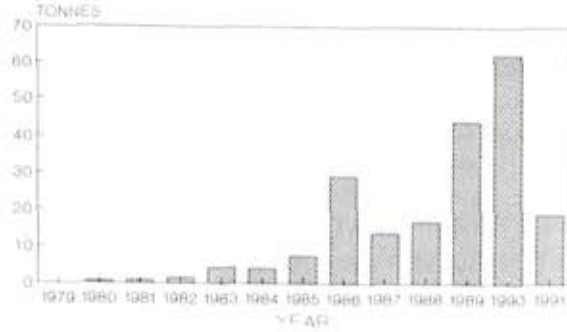
The sexes are separate and maturity is reached at 1 year. Spawning is temperature-dependent, with the black urchin usually spawning in winter and the white urchin in summer. The larvae are planktonic for 3—5 days and probably settle close to the parent reef.

Commercial fishery

Sea urchins are harvested for their gonads (roe), which are highly esteemed on export markets. Gonad yield can vary from 3 to 8% and only yellow or orange roe from younger urchins is saleable. (The roe from older and larger urchins is normally brown).

The Victorian fishery is yet to be firmly established but several different enterprises hold a total of five current permits (some permits cover multiple divers) to take urchins from Port Phillip Bay and east of Point Hicks. The fishery in Tasmania supports about 40 full-time and more than 200 part-time divers and has grown from nothing in 1985 to a current annual value exceeding $2 million. The normal pattern for developing urchin fisheries is for initial harvesting to be less profitable due

Figure 7.23: Urchin Landings



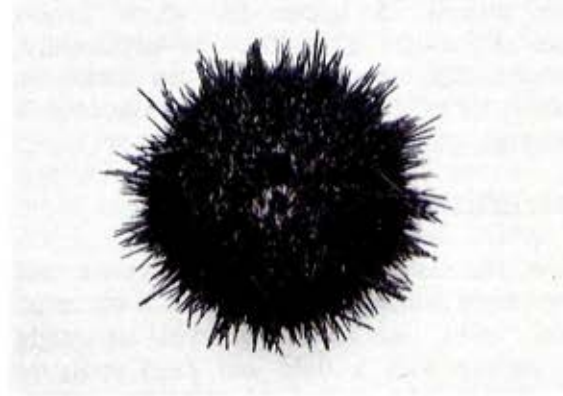
Note: There were no commercial catches prior to the year ending June 1980.

to the small yields of saleable roe. After several seasons of harvesting the roe returns increase, due to lower competition between urchins and also to absence of the larger urchins with unsaleable brown roe. Urchin fisheries are usually associated with high labour costs and require skilled staff to rapidly process and carefully pack roe, which must reach export destinations within 48—60 hours of harvesting.

Recreational fishery

There is no substantial recreational fishery for urchins in Victoria although some specimens may be taken for their novelty or nature study values and also as part of subsistence fishing activity.

Sources: Parry *et al.* (1990); Fell (1987); Bureau of Rural Resources (1992*a*).



Sea urchin.

CRABS

Sand crab *(Ovalipes australiensis)*

Widely distributed in near-shore waters of southern Australia, the sand crab is abundant in the surf zone near all sandy beaches.

Biology

Victorian waters contain a large number of crab species, ranging in size from deep-water king crabs, which may weigh 10 kg or more, to tiny species that inhabit the inshore intertidal zone. Probably the most common of the larger edible species is the sand crab, which grows about 15 cm across the carapace and may weigh almost 1 kg. It has adapted to live in sandy habitats, whereas most other crab species have more restricted habitats associated with reef and/or the intertidal zone.

Little has been published on the biology of Victorian species, but commercial catch trends from eastern Bass Strait indicate that sand crabs have a short life-span.

Commercial fishery

In recent years landings of several species have increased in response to increased local market demand for edible crabs. Prior to this, crabs taken as a by-catch of other fisheries were discarded. Sand crabs are caught in Victoria mainly by trawlers and Danish seiners working in inshore waters. In South Australia they are fished for with baited pots. Large deep-water king crabs are landed as a by-catch of the rock lobster and SET fisheries. Red velvet crabs are also a by-catch of the rock lobster fishery in inshore reef areas.

Total landings of crabs for human consumption in Victoria for the year 1990/91 were around 35 tonnes for which fishers received about $120,000. Additionally, licensed bait gatherers take an unknown quantity of smaller crabs, mainly from eastern Victoria.

Recreational fishery

Some recreational fishers target velvet and sand crabs, mainly with baited hoop nets. Sand crabs are also gathered at night by wading with a light and hand spear or landing net. Many recreational fishers gather small crabs for bait. A number of crabs are also gathered from the shore platform by non-fishers (especially children) who are interested in them for their novelty or nature study value.

Source: Parry *et al.* (1990).

OCTOPUS *(Octopus* spp.*)*

Octopus are widely distributed in coastal areas of all oceans. Off Victoria, smaller species are mainly found at depths of 13—45 m but larger ones at 80 m or more.

Biology

These eight-armed molluscs have no skeleton or shell, and vary in size from several centimetres to several metres. Of more than 120 species throughout the world, nine species of *Optopus* and *Hapalochlaena* occur in the continental shelf waters of southern Australia.

Octopus are eaten by a large number of marine predators and generally seek cover during daylight hours. Smaller ones can effectively hide in or under old shells and light marine growths that are found on mud, sand, and seagrass substrates. Larger octopus require more substantial cover and are seldom found far from reef (or wreck) habitat, where they conceal themselves among cracks, crevasses, and rubble.

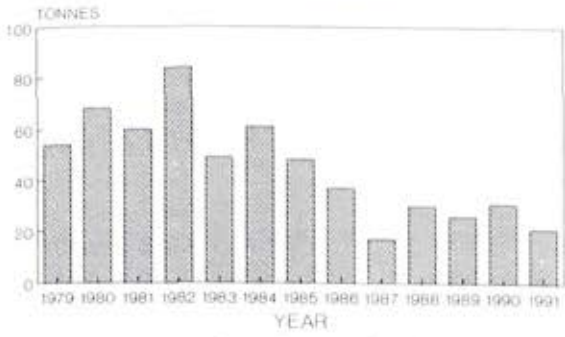
They are carnivorous predators that stalk crabs and other demersal creatures. They seldom catch prey that can actively move away from cover, but corner food species in their hiding places. They also eat shellfish, which they 'drill' into with a special rasping organ. Their saliva contains a neurotoxin and the bite of the blue-ringed, octopus which is found in Victorian waters, can be fatal to humans.

Most species have protracted spawning seasons. Eggs are laid in a hiding place, which the female guards until they hatch. Smaller Victorian species are known to lay 50—350 eggs, depending on the species, but larger ones, such as *O. maorum*, may lay 7000 eggs. Shortly after eggs hatch, the female dies.

Commercial fishery

As well as being in demand for bait, octopus are a traditional cuisine item of many Mediterranean and Asian cultures. They are increasingly in demand in the market-place and fishers currently receive $2 to $4 per kg. Despite some small-scale targeted fishing for octopus in Victoria, commercial landings are predominantly incidental catch, derived from three separate fisheries. Firstly, two small species found on mud, sand, and seagrass substrates are taken from Port Phillip Bay in the scallop and seine net fisheries. Secondly,

Figure 7.24: Octopus Landings



small octopus in Bass Strait are taken incidentally in trawls and Danish seines. Thirdly, significant catches of larger octopus have in the past been taken incidentally in rock lobster pots. Since escape gaps in pots became compulsory several years ago, however, they can escape from pots and landings from this fishery have declined substantially.

Recreational fishery

Recreational fishers and subsistence gatherers take octopus when they occasionally encounter these in tidal pools.

Resource issues

Many commercial rock lobster fishers believe that commercial shark-fishing activity removes a key predator of octopus. This could have an adverse effect on rock-lobster populations.

Sources: Winstanley & Kearney (1982); Russell-Hunter (1987); Parry *et al.* (1990); Bureau of Rural Resources (1992*a*)

AQUARIUM FISH SPECIES

For several decades, new technology has enabled aquarium enthusiasts to keep live marine specimens in display tanks at home. Originally marine aquariums focused on keeping spectacular 'tropical' specimens, but in more recent years interest in display of local Victorian fish and other marine life has been growing. Large tanks that feature fish and marine life specimens (coral, weed, molluscs, crustaceans, etc.) are often valued at several thousand dollars. Even rocks covered with decorative growth can be considered valuable.

Commercial use

Commercial gathering of aquarium specimens has been a relatively small-scale activity, with recent annual landings reported in catch returns not exceeding one tonne. Aquarium specimens, however, can attract very high prices for unusual or quality items and this has increased interest in supplying specimens for a lucrative export market.

Non-commercial use

No quantitative data are available on the non-commercial collection of aquarium specimens.

Management

Commercial collection requires a permit from the CNR.

Issues

Little information is available on the biology and conservation status of many species collected for aquarium usage. Collection and removal of fish, live rock, and marine life from popular diving areas may have a detrimental impact on the recreational experience of divers.

SHORE-PLATFORM FOOD AND BAIT SPECIES

A large number of species found in the intertidal and shallow sub-tidal zones are suitable for use as human food or fishing bait. Collection of these shore-platform species is often neither a commercial nor a recreational pastime, but is better described as a subsistence activity.

Until disrupted by colonial settlement in the nineteenth century, coastal Aborigines carried out this activity for thousands of years. Food-gathering was not restricted to any particular habitat, but rather was a family activity that made use of the species available in sandy beach, rock pool, or mudflat areas. Table 7.2 lists, as example, the species in addition to birds and seals known to have been used by the Gunnai of Gippsland.

In more recent times, however, the activity has been increasingly carried out by new waves of migrants who bring with them the cultural and culinary skills associated with this practice, which is again carried out as a largely family activity. Periwinkles (several species) limpets, mussels, black nerites, and abalone are the main species currently collected.

Many species are also taken for bait by both commercial and recreational fishers.

Table 7.2: Species Used by the Gunnai

Common name	*Gunnai*	*Scientific name*
Exposed rocky shore		
crab	krangalong	various
rock lobster	terndang	*Jasus edwardsii*
shrimp	wath	various
wavy turbo	-	*Subninella undulata*
orange-edged limpet	banawara	*Cellana solida*
variegated limpet	banawara	*C. tramoserica*
beaked mussel	nanjera	*Brachidontes rostratus*
dog winkle	-	*Dicathais textilosa*
top shell (4 spp.)	-	*Austrocochlea* sp.
abalone	walkan	*Haliotis ruber*
rock whelk (2 spp.)	-	*Cabestana sp.*
chiton (11 spp.)	-	9 genera
duckbill		
keyhole limpet	-	*Scutus antipodes*
other limpets	-	5 genera
siphon shells	-	*Siphonaria* sp.
black nerite or crow	-	*Melanerita melanotragus*
Sydney rock oyster	nanduun	*Cassostrea commercialis*
periwinkles (3 spp.)	-	*Melarapha* sp.
beaut. cantharidus	-	*Cantharidus pulcherrimus*
conniwink	-	*Bembicium nanum*
lineated coninella	-	*Cantharidus lineolata*
wine-mouthed lepsiella	-	*Lepsiella vinosa*
southern kellia	-	*Kellia australis*
crenated boring venerid	-	*Venerupis crenata*
Exposed sandy shore		
pipi	pipi	*Plebidonax deltoides*
flame dog cockle	-	*G flammeus*
wedge shells (2 spp.)	-	*Donacilla* sp.
conical top shell	-	*Thaliota conica*
granulated creeper	-	*Cacozeliana granaria*
ribbed coninella	-	*Coninella eburnea*
warted sand whelk	-	*Cymatiella verrucosa*
semiconvex dove shell	-	*Dentrimitrella semiconvexa*
blemished nassarius	-	*Pyrrus burchardi*
jingle shell	-	*Monia ione*
butterfly or wing shell	-	*Electroma georgina*
Cottons bearded horse mussel	-	*Modiolus cottoni*
little black horse mussel	-	*Modiolus pulex*
Estuarine/bay habitat		
mussel	narndewan	*Mytilus edulis planatus*
	marlungdun	
	moornderr	
stepped veneris	-	*Katelysia scalarina*
rigid venerid	-	*Katelysia rhytiphora*
reddish trough shell	-	*Macira rurescens*
sordid sand shell	-	*Polinices sordidus, P. incei*
mud ark	-	*Andara trapezia*
large whelk	-	*Austrosipho maxima*
dosinia	-	*Phacosoma* sp.
papillose volute	-	*Ericusa papillosa*
conniwink	-	*Bembicium auratum, B. melanotomum*
banded nassarius	-	*Niotha pyrrus*
Botany Bay bubble shell	-	*Bullaria botanica*
short bubble shell	-	*Haminoea brevis*
angas' bubble shell	-	*Philine angasi*
razor shell	-	*Solen vaginoides*
little triangle	-	*Notospisula parva*
smoked venerid	-	*Eumarcia fumigata*
Australian flat oyster	-	*Ostrea angasi*

Source: Ferrier-Wesson & Central Gippsland Aboriginal Health and Housing Co-operative (1991).

Commercial Bait Species

There are 29 licences issued for commercial collection of bait species in the intertidal and shallow sub-tidal zones. Species most often taken are sandworms, bass yabbies, crabs, shrimps, prawns, pipis, mussels, and mud cockles. Sandworms represent the most valuable of these resources, with a wholesale value estimated at just under $400 000 for the year 1990/91 (DCE 1992). Landings of sandworms have declined from over 30 tonnes annually in the early 1980s to around 10 tonnes annually.

Management

Commercial bait licences No new bait licences are being issued prior to a review of the bait fishery. Current licensees are restricted by endorsements to use of certain equipment within a specified area.

Shellfish protection areas Regulations prohibit or limit the taking of some species of crustaceans and molluscs from areas of 'recognised shellfish habitat' between Barwon Heads (13th Beach Surf Lifesaving Club) in the west to Arch Rock in Venus Bay (at Inverloch) in the east, as well as all the islands along the

coast between. However, the following areas are excluded: the eastern point of the mouth of the Barwon River off Barwon Heads to the western boundary of the Marine Reserve at Point Lonsdale; the whole of Corio Bay between Point Lilias and Point Henry; the shorelines of Port Phillip Bay southwards from the south bank of the Werribee River to the north bank of the Little River; and the area between the southern limit of the intertidal reef at Kilcunda to Coal Point north of Cape Patterson.

Regulations permit the taking only of squid, octopus, cuttlefish, abalone, squirter, pippi, bass yabbies, rock lobster, crabs, and sand fleas from recognised shellfish habitat. Other regulations (bag limits, etc.) must still be adhered to, but a special bag limit of 5 litres (meat in the shell) for pippi applies.

The only approved method for taking sandworms and bass yabbies from these areas is by means of a hand-operated bait pump with a barrel up to 85 mm in diameter. A sieve may be used in connection with a pump. Only bare hands or feet may be used to collect squirter. The use of any scoop, dredge, spade, shovel, rake, or other digging implement in these habitats is prohibited.

The regulations do not apply to taking of animals from artificial structures of wood, metal, concrete, or plastic; this exemption does not apply to artificial structures of rock or stone such as sea walls, groynes, or breakwaters.

MISCELLANEOUS COMMERCIAL LANDINGS (1990/91)

The following list details Victorian landings of a number of other marine and coastal species that were reported in the catches of commercial fishers during the year ending 30 June 1991.

Table 7.3: Miscellaneous Commercial Landings - 1990/91

Species	(kg) ('00)	$ Value ('000)
Albacore	14	3
Aquarium fish	3	-
Boarfish	45	8
Bream, yellowfin	148	62
Carp (Gipps. Lakes only)	3996	268
Cod, southern rock	3	<1
Cod, unspecified	2	<1
Crab, blue swimmer	12	4
Crab, giant	158	68
Crab, other	218	66
Cuttlefish	<1	<1
Eel (conger)	10	-
Eel (long-finned)	95	12
Gurnard, unspecified	17	2
Harpuku	37	18
Kingfish (yellowtail)	104	32
Knifejaw	2	<1
Latchet	59	7
Leatherjacket (unspecified)	141	16
Ling, rock	4	1
Lobster, shovelnose	4	2
Mackerel, blue	<1	<1
Mackerel, Jack	-	-
Mackerel, unspecified	3086	238
Magpie perch	<1	-
Morwong, dusky	10	2
Morwong, silver	<1	<1
Mullet, flat-tail	36	5
Mullet, red	12	4

Species	(kg) ('00)	$ Value ('000)
Oilfish	8	3
Parrot fish, blue throat	10	<1
Parrot fish, unspecified	36	3
Perch, magpie	<1	-
Perch, orange	37	3
Periwinkle, unspecified	97	8
Pike, long-finned	173	14
Pike, short-finned	13	5
Pike, unspecified	83	7
Queen snapper	3	<1
Ribaldo	1	<1
Ruff	214	33
Shellbait	3	-
Shrimp, ghost	14	-
Silversides, unspecified	16	1
Skate	165	11
Skates and rays, unspecified	17	1
Sole	3	<1
Stargazer	<1	<1
Stranger	169	63
Sweep	28	2
Trumpeter, bastard	3	<1
Trumpeter, striped	205	62
Trumpeter, unspecified	42	3
Tuna, unspecified	35	-
Tuna, yellowfin	27	9
Yellowtail	28	2
Other (all)	2157	1402

MARICULTURE

Mariculture is farming utilising sea or estuarine waters. It can be on-shore, in intertidal or near-shore waters, or off-shore. In restricted circumstances, sea water can be re-cycled in locations remote from the sea.

As with all farming, a source of nutrient or food is required. These can be derived directly from the local environment 'passive feeding' or artificially supplied 'active feeding'. There are a number of pollutant effects associated with mariculture including nutrient stripping, detritus production, etc.

Value

In 1989—90, the value of Victoria's annual mariculture production was slightly in excess of $1.5 million. Inclusion of the value added to wild-caught fisheries products will more than double this figure. Total Australian production exceeded $206 million (O'Sullivan 1991). Unlike wild fisheries, mariculture shows potential for growth. In the second half of the 1980s total Australian production trebled (Treadwell *et al*, 1991) and shows indications of continued growth.

Mariculture production of seafood may reduce pressure on wild fisheries, enhancing conservation and recreational values.

Government jurisdiction

The lead agency for mariculture regulation and development is the Department of Conservation and Natural Resources. Enabling legislation is the *Fisheries Act* 1968.

Other aspects of mariculture are regulated by a variety of Commonwealth and State agencies. Examples include: quality of effluent water, statutory planning, use of Crown reserves, dumping of rocks at sea to form ranch reef, hazards to navigation, coastal landscape values, and consumer safety.

RESOURCE REQUIREMENTS

The requirements of mariculture are influenced by the biology of the varying species being farmed and may vary from industry to industry.

Sea water

The qualities of sea and estuarine water desirable for mariculture - generally those desirable for most other uses - are unpolluted sea water with low coliform levels. These are particularly important for filter-feeding species. Heavy-metal pollution is also undesirable, although some species are more susceptible than others. Preferred sites are distant from effluent plumes and should be in, or adjacent to, areas with good water exchange. Port areas usually have poor water quality and are rarely suitable.

Fin-fish and shellfish crops normally require good-quality water, with minimal chemical or organic pollution and high dissolved-oxygen levels. Fin-fish grow best in nutrient-poor water. Filter-feeders require water rich in planktonic algae - and hence nutrient-rich as usually occurs in bays and inlets. Ocean water usually has too little of this kind of food to promote growth adequate for economic viability. Water that is too rich in nutrient is undesirable, however, as it may depress growth rates itself or promote the growth of toxic or other undesirable algae. Seaweed crops prefer greater enrichment, but cannot withstand levels as high as those found in sewage effluent.

Variation in salinity is not inherently undesirable as, while some are stenohaline, some species are adapted to lower and variable salinities.

Ambient temperatures are generally suitable as most mariculture uses indigenous species adapted to local conditions. Higher temperatures often promote better growth, but without access to cheap heat generated as a by-product of power generation or geothermal heat it is generally uneconomic to heat water (with the possible exception of some on-land re-circulating systems).

The volume of sea water needed for on-shore mariculture facilities varies with species and scale of the establishment. A single establishment probably needs a maximum of around 10 megalitres of sea water a day, and most would require much less. (There have, in the past, been unrealised proposals for trout and salmon mariculture that have suggested requirements in excess of 1000 ML per day.)

Land requirements

Security of tenure is essential, as it enables operators to obtain finance and reach economic viability. On land, the normal means of securing tenure is to obtain a lease and this is

appropriate for on-shore mariculture on Crown and freehold sites.

Off-shore mariculture has the same requirement for tenure, but, in Victoria, an appropriate mechanism has yet to be fully developed. Current operators have a fish-culture permit specifying the area, but it is generally conceded that this is not adequate. Contemporary thought is that the solution to this problem is to lease Crown land underlying an off-shore mariculture farm. Along with the lease would come rights of usage for structures in water above the land. The Department of Conservation and Natural Resources' current policy is to issue such leases, but progress has been impeded by an inadequate statutory framework and, as of September 1992, formal leases have not eventuated.

Infrastructure requirements

Shore-based mariculture is enhanced where access to the normal industrial utilities - the most important of which are electricity, fresh water, and roads - are available, but in some circumstances other utilities may be required.

Off-shore mariculture is like other aquatic activities in that boats are used for transport and produce must be off-loaded, making jetties and other shore-based infrastructure necessary; requirements are similar to those of commercial fishing. Facilities should be close to the mariculture site.

While no mariculture structures exist in shipping channels, ropes, buoys, and other gear used in off-shore mariculture may, depending on their location, pose a hazard to navigation. Port authorities require appropriate marks, lights, and public liability insurance. Economies of scale are such that infrastructural items become proportionally cheaper if ventures are consolidated - hence the establishment of aquaculture zones in Port Phillip.

At this time, stock disease is not a problem, but outbreaks may occur in the future, and the numbers of veterinarians skilled in treatment of fish and shellfish disease are limited. Sale of mariculture produce and public health standards are enhanced if grow-out water is certified to be free of pollutants and toxic algae. In Port Phillip, the Department of Conservation and Natural Resources has a 'clean waters' policy and monitors the water quality using standards that match those of the United States Food and Drug Administration. Applying this standard enhances export, as well as domestic, opportunities for mariculture products. The program does not extend to other marine waters at present.

Site-specific requirements

Exact site requirements vary from industry to industry. See Table 7.4.

As a general rule, exposed areas are not appropriate for mariculture and sheltered areas are more suitable.

High-energy waters can damage support structures: off-shore, buoys and long lines can be moved, tangled, or destroyed, in intertidal areas racks and containers can be damaged, and the pipe-heads of on-shore mariculture operations can be broken. Even in cases where technology has been developed to withstand high-energy waters, costs are still high enough to significantly detract from profitability.

Table 7.4: Requirements of Mariculture Species

Species	Grow-out site	Salinity	Food
abalone	on-shore; ranching	oceanic	formulated food suitable
barramundi	on-shore	oceanic; estuarine	formulated food suitable
live storage	on-shore; off-shore	oceanic; estuarine	nil
mussels	off-shore	oceanic; estuarine	phytoplanktivore (filter-feeder)
oyster, flat	off-shore; on-shore	oceanic	phytoplanktivore (filter-feeder)
oyster, Pacific	on-shore	oceanic; estuarine	phytoplanktivore (filter-feeder)
prawn	on-shore	estuarine	formulated food suitable
salmon & trout	off-shore; on-shore	oceanic; estuarine	formulated food suitable
scallop	off-shore	oceanic	phytoplanktivore (filter-feeder)
sea dragon	on-shore	oceanic	requires live food
seaweed	off-shore; on-shore	estuarine	autotroph

Note: Current CNR policy is to confine Pacific oysters to on-shore locations.

An added problem with off-shore mariculture in exposed sites is that inclement weather increases operator hazard during routine maintenance. Exposed sites have significantly fewer days in a year when maintenance can be undertaken. They do have a slight advantage as far as effluent disposal is concerned, as the high rate of water exchange facilitates the dispersion of pollutants and the breakdown of organic substances.

On-shore water reticulation

Pipes supplying sea water for on-shore mariculture need to be solidly anchored and have intakes placed in water of suitable quality. This is most economic on a solid substratum such as rock.

It is uneconomic to re-circulate water for most kinds of on-shore mariculture. Waste-water must be disposed of, usually by pipe out to sea.

Depending on species, effluent water may have increased nutrient levels. If water flows past the discharge point, enhancing mixing and dilution, disposal will have fewer deleterious effects, and costs of pre-treatment will be correspondingly reduced. Reserved land borders most of the Victorian coast, and mariculture operations may have to construct intake and effluent pipes through this reserve.

To reduce pumping costs for on-shore operations, the site should be as close to the sea as possible in both elevation and distance.

Geographical location

In some cases, areas suitable for mariculture are quite small and situated among unsuited areas. A very detailed description of the coastline would be needed to indentify most of the possible sites.

An unpublished 1983 study by Rankin produced a detailed inventory of potential sites in Victoria: it placed most emphasis on estuaries and embayments and dealt with these areas in a comprehensive manner. Since then, circumstances have changed somewhat and sites along more exposed coastlines may benefit from re-examination.

Mariculture Industries

Victoria currently has three economically viable mariculture industries - based on blue mussels, Pacific oysters, and storage of live fishery produce. There may be pressure for these to expand and technologies based on other species may show potential for development.

Blue mussels

Filter-feeding blue mussels (*Mytilus edulis planulatus*) are grown off-shore on dropper lines hung from buoyed long-lines.

In 1991, there were about 21 mussel farms, mostly in defined aquaculture zones in Port Phillip Bay near the entrance of Corio Bay, but others operate in the Bay at Beamauris, Mornington, and Safety Beach as well as near Flinders in Western Port, Anderson Inlet, and Mallacoota. The Bay also contains a specially defined spat-collection-only zone off Werribee.

Mussel-growing has been proposed for several other sites, one on the northern side of the Middle Sands in Port Phillip Bay and the other off Elizabeth Island in Western Port. Sites require protected areas free from biological and heavy-metal pollution but with sufficient phytoplankton for food. Farms should be near port infrastructure to facilitate maintenance and getting harvest to market.

Annual production of farmed blue mussels is about 400 tonnes, with a landed value of about $880 000 (O'Sullivan 1991).



Mussel farming - Port Phillip Bay.

Pacific oysters

Pacific oysters (*Crassostrea gigas*) are an exotic cupped oyster well suited to domestication. Current policy of the Department of Conservation and Natural Resources is for mariculture of this species to be confined to securely contained waters to prevent feral populations becoming established.

The oysters are farmed in the salt-works at Lara. The current annual value of harvests in

Victoria is about $22 500 (O'Sullivan 1991). A proposed large on-shore farm at Portland has a targeted annual output of about $13.5 million worth of oysters.

Shore-based hatchery/nurseries are needed to supply seed. Some seed, with appropriate health accreditation, is available from other States, but it is costly.

In most places in the world, grow-out of Pacific oysters is intertidal and in estuaries. The most common method is to grow the oysters in mesh bags placed on racks suspended above the sea-bed. Pacific oysters prefer water with salinities of 10 to 30 parts per thousand. They are filter-feeders and require plankton-rich water free from biological and heavy-metal pollution. Under the current constraints, algae-rich water can be obtained from a bay or estuary, or sea-water taken from the ocean, nutrients added, and algae cultivated.

Live storage of fishery produce

Increasing amounts of seafood are sold or exported live. Common types are southern rock lobster (*Jasus edwardsi*), abalone (*Haliotis* spp.), giant king crabs (*Pseudocarcinus gigas*), sea dragon (*Phyllopteryx taeniolatus*), and parrot fish (*Pseudolabrus* spp). Holding live fish and shellfish prior to sale has many requirements similar to those of mainstream mariculture.

Only a small amount of data are available on the location of many live holding facilities. Abalone have been stored live in a barge anchored in harbour water off Portland, and some sea-side fishing co-operatives and commercial processing areas have live storage facilities - for example, at Newhaven. The now-abandoned Pecks factory on Bullock Island had live holding facilities that pumped sea water. Stock is also held in re-circulating systems closer to airports and markets - that is, in urban or industrial areas away from the coast. Aquarium fish are almost exclusively held in re-circulated sea-water systems.

Greater value can be obtained from fish held live. Total exports of live seafood from Victoria are approximately 400 tonnes per annum, and keeping stock alive gives an estimated increase in value of $2 to $4 million.

In coastal facilities, water should have few pollutants and, in the case of stenohaline species such as abalone, no fresh-water dilutant. Since the fish are not fed, there is no requirement for phytoplankton and waste water is low in nutrients. Floating cages require protected water where they present no hazard to shipping but are adjacent to processing facilities.

Other species

Abalone (*Haliotis* spp.) are being experimentally cultivated at Phillip Island, Point Henry, and near Warrnambool, but as yet this is not a commercial activity. Abalone are farmed on-shore and require access to good-quality sea water of oceanic salinities. Phytoplankton are not needed.

Other species - sea dragons (*Phyllopteryx taeniolatus*) and flat oysters (*Ostrea angasi*) - show mariculture potential. It may be possible to base viable aquaculture industries on these species in the near future.

Species such as Atlantic salmon (*Salmo salar*), rainbow trout (*Oncorhynchus mykiss*), barramundi (*Lates calcarifer*), prawns (*Penaeus* and *Metapenaeus* spp.), scallops (*Pecten fumata*), and seaweeds (*Gracilaria* and *Porphyra* spp.) are occasionally proposed as the basis for mariculture, but are unlikely to generate viable industries in the foreseeable future. It should also be noted that new technology may result in many species becoming suitable for mariculture.

ISSUES

* establishment of sustainable harvesting levels for commercially and recreationally valuable species
* future development of industries reliant on marine biota, for example mariculture and sea urchins
* facilities and infrastructure required for commercial activities
* economic significance of the fish resource to Victoria
* fish habitat protection
* provision and analysis of fish catch and effort data
* social significance of subsistence fishing
* allocation of fish to commercial and recreational sectors

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8. EARTH RESOURCES

This chapter outlines the current and potential uses of the natural physical resources along Victoria's coast. These are:

* minerals and extractive industries - minerals, stone, and fuels (coal)
* petroleum oil and gas
* renewable energy sources - wind, wave, tidal, and geothermal energy
* sea water as a raw material
* groundwater

MINERALS AND EXTRACTIVE INDUSTRIES

This section describes the location and relative size of known mineral occurrences and deposits as well as outlining the earth resource potential of the Victorian marine and coastal area, excluding oil and gas. Information has been obtained from previous Land Conservation Council reports, Weston (1992), and Douglas and Ferguson (1988).

The extraction of earth resources in Victoria is conducted under two main areas of legislation, the *Mineral Resources Development Act* 1990 for the exploration and extraction of minerals, such as gold and copper, and the *Extractive Industries Act* 1966 for the extraction and processing of stone. The latter Act defines stone as common natural resources such as rock, gravel, sand, and clay. Both Acts are administered by the Department of Energy and Minerals which grants an Extractive Industry Licence for private land and an Extractive Industry Lease for Crown Land. While ownership of minerals is vested in the Crown, ownership of extractive industry resources is vested in the land-owners.

Mineral occurrences along the coast are described by commodity listed in Table 8.1 and shown on Map 1. They are not economic, either presently or in the foreseeable future.

METALLIC MINERALS

Gold and silver

Minor amounts of gold were recovered from alluvial terraces of the Gellibrand River at Wangerrip, near Princetown, and from sub-basaltic Tertiary gravel at Chilwell, near Geelong. Small quantities were also recovered from beach sands at the western end of Waratah Bay.

Veins of pyrite in the Waratah Limestone near Walkerville, at its faulted contact with Cambrian greenstone, contain minor amounts of silver and traces of gold. This is the most likely source for the nearby Waratah Bay beach deposits. No production has been recorded.

Platinum group metals (PGM)

Strand deposits of these have been located in beach sand in western Waratah Bay. Platinum and osmiridium derived from the adjacent Cambrian greenstone were detected in minor amounts.

Tin

The venture to mine alluvial tin from near Mount Hunter, Wilsons Promontory, was closed because of low grades. Production in the 1920s was approximately 0.1 tonne of concentrate. Corner Inlet has been explored for alluvial tin, but no economic concentrations have been located.

Heavy mineral sands

Thin, discontinuous, storm-wave-concentrated strand-line deposits of heavy mineral sands are found adjacent to headlands along the East Gippsland coast. Deposits at up to 2 m depth in the back beach/foredune area at Point Hicks, Pearl Point, Cape Conran, and Betka River suggest a total reserve of 5070 tonnes of ilmenite with minor zircon and rutile. This is currently considered to be of little economic value (Tan, 1978).

INDUSTRIAL MINERALS AND STONE

Dimension stone

Granites from Cape Woolamai and Gabo Island have supplied ornamental exterior and interior building facings. The Cape Woolamai Granite, now within the Newhaven Flora and Fauna reserve, was initially quarried for the Colonial Mutual Building at 316 Collins Street (now demolished) and was used in a number of other buildings at the turn of the century.

Table 8.1: Mineral Deposits of the Victorian Coast

Location	Resource class[1]	Map number[2]	Easting[2]	Northing[2]	Location accuracy[3]
METALLIC MINERALS					
Gold					
Wangerrip	MIN	7520	-	-	-
Chilwell	MIN	7721	-	-	-
Waratah Bay	MIN	8120	-	-	-
Silver					
Waratah Bay	OCC	8120	413300	5697200	2
Platinum Group Minerals					
Waratah Bay	OCC	8120	415000	5703400	3
Tin					
Wilsons Promontory	OCC	8120	452800	5703900	2
INDUSTRIAL MINERALS AND STONE					
Dimension stone - granite					
Cape Woolamai	MIN	7920	356800	5731700	1
Gabo Island	MIN	8822	756600	5838700	2
Heavy mineral sands					
Point Hicks	OCC	8722	701000	5816000	2
Pearl Point	OCC	8622	666000	5816000	2
Cape Conran	OCC	8622	653000	5815000	2
Betka River	OCC	8822	742400	5836900	2
Anglesea	OCC	7721	253500	5742500	2
Limestone					
Portland	MAJ	7121	541400	5756000	1
Warrnambool	MIN	7424	640650	5744200	1
Strathallan	MIN	7421	640650	5744200	1
Point Lonsdale	MAJ	7821	291700	5761900	1
Walkerville	MIN	8020	412800	5698500	2
Yanakie	MIN	8120	436300	5689500	1
Yanakie South	MIN	8120	436400	5689000	1
Phosphate					
Princetown	OCC	7520	687400	5714900	1
Point Addis	OCC	7721	257500	5746200	2
Torquay	OCC	7721	263600	5757300	2
Potash (jarosite)					
Anglesea	OCC	7721	261000	5748400	2
Salt					
Lara	MAJ	7721	274500	5784800	1
Point Henry	MAJ	7721	273000	5773500	1
FUELS					
Black coal					
Kilcunda	MIN	7920	363400	5733200	1
Cape Patterson	MIN	8020	374600	5720700	1
Brown coal					
Bacchus Marsh—Altona	MAJ	7822	-	-	1
Gelliondale—Alberton	MAJ	8220	-	-	1

Source: Weston (1992).

Notes:

1. Resource class MAJor, MINor and OCCurence
2. 1:100 000 map sheet number and Australian Map Grid Co-ordinates
3. Location accuracy indicates the precision of the grid reference with respect to the stated position: 1 - within 100 m; 2 - within 1000 m, 3 - approximate only.

Limestone

Limestone of various ages has been used from along the coast. Devonian Waratah Limestone was quarried from coastal cliffs in the Walkerville area and burnt for lime in the early part of the century.

At Trewalla, west of Portland, the Portland Limestone Company quarries Bridgewater Formation (Pleistocene calcarenite or dune limestone) for agricultural lime. Calcarenite at Warrnambool has provided sawn blocks for building as well as road-making and agricultural lime. At Yanakie, 5 m thick calcarenite has been quarried for agricultural use.

Several quarries in the Strathallan area, east of Warrnambool, extract limestone from the Miocene Port Campbell Limestone deposits, for agriculture and road-making.

At Point Lonsdale, Recent shell beds are excavated for shell grit and fine carbonate sand, which is used in glass manufacture.

Phosphate

The coastal exposure of the Dilwyn Formation around the Aire River mouth and around Princetown includes horizons with up to 3% phosphate, but investigations have failed to delineate a sizeable deposit. Minor occurrences of phosphate are also present in the Tertiary sediments around Point Addis and Torquay.

Potash (Jarosite)

Seams and large masses of jarosite are exposed in coastal cliffs between Rocky Point and Point Addis near Anglesea. The jarosite formed as a result of oxidation of pyrite in carbonaceous sand of the Demons Bluff Formation. It occurs in beds up to 3 m thick that can be traced for 3 km. The 19 tonnes of basic iron sulphate recorded as produced near Anglesea in 1871 was most probably jarosite. The deposits were also worked during 1926 and 1927, when the jarosite was roasted for the recovery of 100 tonnes of red oxide pigment.

Salt

Cheetham Salt Ltd operates two solar marine evaporation plants at Point Henry and Lara. Solar evaporation concentrates circulating sea water in a series of concentration and crystallising ponds, and salt is harvested from the floors of these. Total production is approximately 60 000 tonnes per year.

Crushed rock

Hard rock quarries produce graded crushed rock and aggregate for road surfacing and concrete, railway ballast, and filter and bedding materials for dam construction, pipe-laying, and beach-erosion-prevention structures. Approximately 70% of the total Victorian production comes from quarries within the Melbourne Supply Area. Basalt and scoria from Newer Volcanics, basalt from Older Volcanics, Palaeozoic acid volcanics, granite, hornfels, and sedimentary rocks are suitable source rocks.

The major coastal quarries occur on the Bridgewater Promontory, south-west of Portland, Port Fairy, and Point Wilson where Newer Volcanic basalt is quarried. Granite quarries include the operating Pioneer and Hillview quarries at Arthurs Seat, Dromana, 2 km inland, and the recently closed Mount Martha quarry. Palaeozoic and Mesozoic sandstones and siltstones provide sources of relatively low-grade or marginal-quality road-making material.

Gemstones

Pebbles of jasper, serpentinite, green tourmaline, and green nickel-bearing quartz occur in the sandy coves of Cape Liptrap and Walkerville. Granite in the Yanakie area contains small specimens of garnet, zircon, green and blue sapphire, topaz, and almandine ruby. At Wilsons Promontory, tourmaline is found in granite as masses and large well-formed crystal and in quartz reefs.

Agate occurs along the south coast of Phillip Island around Kitty Miller Bay. It is small and brightly coloured, with pink, red, and grey banding. Small sapphires and zircons have been found in beach sands at Merricks. A variety of agate and other semi-precious stones have also appeared in beach gravel along the Otway coast at Moonlight Head and Pebble Point. These are presumably derived from conglomerate in the Pebble Point beds.

Zeolites

In the basalt flows of Older Volcanics exposed in the coastal cliffs between Flinders and Cape Schanck, and on the Phillip Island south coast, zeolite and associated carbonate species are prolific within vesicles. The zeolite occurrence

at Cairns Bay, near Flinders, is of international significance. Small zeolites have also been recorded in the Cape Grant quarry, near Portland.

FUELS

Legislation covering coal extraction

Coal is defined as a mineral under the *Mineral Resources Development Act* 1990. Any exploration and initial development of new coal deposits would occur under this legislation. Previous large economically significant developments of coal have been exploited under specific legislation, giving mineral rights to the developer. Examples include the Alcoa coal-mine at Anglesea and coal in the Latrobe Valley area, for which the *SEC* Act gives sole ownership to the State Electricity Commission of Victoria.

Black coal

The Kilcunda and Cape Patterson coal seams - outliers of the main Wonthaggi—Korumburra coalfields - outcrop on the coastal cliffs and along the shore platforms between San Remo and Cape Patterson. They were exploited from 1910 to 1967, operating on a single seam up to 0.7 m thick and producing 522 275 tonnes from an area of 60 ha.

Brown coal

Large deposits of brown coal accumulated during Tertiary times in slowly subsiding basins, with the largest deposits located in the Latrobe Valley coalfields of the Gippsland Basin.

The Gelliondale Coalfield has been proved onshore over an area 11 km by 1.5 km, with extensions offshore. Economically workable coal is confined to the coastal plains with an elevation of 15 m within the parishes of Welshpool and Alberton West. The thickness of the seam varies from a few metres to 118 m, but averages 40 m over about 850 ha. The seam underlies 3—5 m of sand, clay, and gravel. Recoverable reserves are 1050 million tonnes, with an overburden:coal ratio of less than 0.5:1. This indicates *in situ* resources of at least 1700 million tonnes and implies 3500 million tonnes.

Brown coal deposits are present at depth along 100 km of coast from Corner Inlet to Ocean Grange, where near-surface onshore deposits extend offshore. Given current technology and alternative sources, these are currently considered to be sub-economic. The Bacchus Marsh—Altona brown coalfield is buried under Newer Volcanic basalt and Miocene sediments. It extends offshore at depth along the coast from Altona to Werribee. The 22 m thick seam was worked at Altona 1910—19, with total recorded production of 33 780 tonnes, but is similarly considered sub-economic at the moment. Additional sub-economic brown coal underlies the Koo-wee-rup Swamp area at depth, along the north coast of Western Port.

The Anglesea brown coal seam extends offshore at depth near Anglesea and outcrops on the beach at Eastern View.

Tenements

As of June 1992, there were no tenements granted under the *Mineral Resources Development Act* 1990 for the exploration or extraction of minerals along the Victorian coast. Under the *Extractive Industries Act* 1966, 13 Extractive Industry Licences granted on private land and five Extractive Industry Leases were granted on Crown land along the coast, as summarised in Table 8.2. Applications for five Extractive Industry Search Permits targeting offshore sand deposits in Port Phillip Bay and Western Port have been submitted, but as yet have not been granted.

Production

During 1990/91, the Department of Energy and Minerals supervised coastal operations producing more than 600 000 tonnes of extractive material, worth almost $7 million (see Table 8.3). This was approximately 2% of the total State production. Most of this material was Newer Volcanic basalt derived from beneath private land. Only relatively small quantities of non-concrete sand and crushed and agricultural limestone was derived from beneath public land.

EARTH RESOURCE POTENTIAL

The potential for finding new economic resources of metallic minerals along the coast or marine areas is low, with the possible exception of the Waratah Bay greenstone area. Developing further resources of industrial minerals and stone has greater potential, despite strong competing demands for non-extraction. This discussion excludes shell grit and sand extraction from less than 2 m depth, which requires only Department of Conservation and Natural Resources approval.

Table 8.2: Coastal Tenements (June 1992)

Number	Commodity	Area (ha)	Municipality	Map number[1]
EXTRACTIVE INDUSTRY LICENCE (private land)				
LIC 417/2	Sandstone	3.77	Otway	7620
LIC 588/1	Basalt,sand limestone	58.12	Portland City	7221
LIC 700/1	Limestone	45.50	Bellarine	7821
LIC 874/3	Sand	9.93	South Gippsland	8120
LIC 882/1	Gravel,sand	7.25	South Gippsland	8120
LIC 993/1	Limestone	11.13	Warrnambool	7421
LIC1016/1	Limestone	2.61	Belfast	7321
LIC1029/0	Basalt	131.19	Corio	7721
LIC1107/0	Basalt,sand	112.57	Portland	7221
LIC1114/1	Sand	7.98	Portland	7221
LIC1151/1	Basalt	35.54	Belfast	7321
LIC1302/0	Limestone	12.04	Warrnambool	7421
LIC1422/0	Limestone	78.13	Warrnambool	7421
EXTRACTIVE INDUSTRY LEASE (Crown Land)				
LSE 49/1	Sandstone	2.15	Winchelsea	7620
LSE 109/0	Limestone	5.80	Warrnambool	7321
LSE 130/1	Limestone	3.98	South Gippsland	8120
LSE 138/1	Limestone	2.44	South Gippsland	8120
LSE 298/1	Sand	17.67	Portland	7221

Note:
1. 1:100 000 map sheet number

Source: Department of Manufacturing & Industry Development

Table 8.3: Coastal Production of Extractive Materials 1990/91 (Under *Extractive Industries Act* 1966)

Commodity	From Crown land		Total		Percentage of total Victorian production
	Quantity (tonnes)	Value ($)	Quantity (tonnes)	Value ($)	
Basalt	-	-	488 490	6 274 261	6
Filling	-	-	9 600	9 600	10
Limestone (agricultural and crushed)	3 066	42 924	81 182	318 835	23
Sand (non-cement)	10 394	98 482	26 894	201 811	2
Sandstone	-	-	16 364	156 627	4
TOTAL	13 460	141 406	622 530	6 961 134	2

Source: Department of Manufacturing & Industry Development

Extraction of granite and bluestone (basalt) dimension stone could expand along the coast. Potential granite dimension stone outcrops at Cape Woolamai, Yanakie, Wilsons Promontory, Dromana, and East Gippsland and potential bluestone areas include Portland and Port Fairy.

The Tertiary Port Campbell embayment (Moonlight Head to Peterborough) and the Torquay Group (Eastern View to Torquay) sediments offer considerable potential for future limestone extraction along the coast.

Significant potential exists for the extraction of calcareous sands in central and western Victoria. The extensive mobile dunes fringing Discovery and Bridgewater Bays contain enormous quantities of unconsolidated calcareous sand of 60—95% calcium carbonate, representing a potential inexpensive source of lime for agriculture and glass-making. Calcareous sand, generally associated with Pleistocene calcarenite, is also present along the coast at Portland Bay, Warrnambool, Cape Otway, Barwon Heads, Point Lonsdale, Nepean Peninsula, Venus Bay, and Yanakie Isthmus.

Similarly significant potential applies to the extraction of siliceous sands from central and eastern Victoria. Inland from the coast at Lang Lang, Westernport, an important silica sand quarry produces glass-making and other sands, with perhaps further deposits nearby. The sandy barriers and large mobile sand dunes of East Gippsland also provide another possible silica sand resource. Coastal areas include Corner Inlet, Ninety Mile Beach, Point Ricardo to Rame Head, and Mallacoota to Cape Howe. Considerable potential also exists for high-grade sand deposits in the Tertiary sequences of the Otway and Gippsland basins.

As well as onshore deposits, offshore sand can be utilised. Within Port Phillip Bay, government bodies use sand deposits off the eastern and southern coasts to renourish eroded beaches, although their future commercial availability is uncertain.

Sand from capital dredging (one-off dredging of shipping channels), could be made commercially available rather than disposed of at sea. Similarly, sand from maintenance dredging (regular dredging of channels), that is not required along the shore to prevent beach erosion could be commercially useful. Possible examples include sand dredged from The Narrows, inside the entrance at Lakes Entrance, and the western entrance at Western Port. This use should not conflict with returning sand from maintenance dredging to the littoral system to prevent erosion of adjacent beaches. Such sites include Portland, Apollo Bay, Queenscliff, Mordialloc Creek, and Patterson River.

PETROLEUM - OIL AND GAS

Petroleum (oil and gas) exploration is a very high-risk and expensive operation. The success ratio is highly variable. Depending on the size of the field, geological structure, and quality of geophysical and geological interpretation, it may vary from the first exploration drill-hole striking petroleum to several dry holes being drilled. Figure 8.1 illustrates the exploration process.

The economics of petroleum exploration vary, too, depending not only on the market price of oil and gas, but also on company policy and structure, locality of field, and infrastructure required. As a general rule of thumb, 50—150 million barrels of oil is marginally economic offshore, while onshore deposits can be an orders of magnitude less - that is, 100—300 thousand barrels.



Floating petroleum exploration platform production tests Minerva-1 well - Otway Basin

Figure 8.1: Summary Flow Chart for Petroleum Exploration/production

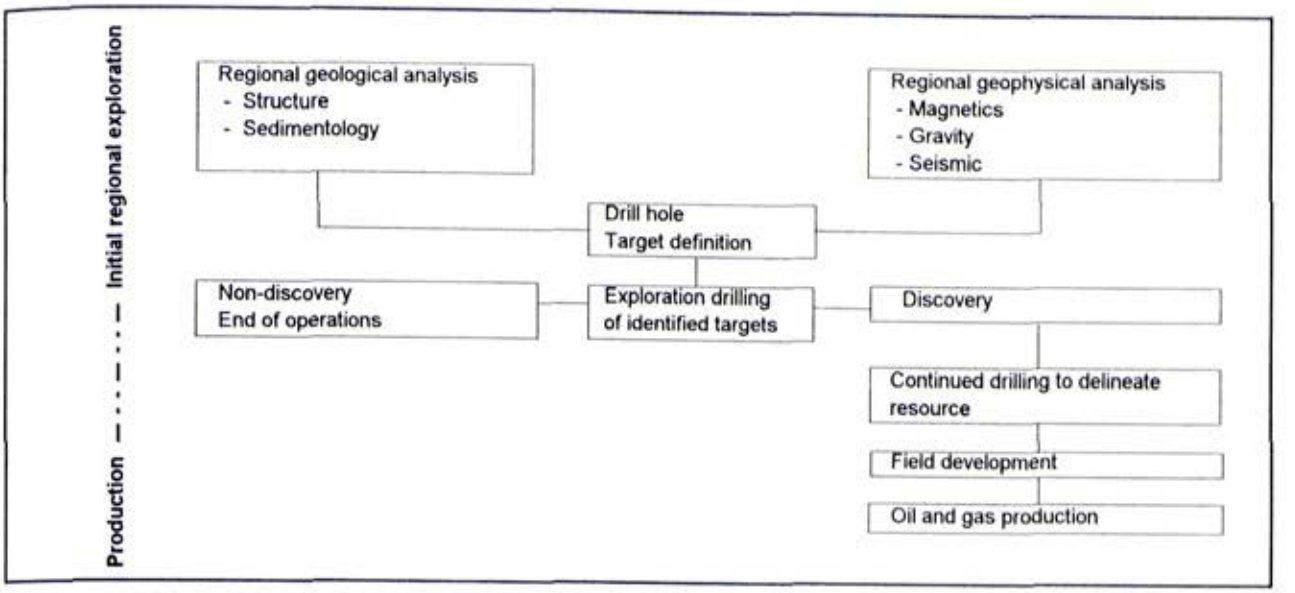
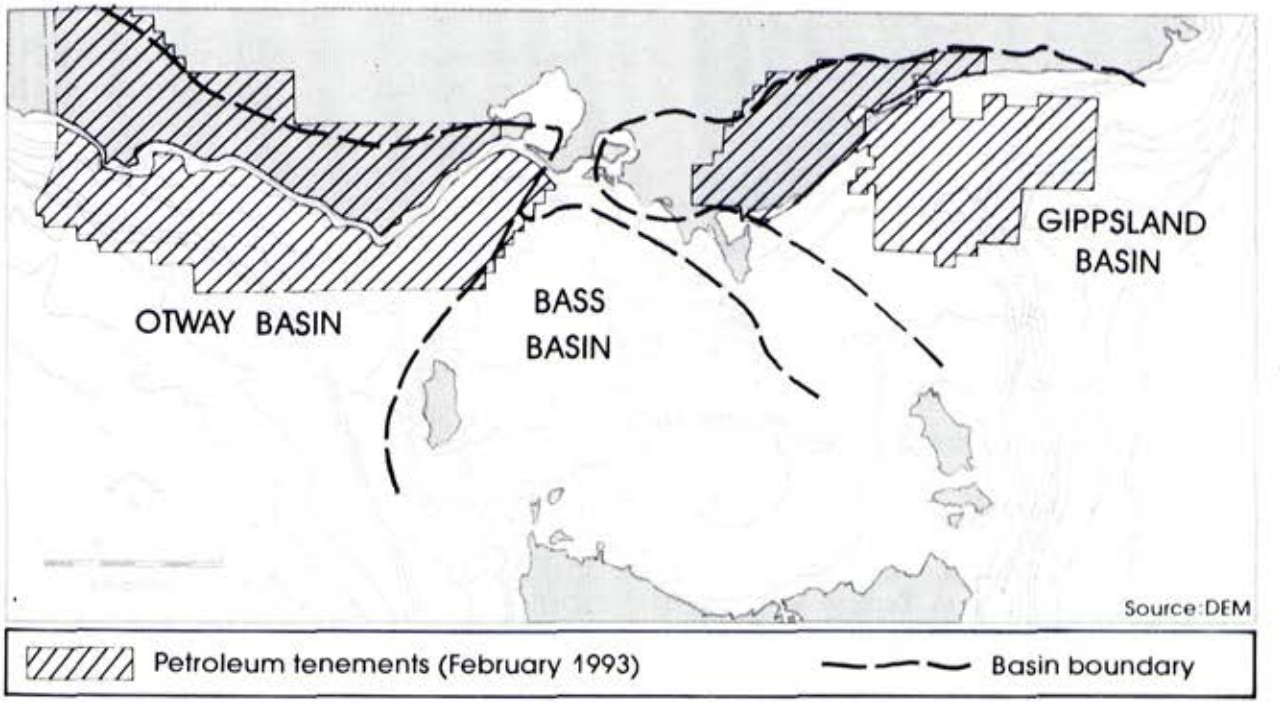


Figure 8.2: Victorian Petroleum Tenements



Two major basins of petroleum potential occur in Victorian coastal areas and adjacent Commonwealth waters: the Gippsland Basin in eastern Victoria and the Otway Basin in the west (see Figure 8.2).

Gippsland Basin

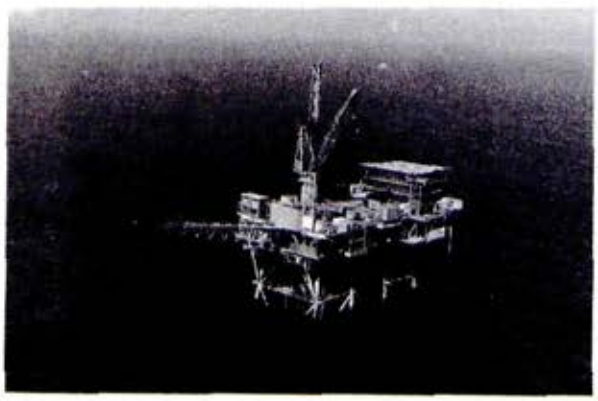
The Gippsland Basin is the only one currently productive. All production comes from platforms that lie at least 15 km offshore and outside Victorian waters (see Map 4). Oil and gas are brought onshore by pipelines in the Ninety Mile Beach area, and piped for processing in plants at Longford near Sale. Offshore facilities are serviced from Victoria by land and sea, from ports such as Lakes Entrance.

Oil and gas were first discovered in 1924 at Lake Bunga in a water well drilled near Lakes Entrance. To 1993, 169 onshore wells have been drilled, establishing only one sub-economic and five uneconomic accumulations. Exploration in offshore areas commenced in 1964. The first well, Barracouta-1, was drilled in late 1964 and produced gas in early 1965. In the last 28 years, 37 discoveries have been made offshore in the Gippsland Basin. Of these, 17 fields are under production. The

commercial oil and gas-fields so far brought into production originally contained 3.65 billion barrels of oil and 8.8 trillion cubic feet of gas, of which less than one-third (oil) and two-thirds (gas) respectively remain.

Some of the undeveloped fields - such as Turrum, Kipper, Blackback, and Terakihi - contain a substantial petroleum resource. These and other discoveries will be developed when considered commercial. They contain a total of 906 million barrels of oil in-place and 4.76 trillion cubic feet of gas in-place.

As stated, 100—300 million barrels of oil in various fields appears marginally economic. This resource may be developed in the future.



Flounder-oil and gas production platform.

Otway Basin

The Otway Basin (Figure 8.2 is a west-to-north-westerly-trending trough. It occupies about 18 500 sq km onshore and 26 000 sq km offshore, mainly in Commonwealth but also including Victorian waters. The Basin contains a sequence of Mesozoic to Tertiary sediments up to 8000 m thick, overlying an igneous and metamorphic basement. These thick sequences of volcanogenic Otway Group Sediments were deposited in an intracratonic basin before the rifting between Australia and Antarctica.

Petroleum exploration in the Otway Basin commenced in 1941. To April 1993, 105 onshore and 11 offshore wells have been drilled. Evidence of oil and gas is common throughout the Otway Basin. The most significant occurrences are small gasfields in the Basal Upper Cretaceous Sandstone in its eastern part. Oil columns in the Basal Tertiary and Lower Cretaceous Sandstone in the central area have also been discovered. Carbon dioxide presence here is believed to be related to the oxidation of petroleum during local volcanic intrusion. The carbon dioxide seepage at Clifton Springs on the eastern margin of the Basin appears to be moving through geological faults and is highly significant to oil and gas exploration here.

Petroleum permit areas

Almost 100% of the prospective onshore Gippsland and Otway Basins and 90% of their prospective offshore sections are currently covered by either Exploration Permits or Production Licences and each offer of new acreage has attracted much interest (see Figure 8.2).

Administrative and legislative context

Three Victorian Acts control the oil and gas industry in the Victorian coastal onshore and adjacent offshore areas: the *Petroleum (Submerged Lands) Act* 1982, *Petroleum Act* 1958, and *Pipelines Act* 1967.

The Petroleum (Submerged Lands) Act 1982 is `mirror legislation' to the Commonwealth PSLA 1967, but operates in the area between mean low-water mark and 3 nautical miles seawards. It gives effect to a resolution passed at the Premiers' Conference on 29 June 1979, which agreed on a legislative package to be drawn up by all States and the Commonwealth that would result in the return of the territorial sea to the adjacent States in relation to the administration of certain matters, including ports and harbours, fisheries, marine parks, historic shipwrecks, crimes at sea, and the exploitation of the mineral resources of such area.

Major matters it covers include: the relationship between the Commonwealth and the State Acts' jurisdiction and management; the issue of exploration permits; retention leases and production licences for petroleum; the issue of pipelines licences; the registration of legal instruments; and general administrative procedures.

Water areas such as Port Phillip Bay, Western Port, and Corner Inlet are not subject to the provisions of this Act, under the terms of agreement of the `baseline', but fall within the jurisdiction of the onshore *Petroleum Act* 1958.

Petroleum Act 1958 covers petroleum exploration and development onshore in Victoria, and permits construction of gathering pipelines of limited length between well-heads and treatment facilities. The maximum holding

permitted under a Petroleum Exploration Permit is 12 500 sq.km. The Act also provides for the issue of Petroleum Production Leases and general administrative procedures, and prescribes the royalty rates applicable to hydrocarbon production.

The *Pipelines Act* 1967 provides for control, ownership, location, construction, and operation of pipelines.

RENEWABLE ENERGY SOURCES

Interest in this topic has increased over the last 20 years as a result of the sharp increase in the oil price that occurred in the early 1970s, as a means of reducing CO_2 emissions from the burning of fossil fuels, and as economic alternative to other forms of power generation. Coasts may provide three renewable energy sources - winds, waves, and tides - that can be converted to electricity.

Although an extensive electricity distribution grid reaches all of the main populated areas of the Victorian coast, renewable energy has two potential roles. It can contribute to the total generating system and it offers grid support. As demand increases at the extremities of the grid, it provides an opportunity to introduce local generating capacity close to the demand rather than improving the distribution system. This distributed generation concept is receiving increased attention in the United States.

In order to make a reasonable contribution, power generation from a particular site would need to be in the range of 1—5 MW. Consequently, renewable energy sources along the Victorian coast have been assessed in this context.

Geothermal resources, also present along the coast, may provide direct heating, thus substituting for heat derived from fossil fuels.

WIND ENERGY

Wind-powered generators, which are usually built on land, can convert wind energy to electricity. The energy is proportional to the wind speed cubed.

In the early 1980s a review of Victorian wind data, to identify prospective areas for wind generation, showed that the coastal regions have the greatest potential. Following the review, a detailed assessment of 50 coastal sites led to establishment of 10 wind-monitoring stations in 1985. Wind speed was recorded for the following 2 years. Results suggested that two coastal stretches had the highest wind energy: from the South Australian border to Cape Otway and from Portsea to Wilsons Promontory. Possible candidate areas for megawatt-scale wind farms (wind regime of 8 m per sec. or greater with sufficient area to hold several machines) were at Bridgewater, Port Fairy, Port Campbell, Apollo Bay, Kilcunda North, Cape Liptrap, Yanakie, and Toora.



Breamlea wind turbine.

The wind speeds measured along the Victorian coast, although not the strongest in Australia, have good potential for future wind generation. A demonstration grid-connected wind turbine has been tested on the coast at Breamlea between Point Lonsdale and Torquay. The SECV is evaluating (1992) tenders to install and operate a 10 MW wind farm at Toora, planned to be operational by mid 1994, which should produce about 30 GWh - enough electricity for the needs of some 5000 households.

WAVE ENERGY

Installations to convert wave energy to electricity may be built either on the shore (given favourable topography such as headlands and exposed sections of coast with deep water to the shore) or offshore. Offshore installations may overcome the constraints imposed by unfavourable topography or other uses of the shore.

In 1992 several prototype wave-energy devices had been demonstrated around the world including two in Norway and one each in Denmark, the United Kingdom, Japan, and India.

Wave power is proportional to the square of wave height (and therefore wind speed, the time for which the wind blows, and the length of water over which the wind blows) and wave period. Victoria's enclosed waters - bays and inlets - are too protected for the production of sufficient wave energy. Wave energy is described more fully in Chapter 2.

The most energetic zone stretches from the South Australian border to Cape Otway, with the mean offshore wave power estimated at about 46 kW per m of wave front. The wave energy is generated from the westerly swell of the Southern Ocean.

Wave-climate energy varies markedly across the zone from Cape Otway to Wilsons Promontory. From Cape Otway to Point Lonsdale the mean annual offshore wave power is about 9 kW per m. It increases to 12 kW per m at Cape Schanck, to 17 at Cape Paterson, and to 19 at the Promontory. It is generated from both the Tasman Sea to the east and the Southern Ocean to the west.

Offshore wave power averages 13 kW per m between Wilsons Promontory and Cape Howe. The wave energy is generated in the Tasman Sea to the east.

From a resource point of view an average offshore wave energy of 30 kW per m is considered attractive, so offshore waters from the South Australian border to Cape Otway have high potential. Based on available energy and coastal topography (water at least 10 m deep immediately offshore) the report suggested Cape Sir William Grant, near Portland, as a favourable site for a demonstration wave-energy facility.

TIDAL ENERGY

Tidal energy can be harnessed from currents generated at the entrances to bays and estuaries as they fill and empty with the rise and fall of the tide. It is generally considered that the average tidal range needs to exceed 5 m for for this to be viable option for electricity generation.

The Victorian ocean coast has a range of 0.5 to 2.0 m, with its maximum in the central region of Bass Strait, which is also the only part with large bays or estuaries having any significant potential for tidal power development. The approximate energies of these bays and estuaries have been assessed by the SECV and would be capable of producing some 1500—2000 GWh a year, compared with the State's energy needs of 40 000 GWh a year.

Civil works required to harness tidal energy are extensive and may have considerable environmental effects. Changes in the tidal flow regime could be expected to reduce the flushing of these bays, with consequential environmental effects on water quality, sediment movements, and shoreline vegetation. Consideration would need to be given to the requirements of shipping negotiating tidal locks in exposed waters. Less energy-efficient schemes could, however, be devised using only parts of the bays, probably at significantly higher unit cost.

Technology for harnessing tidal power is available but does not seem likely to be significantly improved in the immediate future. World-wide, the resource is seldom used, even where useful tidal ranges are available.

GEOTHERMAL ENERGY

The greatest opportunity in Victoria to develop geothermal resources lies in the Otway and Gippsland Basins. Deep aquifers used for town water supply have quite high temperatures. At Portland, water from sand and gravel aquifers in the Dilwyn Formation, extracted from a depth of 800—1300 m, reaches the surface at 60°C. At Port Fairy, Peterborough, and Port Campbell, groundwater from the stratum between 800 and 1400 m ranges in temperature from 41°C to 55°C. Towns with an existing supply of hot groundwater are ideally suited to utilise this heat, which is currently discharged to the atmosphere through expensive-to-operate cooling towers. Potential exists for even hotter water to be recovered at greater depths. At Rye, water from 530 m is 50°C and, while high salinity makes it unsuitable for human consumption, this groundwater, offers a potential geothermal resource.

In the Gippsland Basin, geothermal gradients are greatest inland, near Morwell and Traralgon but elevated gradients occur in the Yarram—Port Albert and Lakes Entrance—Bairnsdale coastal areas. The first bore in Victoria drilled expressly for the development of geothermal groundwaters are located at Metung. These warm groundwaters are located in early Tertiary sands at shallower depths than the Otway Basin waters.

In the Lakes Entrance—Bairnsdale region, groundwater at 35°C—50°C is available at

depths of 400 to 700 m. Around Yarram—Port Albert, groundwater at 35°C is also available at relatively shallow depths. These waters are of marginal use for geothermal power as, with current technology, 40°C is the minimum temperature for water for general heating purposes. The greatest potential along the coast for hot, deep, good-quality groundwater is at Golden Beach—Loch Sport, where groundwater from a depth of 1800 metres would be available at 60°C. Currently, geothermal resources are only being utilised at Portland. Groundwater extracted at 60°C is passed through several heat exchangers, heating four municipal buildings and an Olympic-size swimming pool. This saves the Council $300 000 a year in fuel bills (1993 data). Heating is also provided to motels, hotels, the public hospital and some State Government offices. After cooling to 20°C, the water provides the town water supply. Use of the geothermal resource at Portland is capable of further expansion and horticultural and aquacultural applications are currently under investigation. Further development of geothermal resources along the Otway coast, also has potential.

SEA WATER AS A RAW MATERIAL

Sea water, itself, has several industrial functions, including as a medium for onshore mariculture, as an industrial coolant, and as feed-water for salt production. While water volume will not be a problem, other considerations, as listed elsewhere in this report, may limit such usage.

* Mariculture involves water-quality and effluent-disposal requirements, and also needs suitable foreshore land.
* Industrial coolant applications must meet water-quality standards, covering the impact of thermal pollution and contaminants that may have become mixed with the coolant.
* Use as feed-water for salt production requires low-lying coastal land that can be readily flooded and climate with low annual rainfall and a high net evaporation.

GROUNDWATER

The groundwater has generally been used in Victoria only where surface water is not available in sufficient quantities or is of inferior quality. Approximately 10% of the State's onshore water use comes from groundwater resources. Offshore, but beyond Victorian waters, about 100 000 ML a year is extracted for oil production purposes.

Both the Otway and Gippsland Basins contain groundwater. Quality varies from very good to marginal in the former, with smaller, local sources tending to be brackish, and is generally good in the Gippsland Basin.

Major fresh-water aquifers within the Otway Basin occur in the early Tertiary Wangerrip and Heytesbury Group sediments. In particular, the sand and gravel sequences of the Dilwyn Formation of the Wangerrigo Formation contain good-quality water, which Portland, Port Fairy, Port Campbell and Peterborough use - either totally or in part - for town water supply. These groundwater bores are located in or adjoin the coastal zone. A large proportion of water for agriculture, stock, and domestic use is derived from relatively shallow aquifers of the Heytesbury Group limestones.

Non-marine sediments of the Gippsland Basin also contain significant aquifer systems. The main ones are the Latrobe Group sands, the Latrobe Valley coal measures, and the relatively shallow Balook Formation, Boisdale Formation and Haunted Hill Gravel.

The small coastal townships of Seaspray and Loch Sport derive part of their water supply from these aquifer systems. On the western flank of the basin, the coastal settlements of Venus Bay, Tarwin Lower, and Sandy Point also rely on groundwater for their town water supply as do holiday and domestic water-users who draw from shallow aquifers. Again, the bores are located in or adjoin the coastal zone. It should be noted that the widespread use of groundwater for stock and domestic purposes depends mainly on the availability and reliability of groundwater supplies, and that good quality - if it is found, as in the Gippsland Basin, is a bonus.

While significant undeveloped groundwater resources are available in the Gippsland and Otway Basins, in some sections of the coast - Western Port, Nepean Peninsula, and Werribee, for example - there is concern about sea-water intrusion as a result of groundwater depletion. For Westernport this led in 1971 to the declaration of the Western Port Basin as a groundwater conservation area, enabling water resource development to be controlled and to halt the intrusion of sea water.

ISSUES

* Further information regarding the location of earth resources such as oil and gas as well as minerals, sand and stone is required.

* The future potential for tidal, wind and wave power generation and the implications for other uses and activities.

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9. RECREATION

Recreation is defined as any activity relating to pleasure, relaxation, or sport done on a voluntary basis.

Of all outdoor recreational activities the most commonly pursued, particularly in the warmer summer months, are those enhanced by or based on water. A DASETT national survey in February 1991 showed that 25% of respondents had visited 'the beach' in the week preceding the survey.

Beaches and the coastal waters of bays, inlets, and estuaries play a major role in providing opportunities for recreation for most Australians. The maintenance and wise use of these resources are particularly important in a country where the majority of people are concentrated near the coast. Activities range from as simple as a swim at the local beach to scubadiving, which requires special equipment (a wetsuit, air tanks, a boat, and specialist training licences) and for country-based people a long car trip. Many, such as fishing, have evolved from former necessities of life. Others use devices such as jet-skis and surfboards that have resulted from changes in technology or, like swimming and beachcombing, are as old as human existence.

Social and economic benefits

Recreation is an intrinsic feature of our way of life. Its social benefits include:

* the opportunity to 'have a break' and recoup vital energies necessary in an increasingly pressured society
* development of self-awareness through challenge, achievement, and commitment to freely chosen activities
* entertainment and social interaction
* development of 'personal identity'
* a direct appreciation of environmental values and issues
* contribution to individual and societal fitness

Participation in recreation also provides a number of economic benefits:

* transport and overnight accommodation (for some towns, such as Mallacoota, this is an important component of the local economy)
* development of recreation facilities for the local community (for example, schools and clubs); this may lead to improved quality and diversity of tourist opportunities for intrastate, interstate, and international visitors
* development of private entrepreneurial activity based on specific recreational resources (for example, the dive charter industry)
* purchase and hire of equipment (boats etc.) and the purchase of consumable items such as fish bait
* publication of numerous magazines based on outdoor recreation

In a Parliamentary report, the Natural Resources and Environment Committee (1987) made recommendations on recreational use of public land, based on the following beliefs.

* Economic and social factors should not arbitrarily limit the access of Victorians to our recreational resources.
* The extent of Victoria's recreational resource and the range of recreational opportunities available should be publicised.
* The recreational experience should be enhanced through the publication of interpretive material.

Coastal recreation

Activities may be divided into two categories: water-based (impossible without suitable water - for example, surfing or fishing); and water-enhanced (more pleasurable on or near water - for example, picnicking).

Often a number of recreational activities of both categories are undertaken together, such as car-based camping and swimming or angling when on holiday. The coastal zone may also offer recreation activities that neither require nor are directly enhanced by a coastal setting. Such activities - bowling, racing, shooting, etc. - are not described here.

ASSESSMENT OF THE RECREATIONAL RESOURCE

For activities that have been practised for thousands of years, such as angling, the minimum requirements are well known. The

equipment, such as a hook, line, and sinker, is enduring although it has become increasingly specialised. However, the motivation has changed. Whereas once fish were caught and eaten as a necessity of life, now anglers are more likely to go fishing to relax in the outdoors.

By comparison, some recreational activities have become possible only as a result of technological and manufacturing changes over the last 20 years. Commercial dive charters are only possible with the recent manufacture, following World War II, of safe easy-to-use scuba equipment and dive accessories, such as wetsuits. Windsurfers, hang-gliders, sea kayaks, jet-skis, and fibre-glass surfboards are also recent recreational items. They result from new technologies and materials. Each item has either extended or made its own new demands for water resources. Consequently the potential use of coastal waters may evolve with changing technology.

The extent to which a particular section of the coast, bay, inlet, or estuary will be used for recreation depends on a number of factors that, for simplicity, are grouped as follows:

* physical, biological, cultural resource, and aesthetic requirements
* socio-economic conditions
* land use and management decisions

Resource requirements

Before an activity may take place, a number of such requirements must be met. Physical requirements include depth of water, surf, wind, and other weather conditions, and presence of reefs. Biological requirements include habitat, presence of particular species, biodiversity, abundance of organisms, absence of engine-choking vegetation, and absence of pathogens. Cultural requirements include the presence of features such as shipwrecks, historic buildings, and Aboriginal sites, which may form the basis for leisure-time learning experiences. Aesthetic requirements include scenery, clean air, clean water (absence of turbidity caused by suspended solids or algae or of pollution with plastics), and quietness.

Some recreational activities may take place without these requirements being met. However, the quality of the experience may be reduced.

The timing of recreational activities is also important. Some can only be pursued during certain periods; others can take place throughout the year. An understanding of the physical distribution and seasonal variation in resource quality assists long-term planning by defining Victoria's competitive advantage in recreational resources.

Table 9.1. summarises the major requirements, the facilities that enhance the recreational use of an area, the location of the coastal areas used, and frequency and seasonality of different recreational activities.

Two other issues are relevant to coastal recreation water temperature - where immersion is involved or is a risk; and exposure to ultraviolet radiation.

Along the Victorian coast, maximum Summer water temperatures are commonly between 17—18^{O}C in the west, and 19--20^{O}C in the east, although it may exceed 20^{O}C in the smaller shallow inlets. Temperatures in winter are often 5^{O}C less and may decrease with water depth. The extent to which people can remain immersed and enjoy these water temperatures varies with the individual. However, they are sufficiently low compared with those of northern New South Wales or Queensland, for example, to limit water-based activities, especially in the colder months. On the other hand, the advent of wetsuits for activities such as diving, surfing, and wind-surfing has extended the time in the water on any one occasion and the number of days of the year for pursuing an activity with relative comfort. A thriving wetsuit-manufacturing industry has developed at Torquay, providing for domestic and export demands.

Promotion of the 'slip, slop, slap' approach to outdoor activities has made the community aware of the dangers of exposure to ultraviolet radiation, and how to avoid it. As both water and sand reflect UV radiation, additional care is required for many coastal activities. Over the last couple of years, in some areas, beach visitation patterns have changed, suggesting that people are avoiding the high-radiation periods during the middle of the day.

Socio-economic conditions

Participation in outdoor recreation has increased rapidly since the 1950s and in most instances is growing faster than the population. This increase can be attributed to the following factors.

Table 9.1: Coastal Recreational Activities

Physical, biological, cultural, and aesthetic requirements	Coastal environment	Other resources and infrastructure considerations	Occurrence
Fishing Presence of target fish or shellfish free of biological or chemical contamination and of required size	From beaches, and from boats within bays, inlets, estuaries, and in offshore areas	Enhanced by access to car-parking, or boat launching facilities when fishing from a boat	Keen fishers tend to fish year round, though particular species may be only seasonally available
Scuba (snorkelling) Unpolluted clear water, good underwater scenery, interesting flora and fauna, and structures	Water depths from 30—40 m within the bays and generally within 5 km of the open coast (snorkellers use the shallower waters close to shore)	Enhanced by marine wildlife (e.g., seals) and interesting features (e.g., shipwrecks, unusual rock formations); enhanced by good car and boat access	Year round, although summer months are more popular
Swimming Water free of pollution, currents, and waves, warm water, sandy and vegetation-free bottom	Within 100 m of shore	Enhanced by adjacent sandy beaches, life-saving facilities, and in popular areas changing-rooms and kiosks	Warmer days during summer, particularly weekends and holidays, mainly around holiday centres and coastal towns
Power-boating Dependent on sea-going capability, with attention to obstacle-free water of sufficient depth and suitable sea-surface conditions	Within the bays and larger estuaries; and offshore areas for suitably designed boats	Launching facilities for trailerable boats; wet moorings and slipways for large boats; provision of weather warnings and marking of navigational hazards	Year round, summer more common but dependent on reason for boat use - e.g., fishing, diving, etc.
Sailing Obstacle-free water of sufficient depth, suitable wind, and sea-surface conditions; tidal currents may be a problem	Within the bays and larger estuaries; and offshore areas for suitably designed boats	Launching facilities for trailerable boats; wet moorings and slipways for larger boats	Year round, summer more common
Wind-surfing Flat windswept waters, preferably with limited fetch; wave-jumping requires areas of breaking swell	Within 200 m of the shore	Enhanced by car-parking and rigging areas adjacent to the shore	Year round, more popular during summer
Surfing Unpolluted water, well-formed, progressively breaking waves (1 to 4 m plus in height)	Within 200 m of shore, although breakers on reefs further offshore may be surfed	Convenient access, though modern boards are easy to carry, and it is practical to carry them some distance	Open coast only, more popular during summer, although wetsuits allow year-round surfing
Sea kayaking Good coastal scenery; wind and currents preferably in the direction of travel; no breaking waves	Within 200 m of shore and outside the surf zone, areas may be further offshore where waves may break over reefs	Scenic landings for camping on overnight trips	Year round, although summer months are more popular
Beachcombing and fossicking Availability of items of interest	Intertidal zone and beach immediately above it	Pleasant beach scenery	Year round, although looking for lost items more common in summer
Nature observation Presence of particular species (whales, sea birds, etc.) or habitat	Coastal wetlands, intertidal flats, and cliff lines; observations often done from land (observations may also be from boats)	Good habitat	Opportunistic or interested people may travel to an area at a particular time of the year (whales at Warrnambool in winter)
Pleasure-driving and picnicking Coastal road with good coastal scenery; fine weather	Road usually located within 0.5 to 1.0 km of the beach	Scenic stops and picnic areas	Year round, but most common during holiday periods
Dune buggies/off-road driving Off-road driving not permitted under the *Land Conservation (Vehicle Control) Act* 1972, except by permit.	A designated Dune Buggy Area located in Discovery Bay Coastal Park	-	-
Bushwalking Natural or semi-natural settings; good views	Within 1 km of the coast, across headlands and beaches	Good camping spots for overnight trips, drinking water (walks may vary from marked and formed tracks to routes)	Summer months, particularly during holiday periods
Hang-gliding Clear airspace, rising onshore wind, clear landing spots	Over coastal cliffs and hills between 15 and 250 m above sea level	Convenient vehicle access to launch locations	Year round, but dependent on suitable wind conditions
Hunting Presence of target species (water-birds and hog deer)	Coastal wetlands (for water-birds); coastal hinterland and islands (for hog deer)		Seasonal

* Choice of activities has widened. As described earlier, changes in technology and manufacturing have led to new recreational activities. The advent of convenient, lightweight outdoor equipment has also encouraged more participants.

* The public has an improved knowledge of the extent of the recreational resource and the range of activities available. This has occurred through the promotion of the outdoors in general, conservation of the environment, and the development of outdoor recreation programs in schools.

* Ability to participate in recreation has increased. Decreasing and more flexible working hours have increased public leisure time. Participation has also been encouraged by the near-static fuel costs. These factors, combined with improved road conditions, have led to an increase in the range of resources that can be used during weekends and holidays.

* Commercial provision of outdoor recreational services has grown rapidly.

Detailed statistical data on recreation trends and participation rates tend to be fragmented. Notable exceptions are fishing and boat ownership. However, even for these activities, some data are known only in general terms. These include: the frequency of participation (e.g., weekly, monthly, etc.); participation throughout the year according to seasonal weather and sea conditions or holiday periods; and the occurrence of the activity along the coast - all of them important to the projection of future trends, planning, and management.

Land use and management decisions

The rapid increase in participation and the demand for resources has required land use and land management agencies to ensure the diversity and quality of recreational experiences are developed and maintained, while minimising the impact on the sensitive areas.

Land use and management decisions may enhance or adversely affect recreation. The construction of a breakwater may, for example, provide access to deeper-water fishing, promenading, and a haven for boats. It may, however, change the pattern of sand movement along the coast, resulting in beach erosion and a reduction of beach-based recreation such as walking, sunbaking, and also swimming. Decisions to improve road access or publicise the resource will also have a major impact on resource use. In general, improving the road and increasing publicity, will increase the use of the resource, but may attract different types of users seeking different experiences.

In recognition of the recreational importance of public land and the potential impact of such decisions, recommendations arising from regional studies of the Land Conservation Council have led to the establishment of a State-wide network of areas broadly suitable for a wide range of recreational activities.

As a result of an increasing population, and improvement and extension of the road network, options for future planning are becoming increasingly limited compared with the those available in the 1960s. This is particularly true for recreational activities requiring only minimal development, such as long-distance and remote bushwalking, and where crowding is an issue at popular fishing, surfing, or diving spots.

Within a particular activity, people will seek different settings: some seek isolation and remoteness; others prefer the companionship of large numbers of people and developed facilities. One way to provide quality opportunities for the whole community is to plan for diversity. Such planning implies setting aside sections of the coast to provide different types of opportunities and experiences. A gradation is required between areas where major developments can occur, providing for high user numbers and high-quality recreation, and those where development is minimal and the number of people low.

This approach is reflected in the 'recreational opportunity spectrum', now the basis of land



Enjoying the beach - Cape Bridgewater.

use planning for recreation on Victoria's public land. The five settings in this spectrum are defined in Table 9.2. The concept of different settings is based on the way vehicle access and other facilities affect the recreational use of extensive areas of land. Its application to linear features, such as the coast, and to marine areas has yet to be tested in Victoria.

Table 9.2: Recreation Opportunity Settings

Remote setting
Essentially unmodified environments of large size where interaction between users is very low and evidence of other users is minimal. Evidence of restrictions and controls is absent. Motorised access by the public is not permitted. The recreation emphasis is on tranquillity and self-reliance. Such areas offer a high degree of challenge and risk opportunity.

Semi-remote setting
Predominantly natural or natural-looking environments of moderate to large size. Interaction between users is low, but there may be evidence of other users. Minimum on-site controls and restrictions may be present but subtle. Limited vehicle tracks exist, for vehicle access if permitted. The probability is high to moderate of experiencing: isolation from the sights and sounds of humans; independence; closeness to nature; tranquillity; and self-reliance. Such areas offer a moderate degree of challenge and risk.

Roaded natural setting
Natural-looking environments with moderate evidence of the sights and sounds of humans. Interaction between users may be low to moderate, but evidence of other users is prevalent. Opportunities for both motorised and non-motorised forms of recreation are available with a high degree of interaction with the natural environment. Impressions of nature are not dominated by modifications and recreation facilities.

Semi-developed setting
Substantially modified natural environments. Sights and sounds of humans are readily evident, and interaction between users is often moderate to high. Includes facilities designed for use by large numbers of people and those providing for special activities.

Developed setting
Substantially urbanised environments, although the background may have natural-looking elements. Vegetative cover is often exotic and usually heavily managed. Sights and sounds of humans are predominant and large numbers of users can be expected. Opportunities for competitive and spectator sports and for passive uses are common.

Adapted from: Department of Conservation, Forests and Lands (1988). 'Recreation, Policy, Planning and Monitoring.' (Department of Conservation, Forests and Lands: Melbourne.)

COASTLINES AND COASTAL WATERS: RECREATIONAL CAPABILITY AND USE

Capability is independent of use and describes the extent to which an area meets the physical, biological, and aesthetic requirements of a particular recreation activity. In surfing, for example, an area with poorly developed or no waves has very low capability, but where swell and good surfing conditions are common throughout most of the year, capability is high. This remains true irrespective of the amount of use, which is more likely to reflect management-related factors such as provision of facilities, or ease of access, or the promotion of a particular area, or distance from a population centre.

Recreational planning process involves determining firstly the capability of an area for a particular activity and then its potential use. Each area, depending on the extent of development, can support different levels of use. Developed camping areas, for example, range in physical capacity from less than 100 to several thousand. Each area, big or small, has an optimum carrying capacity, and exceeding that optimum reduces the quality of recreational experience. Use usually varies seasonally. A recreational area may reach its capacity or have the maximum visitor numbers during periods of warmer weather, in school and key public holidays, and during long weekends. It is therefore important to be able to determine and monitor the maximum use.

The information necessary to rate coastal land and waters in Victoria according to their capability for different recreational activities is far from complete; by comparison, recreation use can be more readily estimated. Data on use are gathered by surveying particularly localities, clubs, and from State-wide polls. The most reliable method is to count the number of participants using the resource. Automatic vehicle-counters make it relatively easy for areas with limited access, such as developed picnic areas or boat-launching ramps. However, few recreational activities are carried out at locations that permit ready measurement of use. Anglers, canoeists, and car-based campers are often dispersed over kilometres of water or coastline, making this difficult.

SALT-WATER RECREATIONAL FISHING

Recreational fishing - any activity, undertaken primarily for sport or recreation purposes, that

involves the taking of fish or other aquatic animals for personal use but not for sale or other economic gain. This definition is consistent with that used in the draft national policy for recreational fishing in Australia, which the Department of Primary Industries and Energy released in 1992. Such activities include angling, spear fishing, legitimate types of netting and trapping, collecting by hand and bait collecting, but not subsistence food-gathering.

Recreational fishing has probably occurred to some extent in Victorian bays, inlets, and coastal waters since the earliest days of European settlement. However, the biggest increase has occurred since World War II, due partly to population growth and partly to the improved living standards of most Australians. Along with many other activities, it is increasingly promoted on television and radio and in newspapers and magazines. Consequently, it now has the second-highest adult participation level (after swimming) of any sporting or recreational activity in Australia (PA Management Consultants 1984).

The catching efficiency of recreational fishers has probably also improved significantly following rapid increases in the sophistication and durability of their equipment (e.g., boats, outboard motors, radio communications, electronic fish-finders, and fishing tackle). This trend, combined with the increasing number of people participants, means that recreational pressure on fish stocks and target-bait species has probably been increasing steadily over the last 40 years or more.



Fishing - Gunnamatta Beach.

Participation

The most recent public opinion poll conducted on a national scale (PA Management Consultants 1984) indicated that about 28% of all Victorians over 14 years old go recreational fishing at least once a year. An unpublished 1987 Victorian survey by Morgan Research confirmed this and indicated that about 62% of all the State's recreational fishers live in the greater Melbourne metropolitan area, that just under 70% are male, and that about 36% were not undertaking paid work at the time. Available information on methods (PA Management Consultants 1984; MacDonald and Hall 1987) indicates that angling (which includes any form of line fishing) is by far the most popular catching method, being used by at least 80% of all recreational fishers.

The Morgan survey further indicates that well over 50% of all Victorian recreational fishers fish at least once a year in local bays, inlets, estuaries, or coastal waters, and that about 48% fish mostly in these waters. Port Phillip Bay is by far the most popular salt-water fishing location in the State, being used at least once a year by about 29% of all Victorian recreational fishers, and being the fishing location most frequently used by about 22%. The next most popular salt-water locations are open coastal waters (fished by 23%; preferred by 13%), the Gippsland Lakes (11%; 6%), Western Port (9%; 5%) and other bays and inlets (4%; 1%). Popularity rankings for these fishing locations have been verified by two other surveys, Beinssen (1978), and an unpublished one for the L.C.C. by Craig in 1993, although the latter indicates that locations remote from Melbourne (e.g., the Gippsland Lakes and Corner Inlet—Nooramunga) are more important to country based recreational fishers than is Port Phillip Bay.

Morgan Research found that, of those Victorians who fish mostly in salt-water, 25% fish 10 times or more per year and collectively account for at least half of the total annual fishing trips made by this group. Conversely, more than half (52%) of the same group fish

three times or less per year and collectively account for less than 19% of total trips.

The recent Craig questionnaire survey has provided information about opinions on some aspects of fishing not covered by previous public opinion surveys. Issues canvassed included preferred methods and perceived limitations on bait collection, adequacy of boat ramps and car access to fishing spots, and perceptions about legal constraints and any other factors and concerns affecting salt-water fishing in Victoria.

It must be recognised that the majority of respondents to this particular survey were experienced, long-term fishers who do a lot of fishing, and as such are not representative of all salt-water fishers in Victoria. They are, however, likely, to have greater interest in and knowledge of fishing issues, than most other fishers and, because of their skill and days spent fishing, their activities may have by far the greatest impact on the resource. Their views, therefore, are of importance in managing the resource.

The survey found that personal bait-collection (as opposed to purchase of commercial bait) is a major activity, particularly for country fishers. The main target species are, in order of preference, sandworm, bass yabbies, pipis, mussel, small fish, shrimp, crab, and squid, and 42% of respondents did not perceive any limitations on their ability to collect bait. Of those that did perceive limitations, 81% specified the constraints of existing fisheries legislation and regulations.

Boat ramps and car access to fishing locations were generally found to be adequate, except for the lack of water depth and siltation at ramps at Inverloch, Warneet, Sorrento, Williamstown, St Leonards, Black Rock, Corinella, Mann's Beach, Newhaven, McLaughlin's Beach, Mornington, and Kananook Creek, and unsatisfactory car-parking at some boat ramps.

Among the respondents, 47% did not perceive any legal constraints on recreational fishing. As the respondents are probably more aware of such issues than the average salt-water fisher, it is likely that an even lower percentage of all salt-water fishers would perceive such constraints. Survey respondents considered the main factors adversely affecting their fishing activities to be commercial netting, pollution, and scallop-dredging (not necessarily in that order). However, almost 25% of them indicated that they were unaware of any form of disturbance affecting their recreation.

Target species

The Craig survey also listed preferred species: recreational fishers in Victorian bays, inlets, and estuaries seek black bream, King George whiting, snapper, and flathead (several species), whereas in open coastal waters the preferred species are Australian salmon, snapper, flathead, and shark (several species). However, target species vary somewhat between specific locations. For example, snapper and King George whiting - the two most sought-after species in Port Phillip Bay and Western Port - are comparatively unimportant in the Gippsland Lakes and other east Gippsland estuaries, where black bream is by far the preferred species (Hall and MacDonald 1985a,1985b 1986a; Hall *et al.* 1985; MacDonald and Hall 1987). Sand flathead is the predominant flathead species in Port Phillip Bay catches, whereas rock flathead is much more important in Western Port and Corner Inlet/Nooramunga and dusky flathead is the main one in the east Gippsland estuaries.

Variations in target species for open coastal waters appear to depend more on the type of fishing platform used than on specific location along the coastline. For example, Australian salmon, which is often caught close to shore on beaches and rocky headlands, is much more highly rated by shore-based than boat-based anglers, while the converse is true for species such as tuna, yellowtail kingfish, barracouta, and sea pike, which are usually less susceptible to shore-based fishing.

Target species of lesser importance State-wide, but of local or regional significance, include calamari, garfish, and yellow-eye mullet in Port Phillip Bay, garfish in Lake Tyers, estuary perch in east Gippsland estuaries, and mulloway in the Glenelg River estuary.

Catch and effort

Information on the total amount of recreational fishing effort applied to Victorian salt-waters and the size of the total catch from such waters is very limited. Realistic estimates of total catch and effort cannot be obtained through public opinion polls or retrospective questionnaire surveys because of the inability of most individuals to accurately recall the details of every fishing trip for up to 12 months prior to being interviewed.

The Department of Conservation and Natural Resources (CNR) has undertaken a number of short-term monitoring projects to make direct estimates of total angling effort, catch per unit effort (CPUE), total catch and catch composition for many of Victoria's larger bays and inlets (see Table 9.3). Systematically collected angling catch-and-effort data are not available for Victorian coastal waters or for the bays, inlets, or estuaries other than those listed in the table, nor are quantitative catch-and-effort data available for recreational fishing methods other than angling (e.g., spear-fishing, hand collecting, or bait-collecting). Furthermore, the data summarised in the table were in most cases collected over too short a period to detect any trends in each bay or inlet.

Nevertheless they confirm public opinion poll findings that Port Phillip Bay is subjected to by far the highest amount of angling effort of any bay or inlet in the State, followed by the Gippsland Lakes. However, if angling pressure is measured in terms of number of hours fished per hectare of water, then Mallacoota Inlet - because of its comparatively small size - becomes the most heavily fished (Hall and MacDonald 1986a).

Catch rates (CPUE values) for all the bays or inlets in Table 9.3 except Mallacoota Inlet and Western Port exceed 1.00 fish per hour. This compares favourably with catch rates estimated for other Australian bays or estuaries (Hall and MacDonald 1985a). It is not possible to comment on the Western Port catch rate because of the small period (4 months) over which the estimate was generated. However, the estimate for Mallacoota Inlet does suggest that the main target species (black bream and dusky flathead) are not as easily caught in this estuary as they are elsewhere.

Comparison of the bay and inlet angling catches in Table 9.3 (converted from fish numbers to total catch weight) with commercial catches from the same times and places (Hall and MacDonald 1986b; CNR unpublished data), reveals that for nearly all species caught by both user groups the total recreational catch is at least as large as the total commercial catch if not larger. Species in this category include snapper, King George whiting, black bream, garfish, calamari, and flathead. One significant exception however is yellow-eye mullet in Port Phillip Bay and the Gippsland Lakes, where the commercial catches are substantially larger than the angling catches.

The CNR re-commenced routine surveys of angling catch and effort in Port Phillip Bay in December 1989. Data from this project have not yet been published, but preliminary analyses of data for 1990/91 and 1991/92 indicate that total annual fishing effort has risen about 10% since 1982/83, that catch

Table 9.3: Angling Catch and Effort Surveys Along the Coast

Area surveyed	Survey period	Annual effort (angler hours)	CPUE[1] (fish per hour)	Annual catch (number of fish)	Main species caught
Port Phillip Bay[3]	Feb-May 1977	976 000[2]	1.08	1 056 000[2]	snapper, whiting, garfish, flathead, squid
Western Port[3]	Feb-May 1977	256 000[2]	0.31	80 000[2]	snapper, whiting, flathead
Gippsland Lakes[3]	Feb-May 1977	234 000[2]	0.39	90 000[2]	bream, garfish
Gippsland Lakes[4]	Apr 1979-Feb 1983	1 297 000	1.14	1 472 000	bream, mullet, tailor, garfish, flathead
Mallacoota Inlet[5]	Dec 1981-Jun 1984	154 000	0.30	48 000	bream, flathead
Lake Tyers[6]	Jul 1984-Jun 1985	119 000	1.09	92 000	bream, garfish, mullet
Corner Inlet/ Nooramunga[7]	Oct 1983-Mar 1984	210 000[2]	1.27	244 000[2]	whiting, flathead
Port Phillip Bay[8]	Oct 1982-Sep 1983	3 211 000	1.29	4 083 000	flathead, whiting, snapper, garfish, squid

Notes:
1. CPUE = Catch per unit effort.
2. Estimates based on data collected for periods less than a year

Sources: Beinssen 1977 (3); Hall and MacDonald 1985a (4); Hall *et al.* 1985 (5); Hall and MacDonald 1985b (6); Hall and MacDonald 1986a (7); MacDonald and Hall 19875 (8).

rates for shore-based anglers have declined considerably and that, consequently, total annual catches are down by about 6%.

Economic significance

The economic value of recreational fishing is difficult to determine because it is by definition a non-commercial or non-profit activity. Nevertheless such value is frequently inferred by measuring total expenditure on associated goods, services, and activities.

In the most recent national survey (PA Management Consultants 1984), it was estimated that Australian recreational fishers spent about $2.2 billion on fishing-related goods, services (excluding accommodation), and activities in 1983/84. The same survey indicated that at least 20% of all Australian recreational fishers reside in Victoria, and the more recent (1987) Victorian Poll indicated that approximately 50% of these residents fish primarily in Victorian salt-waters. If we assume that the *per capita* expenditure on fishing-related items is at least equivalent to the national average, then it is reasonable to conclude that in 1983/84 they spent more than $200 million on goods, services (excluding accommodation), and activities associated with this recreational fishing. Dragun (1991) estimated an annual expenditure of at least $380 million by Port Phillip and Western Port fishers alone, but did not clarify how they generated this estimate.

SCUBA AND SNORKELLING

Scuba- and skin-diving give access to the spectacular underwater world along the Victorian coast. Divers require unpolluted water that gives good visibility and is relatively free of unpredictable currents and turbulence. People dive to admire and photograph the underwater environment and its flora, fauna and rock formations, to explore shipwrecks, to collect abalone, rock lobsters, or scallops, to play with seals, and to spearfish.

Skin-diving or snorkelling - the earliest form of diving - has been practised for more than 1000 years since ancient Romans and Asian pearl-divers began it. Skin-divers use minimal equipment: snorkel, face mask, flippers, and in cold water a wetsuit.

Scuba diving equipment became available in the 1940s - invented by Captain James Cousteau among others. Australia was one of the first countries in which scuba-diving



Loch Ard - one of the best wreck dives in Victoria.

became a popular recreational activity in the 1950s and '60s. Although there is no formal register of scuba-divers, Victoria probably has about 100 000 qualified divers and the industry considers the number to be growing at 25% per annum. A 1992 Queensland survey of divers found that 15% of the surveyed group had not dived in the previous 12 months, 54% had dived less than 10 times, 11% had 10—20 dives, and 20% had more than 20 dives. A similar pattern of participation probably occurs in Victoria.

In addition to snorkelling equipment, scuba-divers need a tank with compressed air, breathing regulator, buoyancy-compensating jacket, underwater watch, depth gauge, tank pressure gauge, and, in Victoria, thick (7 mm) head to toe wetsuit, gloves, and booties. Modern diving computers often replace watch and depth and pressure gauges and calculate the maximum times allowed for dives, including decompression times.

Scuba-divers require training and an accredited qualification for two main reasons: the health risks associated with diving, and the use of sophisticated equipment. Training requirements are now established (Australian Standard 4005.1). Increasingly, agencies responsible for shipwrecks are encouraging, as part of the training, an ethos for protecting the underwater heritage akin to 'take nothing but photos, leave nothing but footprints'.

Risks of pressure injuries (resulting from failure to equalise differing pressures within the body's gas spaces and the surrounding environment) and gas poisoning (oxygen, carbon dioxide and carbon monoxide, and nitrogen) limit the time and depth of diving. Air decompression tables specifying the allowable depths and times have to be

understood and used to help prevent development of pressure injuries. To increase diving safety a limit for recreational diving is often set at 30—40 m and most diving is done with a 'buddy'. The dive industry and recreation organisations encourage licensed diving to maintain high safety standards.

Although not a legal requirement, a recognised accredited qualification is needed to have tanks filled and for chartering boats. Four major accredited organisations (PADI, NAUI, NASDS, and SSI) offer diver courses leading to internationally recognised licences. The courses range from basic skills through to instructional and specialist skills, including wreck diving, caving, search and rescue, underwater photography, night diving, and marine biology courses.

The advantage of scuba-diving over skin-diving is that it allows for longer and deeper dives. Novice skin-divers may hold their breath for 10—20 seconds and reach a depth 1—2 m, while experienced ones may hold their breath for 60—120 seconds and reach a depth of 10—20 m. By comparison, a scuba-diver can dive at a depth of 20 m for an hour or so, although, because of water temperature in Victoria, most dives last about 30 minutes. Consequently skin-diving is restricted to surface and near-surface shallow areas, which are with few exceptions along the shore. On the other hand because of the lightweight nature of their gear, skin-divers can walk some distance to dive locations, whereas scuba-divers, because of the heavier gear, will use areas adjacent to car parks and accessible by boats.

Dive charter facilities in Victoria are excellent: in summer, for example, up to 20 boats operate out of Portsea, Sorrento, and Queenscliff. Boat-hiring is also available from Geelong, Western Port, Port Campbell, and Portland. The boats are small (6—10 m), operate on a daily basis, and do not venture beyond 5 to 10 km off-shore. The bigger (12—15 m), live-aboard ships operate mainly from around Wilsons Promontory. They offer trips of 2—7 days, and may travel up to 50 km off-shore to, for example, Tasmania's Deal and Flinders Islands.

Reefs are the most popular areas for diving. They often shelter the most colourful and the most abundant marine life, including the prized and elusive crayfish and abalone, which are collected usually in 8—30 m waters up to 1—2 km off-shore. But divers also choose sandy bottoms to collect scallops. Ship-wreck-diving is another popular form. Shipwrecks occur on a number of bottom types and a number of them within Port Phillip Bay, such as William SalthHouse, have been actively promoted as part of the shipwreck trail to enhance diver pleasure and understanding of the wrecks and their cultural value. Most of them occur close to the shore, the result of ships running into near-shore reefs or stranding on the shallows. Some wrecks of scuttled ships lie some distance off-shore, for example 'The Ships Graveyard', 5 km off Barwon Heads.

Instead of remaining in a single locality, a scuba-diver can drift-dive with the current (mainly in Port Phillip Bay and Western Port) and thus cover many kilometres without much effort. This sport is very exhilarating, as the diver almost flies over large and fascinating areas

Most areas of the Victorian coast offer opportunities. The west coast, from Cape Bridgewater to Melbourne (including Port Phillip Bay and Western Port), is particularly fine for diving and photography and has a number of spectacular rocky reefs and interesting wrecks. Wilsons Promontory on the east coast offers some of the best diving in the State including frolicking with the seals. The areas around Cape Conran and Croajingolong National Park are also considered very good. The only area of Victorian waters rarely used is the Ninety Mile Beach in East Gippsland. The diving activities and specific locations are shown on Map 3.

SWIMMING AND SUNBAKING

Swimming may be done in most coastal waters, and is most popular over summer when the water and air temperatures are generally higher, although the use of wetsuits enhances year-round swimming.

The best conditions occur when the water is free of waves, currents, and pollution, the sea-bed and shore are sandy and gently sloping, and both are free of objects likely to cause injury, such as glass, partly buried structures, rocks, and stinging or biting wildlife. Although the suitability of extensive sections of the coast may be taken for granted, ideal conditions are not widespread. Swimmers avoid waters adjacent to the extensive rocky sections, the sheltered muddy or weedy areas of estuaries, inlets, and bays, sandy beaches swept by strong inshore currents, or localised areas affected by ocean outfalls. In addition, some

areas may become temporarily unsuitable for swimming when affected by storm-water run-off after heavy rain or big seas following storms.

The Surf Life Saving Association of Australia is currently completing a Beach Safety Program for 7000 beach systems around Australia. The program will, among other things, grade beaches according to their physical characteristics and natural hazards under all weather, wave, and tide conditions, indicating their level of safety. The most intensively used swimming localities adjoin population centres and coastal holiday resorts. In summer, local surf life saving clubs will often designate and patrol local safe-swimming areas.

Swimming and sunbaking are often combined and form the focus for a day at the beach. Increased public awareness of skin cancer as a result of exposure to ultraviolet radiation has led to a change in beach visitor-use patterns in some areas to avoid the high-radiation times of the day. Optional-dress beaches providing for nude sun-bathers have been designated at several locations.

BOATING

With its semi-enclosed and offshore water, the coast provides diverse opportunities for a wide range of craft. For convenience these can be grouped as:

* engine-powered - jet-skis, hovercraft, cruisers, ski-boats, etc.
* wind-powered - yachts, windsurfers, etc.
* human-powered - surfboards, surf-skis, sea kayaks, etc.

These watercraft vary in sea-going capability, the way they are used, and therefore the on-shore and off-shore requirements that are necessary or enhance their use. These are discussed below.

Demand

Watercraft are used for fishing, sailing, cruising, diving, racing, water-skiing, etc. Consequently demand for these specific activities - particularly fishing, which is the most common recreational use, will, among other things, influence growth in boat ownership. Of the areas suitable for general boating in Victoria, Port Phillip Bay is the most commonly used, undoubtedly reflecting the demand from the large population living adjacent its shores.

Table 9.4 shows that boat-ownership has more than doubled in the last 20 years. Demand for boats (and boating facilities) is complex due to the segmented nature of the market. It is clear that the total stock of boats has continued to grow since records have been kept. However, the ownership of particular classes of boats, particularly some classes of sailing craft, has declined as a result of socio-economic conditions. For the same reason, in the short run, latent demand, which would become effective with improved facilities, is small. In the longer term it could significantly contribute to an increase in the growth of boat ownership. The most recent projections (1988), based on a study commissioned from USE consultants by the State Boating Council, predicted a 42% increase in boat numbers in Victoria, from 124 000 in mid 1987 to 176 000 in 2001. While a considerable proportion of this is expected to occur in the Melbourne metropolitan area, it is expected that other places, such as Western Port, will also receive a considerable component of new boat use.

Table 9.4: Boat Registration

Year	Vessel registrations ('000s)	Year	Vessel registrations ('000s)
1973	52	1984	n.a.
1975	59	1985	108
1976	71	1986	111
1977	77	1987	114
1978	87	1988	116
1979	91	1989	120
1980	93	1990	122
1981	95	1991	125
1982	98	1992	124
1983	100		

Source: VicRoads

Facilities

Appropriate facilities, particularly for launching boats, are a necessity. A 1987 survey of Port Phillip Bay found that facilities in general are not of themselves important determinants of boat usage and boat demand, but act as an attractor for boating enthusiasts rather than as a barrier for new boaters.

Broadly the location of many launching areas has been determined by a combination of the distribution of boat owners in coastal towns or tourist destinations and the practical constraints

imposed by wind, wave and water depth considerations, for example.

Boating facilities can be grouped into three basic categories: off-the-beach; boat ramps; and marinas and mooring areas.

Off-the-beach launching is suitable for windsurfers/sail-boards; yachts - dinghies and small catamarans; jet skis; small motor powered-craft or rowing craft. These craft can be transported to a point near the beach by car then manually moved onto the beach, from where they can be launched.

Physical provisions required for an off-the-beach facility include:

* vehicle access and car-parking
* access from car-parking area to the beach
* beach area for rigging and launching of craft

Such areas are most commonly found in the more popular boating areas such as Port Phillip Bay particularly adjacent to metropolitan areas where wind-surfing and the sailing of lightweight craft are popular.

Boat ramps permit launching of craft that vary in length up to 8.0 m, although most boats would be smaller. These craft are trailerable and include: motor-powered boats (runabouts) and cruisers; and trailer-sailor yachts.

Physical provisions required for an adequate boat ramp facility include:

* vehicle access, queuing area, rigging lanes, and car- and trailer-parking area
* concrete ramp designed to appropriate standards, from which craft may be launched directly from the trailer
* appropriate water depth at the toe of the ramp suitable for launching and retrieval at all stages of the tide
* seaward lay-by facility so that the ramp is occupied for the least possible time
* protection from severe weather conditions and the presence of quiet water seaward of the ramp
* safe navigation access from the ramp to deeper water

In some areas, trailerable boats have been launched directly across vegetated dune areas, resulting in the loss of vegetation and erosion.

Launching facilities are located along much of the coast, wherever demand is sufficient. There are more than 60 ramps within Port Phillip Bay, about 20 in Western Port and others along the open coast (most occurring adjacent to coastal towns or popular visitor areas. Map 4 shows the location of boat ramps.

Protected mooring areas and marinas have advantages, but the primary determinant as to whether a boat-owner uses them is the cost and whether this outweighs the practicality of launching, retrieving, and storing large boats or convenience, where practicality is not an issue. Protected mooring areas may include swing or fixed moorings and may also contain a marina providing dry-berth facilities. Physical provisions for protected mooring areas (marinas) include:

* all-weather vehicle access and car-parking
* land-based facilities that complement the marina—harbour facility, and enhance its market acceptability and economic viability
* means of all-weather protection for moored craft
* mooring facilities
* safe navigation access from marina-harbour to deep water

In some areas marina proposals have caused local controversy and views on the merits of the proposal have differed.

As a result of failure to approve such proposals and because of the high cost of providing protected moorings and the associated infrastructure, comparatively few such facilities have been developed. Those few are located in the high-demand areas of Port Phillip Bay and Western Port. Mooring facilities for larger craft are also often provided in port areas.

Power-boating

Power-boats used along the coast vary in size, speed, and capability - from small dinghies that may be used for fishing in sheltered waters and single-person jet-skis and hovercraft to powerful cruisers. They are used for fishing, diving, jet-skiing, racing, cruising, and sailing. Their handling characteristics vary considerably in different sea and weather conditions.

Those used for fishing and diving provide access to areas in both enclosed and open coastal waters and can be used as mobile or stationary fishing and diving platforms. Many



Boating - a popular water-based activity.

can, under favourable conditions, reach speeds of 35 knots or more, thus allowing access to much of the coast and off-shore waters from the existing extensive network of launching sites. However, the speed and distance travelled depend on sea and weather conditions and social factors such as the intention of the trip, which may be to leisurely cruise and enjoy the surrounds.

Water-skiing requires reasonable boat speeds, and a water body several kilometres in length, wider than 30 m, and free of obstacles that may damage the boat or injure the skier. The water must also be protected from wind and swell. Consequently the best coastal conditions are usually found in the larger inlets and estuaries along the coast and, when calm weather prevails, in the bays. In general, however, inland waters provide better water-skiing conditions than the coast. Water-skiing usually take place from spring to autumn.

Power-boat racing, while more common on still inland waters, also occurs along the coast.

Cruisers require weed-and snag-free water of a depth greater than 1—1.5 m and of sufficient size to allow for overnight stops at sheltered locations with secure anchorages. Only the larger bays and estuaries are suitable for cruising.

Dinghies, by virtue of their low weight, shallow draft, and low speed, have modest requirements compared with other power-boats. Often they can navigate weed- and snag-free water less than a metre deep. Although launching facilities and car- and trailer-parking are important in high-use areas, dinghies can often be manually launched from gently sloping banks. Their use is restricted to the more-sheltered waters of the inlets and estuaries.

Jet-skis are a recent introduction to Victoria. They can be used in a variety of conditions - from riding through the surf breaks on the open coastline to the calmer water in the bays and inlets. Jet-skis can operate in waters less than 1 m deep and are commonly used within 30—200 m of shore.

Recreational hovercraft, due to their design, are the only power-boats able to cross shallow weedy water and exposed sand- and mud-flats, but need water protected from swell and strong winds.

The most heavily used areas are the suitable waters adjacent to population centres, such as Port Phillip Bay and Western Port. During summer, boat use on suitable waters near resorts will increase, as holiday-makers take their boats with them.

Wind-powered craft

Sailing is predominantly a club-based activity. Some 56 of the 89 member clubs of the Victorian Yachting Council are associated with Port Phillip Bay and Western Port or are based in major towns along the open coast from Portland in the west to Port Albert in the east. The craft sailed vary from club to club.

Requirements for sailing depend on the nature of the craft and the reasons for sailing. As with many activities, sailors have a tendency to select the waters that match the capability of the craft and to only sail under suitable conditions. Breaking surf or shallow water where the craft may run aground are obviously unsuitable. Wind is a key prerequisite, although comfortable sailing conditions vary from craft to craft. Sailing of smaller craft, off the beach or trailer-sailors, is generally restricted to enclosed waters, such as Port Phillip Bay, Western Port, the Gippsland Lakes, and Mallacoota Inlet, that have



Sailing at Norman Bay - Wilsons Promontory.

extensive areas with at least 2 m of water depth. These craft may also use the near-shore areas along the open coast such as at Torquay. Keel craft require water depths of 4m or more and therefore are restricted to the larger bays. They are, however, suitable for sailing along the open coast and offshore waters. The need for safe havens varies, depending on yacht design and ability to make speed to shelter or to survive adverse conditions. Safe anchorages, however, certainly enhance overnight-cruising opportunities.

Yachts under power can, like other power-boats, navigate narrow channels, but when under sail require wider ones. The marking of channels, and of navigation hazards (including overhead power lines) in the upper reaches of estuaries, is also of importance. It is especially important that racing courses be free of navigation hazards. Olympic course racing requires approximately 4 square nautical miles of clear water. However, it is often possible to avoid localised navigation hazards in long-distance races. These races, by keel yachts, may involve much of Port Phillip Bay, for example, or off-shore areas such as those used for the annual Melbourne to Hobart race.

Appropriate launching facilities are important and, as sailing is mainly club based, the provision of foreshore facilities is also a consideration.

Windsurfing

Windsurfers or sail-boards first became available in Victoria in 1970. In the last 20 years their design has evolved and specialist designs for activities such as speed-sailing and wave-jumping are now available.

Board-sailing requires several hundred metres of windswept water free of obstacles. The higher speeds are more suitable for experienced sailors with appropriately rigged boards. Strong winds over water bodies with a short fetch give rise to water that is smooth but has a 'ball-bearing-like' surface suitable for speed sailing. Such conditions commonly occur at Shallow Inlet behind Sandy Point and it is a favoured location for attempts at the speed sailing record.

Beginners prefer on-shore winds that can blow them back to shore should they experience difficulties.

From time to time the larger more exposed coastal bays inlets and estuaries experience suitable wind conditions. Wave-riding opportunities are only provided on ocean beaches exposed to swell.

Ease of vehicle access and parking, and suitable rigging areas close to the water enhance the use of an area for sail-boarding. Venues close to population centres, such as Elwood Beach in Port Phillip Bay, receive more-intensive use. However, localities distant from population centres but providing better opportunities, such as Sandy Point, will be in demand during weekends and holidays.

With the growth in popularity, regattas are now a part of the yearly calendar. Suitable clothing allows board-sailing throughout year, but the activity is more pleasurable and popular during warm weather.

Human-powered craft

Surfing involves catching breaking waves. Body-surfing is its simplest form: surfboards, bellyboards, lilos, or surf-skis extend the range of surfing opportunities and experiences.

Boardsurfing is one of the recreational activities that became popular with the advance of technology. Although practised through the 1920s to 1960s, the sport virtually exploded with the introduction in 1960s of the short, lightweight surfboards and wetsuits. The modern surfboard is fast, highly manoeuvrable, and easy to handle (light to carry) compared with the larger Malibu boards. Since the advent of new surfboard designs in the 1970s the surfer can now attempt more difficult and challenging conditions. Wetsuits allow surfers to stay longer in water, particularly in winter, when Victorian surf conditions are often the best.

Pollution-free water is a critical consideration. Good surf conditions are determined by near-shore depth profile, swell and wind conditions, and the shape and alignment of the coast. The best swell comes from waves produced by storms thousands of kilometres from the coastline on which they eventually break. Absence of strong currents, rips, and sharks increases the safety of the sport. As surfing is dependent on swell, suitable conditions occur mainly along the open coast. Sheltered waters of bays and inlets and estuaries are rarely suitable. On occasions, marginal surf conditions may occur in Port Phillip Bay. Most surfing takes place within 200 m of the shore. In some areas along the Port Campbell coast, where surf breaks much further out,

enthusiasts may surf up to 1 km from the shore.

Headlands and sand bars determine where and how the waves break under certain swell conditions. Off-shore breezes give the best surf, because they provide a steeper-breaking wave and because of the short-fetch smoother water. Alignment of the coast in relation to dominant swell directions makes some sections less suitable - for example, the north-east of Wilsons Promontory and the southern end of Ninety Mile Beach.

The Victorian ocean coastline provides good surfing spots, but some favoured locations combine excellent access and regular, ideally sized and shaped waves. With good surf these locations may become congested with board-riders and spectators.

While car-parking adjacent to the beach provides convenient access, surfers will walk considerable distances if they know a good break will be present.

The most popular surfing areas close to Melbourne are the back beaches of Mornington Peninsula and Phillip Island. The coast from Wilsons Promontory to Wonthaggi and from Torquay to Apollo Bay also offers good surfing. Torquay has become a significant manufacturing centre for surf equipment with world-wide exports, while nearby Bells Beach has surf of international renown and is the venue for annual international Easter championships in Australia. The coast between Cape Otway and Portland provides most challenging surf conditions. The two sections of the Victorian ocean coast not really suitable for surfing are the Ninety Mile Beach, which stretches from Lakes Entrance to Wilsons Promontory, and the almost inaccessible coast from Portland to Nelson.

Sea-kayaking

Sea kayaks are specifically designed for the wind and swell conditions likely to be encountered in coastal waters.

Their design incorporates safety features necessary for trips to distant landing places, including watertight compartments to reduce the chances of sinking. Experienced sea-canoeists will carry flares, and two-way radios are becoming more common.

Sea kayaks are usually paddled, although wind assistance can be obtained by small sails or by the flying of kites. Trips may vary in duration from a few hours to several days or longer, requiring overnight camping. Depending on the aim of the trip, the skills of the group, and the prevailing sea conditions, distances of between 10 and 40 km can be travelled daily.

Beginners will seek the more sheltered waters of the enclosed bays, inlets, and estuaries, or undertake short trips along the coast during calm sea and weather conditions. Such conditions may also be suitable for kayaks and canoes that would be more commonly used on inland waters. Increasing skill and experience can allow longer trips along the open coast with more challenging conditions. A skilled canoeist is able to land and launch through surfs breaking on sandy or rocky shorelines. While some conditions will create difficulty for even the most experienced kayaker, a skilled canoeist can roll up after a capsize to obviate the need for rescue by others.

Sea-canoeing trips are usually carried out in small groups. The sport now appears to be developing rapidly in Australia. Both Australia and Tasmania have been circumnavigated in sea kayak, and many island-hopping crossings of Bass Strait are completed annually.

Sheltered waters, especially those closest to population centres, are used by beginners and by experienced canoeists as convenient training grounds.

Canoeists who have sufficient skills and are prepared to travel seek coasts and inlets that are natural and remote. Coasts with a mixture of rocky shoreline, headlands, and beaches provide opportunities to land in areas protected to various degrees. Coastlines exposed to the weather are the preserve of the very experienced sea-canoeist. Trips in such localities are enhanced by picturesque landing sites, and camping locations are necessary for overnight trips.

While the opportunities for sea-kayaking along the coast have not been systematically assessed, popular venues include: south-eastern Port Phillip Bay, Western Port, and Gippsland Lakes (novice to intermediate skills); and Port Phillip Bay Heads, Wilsons Promontory, and Cape Otway coast (intermediate to advanced skills). Other areas of the coast used by more experienced canoeists include Cape Woolamai and Point Hicks to the NSW border.

BEACHCOMBING AND FOSSICKING

The collection of bits and pieces from the beach is a popular activity and many children and adults have at some time collected their special shells, stones, or pieces of driftwood. Some items are collected for specific purposes - for example driftwood for free-form sculpture and furniture, or cuttlefish for pet birds. Gear that has been lost overboard or abandoned by ships may also be of interest.

With the advent of cheap and lightweight metal detectors, the systematic searching of the more popular beaches during the summer for items lost by beachgoers has become a popular activity for a small group of enthusiasts.

Fossicking - a general term covering the search for gems, semiprecious gems, precious metals, minerals and fossils for home collections, may take place wherever people expect to find these items. The Victorian coast and its inlets and estuaries are not noted for their gold or gemstone potential and most of the fossicking effort for them occurs inland. Chapter 8 describes any that does take place.

CAR-BASED CAMPING

This involves camping adjacent to the car, in either a tent or caravan. The shores of the larger bays, inlets and estuaries, and the open coastline are popular destinations in summer, particularly during weekends and holidays. Coastal camping venues also often provide opportunities for fishing, swimming, boating, surfing, and beach-walking. The camping area should ideally be well drained, flat, grassy, picturesque, and protected from strong wind.



Pelicans - a delight to watch.

Camping sites vary widely, from bush camps with only basic facilities to developed sites managed by local or private authorities, which often have ablution blocks, laundries, and kiosks. Bush camps are most commonly provided where the strip of public land along the coast is at least 5 km wide. Those at Wingan Inlet and Point Hicks in Croajingolong National Park are popular examples. Developed camping areas are usually located in or adjacent to coastal towns, often on cleared land, such as that overlooking the estuary at Mallacoota.

NATURE OBSERVATION

Often undertaken in conjunction with other recreational activities (such as walking, canoeing, boating, and diving), Nature observation involves the appreciation and understanding of flora and fauna. Some participants only have a casual involvement, while others with extensive and detailed knowledge undertake flora and fauna surveys as a recreational activity.

Suitable habitat may be the key. It is often characterised by tranquillity, beauty, and a variety of natural features. Some habitats provide particularly good conditions for Nature observation, with abundant flora and fauna of interest and ease of access to observation points. For example, artificial and natural coastal wetlands and intertidal flats are ideal for bird-watching. Werribee Sewerage Treatment Farm is one of the prime Victorian locations. Marine life can be observed from the shore, boat, and underwater. For the shore-based observer it is a delight to see whales at Warrnambool, penguins and seals at Phillip Island, and dolphins along the coast. For the underwater observer, the diverse and colourful marine flora and fauna, interesting reef formations and opportunities to see seals and dolphins are valued experiences. The underwater world also gives plenty of scope to the keen photographer.

PLEASURE-DRIVING AND PICNICKING

Coastal roads with views of the sea are popular for scenic drives. The wayside lookout stops with picnic facilities and opportunities to walk along the beach are well utilised. Picnicking and pleasure-driving are complementary activities often undertaken in fine weather. They can be conducted from home or a holiday base or be part of the holiday itself.

The main roads linking coastal towns are sealed. Coastal access roads from adjacent highways are mostly of two-wheel-drive standard, although they may not be sealed. Some may be seasonally closed during winter, or be suitable only for four-wheel-drive vehicles immediately following heavy rain.

Picnic opportunities are widespread and sites vary from basic to those with shelter sheds, toilet blocks, and facilities for large groups. They may also be the trail-head for short walking tracks. Larger picnic sites with developed facilities are usually close to population centres or are popular tourist destination points

The best-known and promoted road for pleasure-driving is the Great Ocean Road from Queenscliff to Portland. Along the Otway coast, the road hugs and winds along the cliff line within 100 m of the sea below, giving spectacular views.

DUNE BUGGIES/OFF-ROAD DRIVING

In Victoria, motor vehicles are not permitted to move off-road on public land under the *Land Conservation (Vehicle Control) Act* 1972. Motor vehicles are allowed only on designated roads and car-parking areas except with approval of the management authority such as CNR, committee of management, or municipality. Permits provide the authority for particular individuals and vehicles to use specific areas for purposes such as surf life saving, research, or fishing. Vehicles are generally those that can negotiate the sandy conditions along the coast.

The Portland Dune Buggy Club holds such a licence, allowing its members to operate within the Designated Dune Buggy Area in the Discovery Bay Coastal Park - the only such area along the Victorian coast. The Dune Buggy Area, south-east of Swan Lake, covers approximately 10 sq. km of 50 to 75 m high sand dunes. The licence specifies the number and type of vehicles that may use the area, its care and maintenance, and other relevant conditions.

BUSHWALKING

Trips range from short ones along well-established trails to longer ones through both well-defined routes and untracked remote areas. The shorter trips may take half to one day covering between 15 and 30 km. Longer ones may take weeks (covering some 20 km daily and require overnight camping. Camping spots set in beautiful surroundings enhance the experience. Short-distance walks often use well-graded tracks. For the longer backpacking trips, where the experience of solitude in a natural setting is a priority, the main requirement is a large area, remote from roads and large concentrations of people.

The smell, sight, and sound of the sea can draw people to the coast. Coastal areas feature specialised and diverse vegetation and wildlife, interesting geological features, and spectacular scenery. They can vary from gentle, easily accessible beaches to remote, rugged, windswept rocky shores of open coastline. Coastal walking areas offer prime walking experience and are often in great demand. To address this demand, a long-distance (about 350 km) walking track between Anglesea and Portland was proposed. A study showed that it is both feasible and desirable, but financial and administrative issues have yet to be resolved. This and other popular coastal walks are described in Table 9.5.

As with any outdoor physical activity bushwalking has its list of potential hazards. Careful trip-planning, good navigational skills, and knowledge of first aid are important.

Bushwalking is a popular form of recreation; Victoria contains almost 60 bushwalking clubs with total membership of around 5000, plus many other walkers. Due to recent technological development, modern clothing is more comfortable, light, warm, and wind and waterproof and the hiking equipment is light and strong. As a result, bushwalking is now a more enjoyable experience than some 10—20 years ago.

Although all coastal land, except for the reference areas, is available for bushwalking, the most popular areas are parks and reserves.

HANG-GLIDING

Modern hang-gliding was invented and pioneered in Australia in the 1960s by Steve Cohen and Bill Moyes. Australia for many years was at the forefront of world hang-gliding and still has many world-class pilots. Australia is also a base for an export hang-gliding industry. The sport is still growing in popularity and the last 8 years have seen a threefold increase in participants .

With design improvements, hang-glider stability and performance in low wind

Table 9.5: Popular Coastal Walking Tracks

The Great South West Walk in Discovery Bay Coastal Park is a 250-km circuit walk from Nelson to Portland; the coastal part is 108 km. The Walk includes a 2.3 km nature trail, the Smelter walk, and caters specifically for wheelchair access.

Mahogany Walk, from Warrnambool to Port Fairy, covers 22 km of uninterrupted walking along the beaches and dune systems.

Port Campbell and **Otway** (near Apollo Bay) **National Parks** offer a number of short walks from half to 6 hours through exposed dunes to sheltered mountain gullies. The rugged scenery of the coast near Port Campbell is particularly popular, with its natural soft limestone cliff sculptures such as the Twelve Apostles, Loch Ard Gorge, and the Arch.

Surf Coast District Walks cover 30 km from Jan Juc to Aireys Inlet, of which 20 km is along beaches and clifftops.

Peninsula Coastal Walk in Point Nepean National Park is the closest to Melbourne. It stretches from London Bridge to Cape Schanck and features, in addition to fine views and diverse coastal vegetation and wildlife common to all coastal walks, a number of Aboriginal middens and a geological structure - Selwyn Fault.

Wilsons Promontory National Park offers a number of walks with **Tidal river** to **Oberon Bay** (10 km) and **Sealers Cove** to **Little Waterloo Bay** (14 km) probably the most popular coastal walks in Victoria.

Croajingolong National Park contains some short walks on formed tracks near, for example, Wingan Inlet and Thurra River. A popular overnight walking route that includes the beach and occasional old four-wheel-drive tracks is from Mallacoota to Point Hicks. Croajingolong National Park offers the most remote walking area on the Victorian coast.

conditions has improved dramatically. In the late 1970s launching from a high cliff in a steady and strong wind resulted in a couple of minutes flying. Now, hang-gliders can soar easily for many hours in 5 to 10 knot wind from hills only 10 metres high.

Two types are suited to fly above coastal cliffs and hills along the Victorian coastline - hang-gliders and paragliders. The alloy-framed delta-winged glider is the most commonly used. The paraglider resembles a large, wing-shaped, ram-air parachute and has recently been introduced from Europe.

The sport is regulated by the Hang-gliding Federation of Australia (HGFA), a government-recognised, self-regulatory body operating under the Civil Aviation Authority regulations, which oversees all aspects of it in Australia. The issue of graded pilots' certificates or licences is strictly regulated by the HGFA and pilots must undertake lengthy training before being legally permitted to fly solo. Pilots are graded according to their ability, experience, and air law knowledge, and are not permitted to fly at sites classified above their certificate level. This helps prevent inexperienced ones operating at advanced sites beyond their capabilities.

The Victorian Hang Gliding Association is a member of HGFA and has more than 500 licensed pilots. Each one is issued with a Victorian site guide, which lists conditions that apply at sites including flight limits and site land care.



Hang-gliding.

Hang-gliding requires air space with suitable wind, launching and landing sites, and car access. The coast is particularly popular because, in addition to spectacular views, it often provides ideal wind. The on-shore wind blowing into the coastal cliffs and hills provides the necessary lift and is usually smooth without turbulence, thermals, and other air instabilities that frequently occur inland. Optimum wind speeds are 10—15 knots for paragliders and 10—20 knots for hang-gliders. Experienced flyers (but also novices in good weather conditions) may stay in the air for several hours, flying back and forth along the ridge from which they launched. Top pilots may fly from Bells Beach to as far as Apollo Bay (about 80 km!).

Ease of catching the wind increases with the height of the cliff or hill, and the gently rounded cliff-tops make for easier take-off. The launching area, usually a coastal cliff, or

hill-top, may be as small as 100 sq. m and needs to be free of obstructions that may snag on lines of a hang-glider, clip its wings, or cause dangerous turbulence. Height may vary from 30 m for the cliffs at Portsea to 200 m for the coastal hills at Apollo Bay. A safe landing site is a sandy beach without rocks, water-pools or too many people. At some sites - for example, at Spion Kop, near Fairhaven Life Saving Club - it is possible to land at the top of the cliff, but is only experienced gliders.

The Victorian coast has a number of excellent hang-gliding sites that meet the above requirements, listed in Table 9.6 from Discovery Bay in the west to Orbost in the east. Provisions have been made for prepared launch sites at several popular sites - for example, a cleared and fenced area at Portsea back beach and a ramp at Flinders. Most sites have naturally clear and/or gently rounded cliff-tops, such as Mariners Lookout at Apollo Bay or Spion Kop.

Table 9.6: Coastal Hang-gliding Sites

Site name	Suitable wind direction	Type of coastal site	Rating*
Portland area	various	dunes and cliffs	ST—INT
Johanna	SSW	hills and dunes	NOV
Mariners Lookout (Apollo Bay)	SE	coastal hill	NOV
Mt Defiance	E—SE	large hill	ADV
Spion Kop (Aireys Inlet)	S	cliff and hill	INT
Eumeralla (Anglesea)	S—SE	cliffs	INT
Bells Beach	E, ESE	cliffs	INT
Fishermans Beach (Torquay)	SE	dunes	ST—NOV
Barwon Heads	S	dunes and cliffs	INT
Clifton Springs	NW	cliffs	ADV
Portsea	S—SW	dunes and cliffs	NOV
Arthurs Seat	W—NW	large hill	ADV
Sunnyside	NW	cliff	INT
Flinders	SSE or E	cliffs	NOV—INT
Barrys Beach (Phillip Island)	S—WSW	dunes and cliffs	NOV
Kilcunda	S—SW	dunes	ST—NOV
Eagles Nest	SE	cliffs	INT
Cape Liptrap	SW	cliff	INT

* ST = student; NOV = novice; INT = intermediate; ADV = advanced
Source: Victorian Hang Gliding Association (1991).

HUNTING

The main species sought by hunters along the coast are hog deer and ducks.

Hog deer are indigenous to south-east Asia and were introduced into Victoria in 1865. They grow to the size of sheep, with an adult weight of about 45 kg. They occur on the east Victorian coast between Tarwin Lower and Mallacoota, with the main population concentrations on Snake and Sunday Islands, on Wilsons Promontory, and in Gippsland Lakes Coastal Park. Seasonal hunting is permitted, subject to a number of legal requirements including, for example, bag limit and use of certain firearms. It is not permitted in Wilsons Promontory and Snake Island, but is allowed on Sunday Island and in the western area of Gippsland Lakes Coastal Park (east of Beacon Swamp Track on Red Bluff). On the eastern area of Gippsland Lakes Coastal Park (between Jones and Shaving Points on Boole Poole Peninsula) hunting was allowed in 1992 through a balloting system. In 1992 there were approximately 650 hog-deer-hunters and the sport seems to be increasing in popularity. Annually, 135 hog deer are killed (80 from Sunday Island).

The eight species of game ducks are: pacific black duck, Australasian shoveler, grey teal, chestnut teal, Australian shelduck, hardhead, maned wood duck, and pink-eared duck. They comprise an estimated population of between 25 000 and 50 000. Of these 40 to 70% are taken, one-third on the opening weekend of the season (season opens on the third weekend in March and closes at the end of May).

Excluding those who shoot over Gippsland Lakes wetlands, approximately 1000 duckshooters hunt on the Victorian coastal lakes and wetlands. The most popular areas (used by 90% of shooters) are near Marlo (Curlip, Corringle, Beetle and Wat Wat lakes, Ewing's Marsh, Cabbage Tree Lagoon, and Snowy River Flats), Yarram (Jack Smith Lake) and Geelong (Lakes Connewarre and Point Henry). The remaining 10% use the wetlands near Lakes Entrance (Lake Tyers), on Western Port (French and Phillip Islands), near Cape Otway (Aire River estuary), Warrnambool (Kelly Swamp) and Port Fairy (Lake Yambuk).

ORGANISED EVENTS

Many non-competitive recreational activities carried out by an individual, small group of friends, or as a club event may also be organised as competitive events - for example, surfing, fishing, and regattas. Others, however, such as triathlons, are undertaken only on a competitive basis. Some of these events, such as the Bells Beach surf classic held during Easter each year, are known internationally.

*

Competitive events, for the safety of competitors or spectators and to ensure fair competition, may require the exclusive use of particular area from a few hours to a couple of days.

Introduced in the late 1940s, surf carnivals were perhaps the first Victorian coastal competitive events involving beach sprints, swimming, board, and surf-boat events and culminating in a march past. Participation has grown. Events that might have had up to 1000 participants and 3000 spectators in the 1950s may attract 4000 participants with up to 20 000 spectators in the 1990s. All beaches associated with clubs may be used, although some are used more often because of their generally protected nature and ease of access. They include Warrnambool, Lorne, Anglesea, Torquay, Ocean Grove, and Point Leo. While training for these events may be year-round, the events usually occur during October to April.

With changing media and community interests, and mass participation, special events such as triathlons and other short-term events have attracted considerable interest. They may take from less than an hour to half a day to complete. Events near the larger population centres tend to attract the greatest number of participants.

Participant numbers can vary from 100 for a small local event to 3000 for a well-known swim like the Pier to Pub at Lorne. Notable annual events include:

* Geelong Endurathon - Geelong
* Victorian Triathlon Championship - various sites
* Pier to Pub Swim - Lorne
* Torquay Swim/Run Classic - Torquay
* Channel Challenge - San Remo
* Milo Junior Triathlon - Sandridge
* Rip to River Fun Run - Ocean Grove
* Portsea Swim Classic - Portsea
* Peregrine Summer Classic - Torquay/Ocean Grove
* Rip View Swim Classic - Point Lonsdale
* Cerberus Swim Classic - Half Moon Bay
* Club to Club Swim - South Melbourne

In addition to the temporary but exclusive use of the area for the activity, large numbers of competitors and spectators must be provided with adequate parking, first aid, and spectator facilities. Crowd sizes vary considerably from 300 for a small local event to 20 000 for well-known events.

Some 65 mass participation events were held along the coast in 1991/92.

ISSUES

* opportunities and infrastructure associated with the expanding range of recreational uses of the coast
* resources and facilities to ensure adequate safety of people using the coast
* education of the community in terms of the sensitive and sustainable use of marine and coastal areas
* impact of other activities on coastal recreation

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10. TOURISM

Tourism is an umbrella term for all the activities, relationships, and phenomena associated with people travelling. According to one definition, it is the entirety of interrelations - physical, social, and economic - that result from people travelling to, and stopping at, destinations that are neither their principal residence nor their place of work. This may include travel and any activities associated with recreation, study, or work away from the normal workplace.

This chapter considers only tourism related to recreation activities, as tourism related to study or work would not be expected to have a great impact on the coastal environment. It will describe the services, infrastructure, and facilities that support tourism for recreation purposes. Chapter 9 described the natural resources and recreational activities that attract people to the coast, and it is recognised that these activities provide the primary motivation for tourism: for example recreational fishing is a focus for boat hire and charter.

Use of the coast

The coast is a very popular recreational destination. Some 46% of visits (including campernights and day visitors) to all parks in Victoria (National, State, and other parks) in 1991/92, involved parks along the coast. Table 10.1 lists the most popular of these.

Table 10.1: Visitor Numbers in Coastal Parks

Park	Visitors
Point Nepean	1 845 560
Port Campbell	927 940
Phillip Island Penguin Reserve	480 000
Wilsons Promontory	402 790
Gippsland Lakes Coastal Park and The Lakes National Park	264 230
Angahooke—Lorne State Park	256 090
Croajingolong National Park	175 030
Discovery Bay Coastal Park	103 000

Point Nepean's popularity is not difficult to understand. It is a spectacular area, well serviced, with easily accessible swimming beaches close to a big centre of population. Port Campbell National Park is one of the major attractions along the Great Ocean Road and contains, one of Victoria's major natural attributes. Croajingolong and Discovery Bay Parks are far from the major population centres and have few safe swimming beaches; their remoteness and natural coastline are obviously highly valued to attract such large numbers of visitors, particularly to locations such as Mallacoota Inlet, Wingan Inlet, and Thurra River in Croajingolong.

Pattern of tourism

Tourism along the coast is strongly seasonal. Most visitors visit during holidays, particularly over Christmas, New Year, and summer school holidays. In smaller coastal resorts, the increased summer visitation, particularly during January, leads to peak populations that greatly exceed the normal levels. For example, the population of Mallacoota grows from about 300 in May to 8000 in January. In addition, the areas visited most frequently and in the greatest numbers are located near major population centres such as Melbourne, Geelong, and other major coastal towns.

Additional facilities needed

During the tourist season additional facilities may be required to cater for the tourists beyond the needs of residents. The sudden population increases imposed by seasonal use require enlargement of basic services such as water supply or waste-water disposal. The inadequacy or lack of these services has been causing problems in a number of coastal towns. For example, Anglesea sewage receives secondary treatment, but during the summer the treatment plant is overloaded and cannot treat sewage adequately.

Tourist accommodation needs

Visitors to the coastal areas outside capital cities stay in parks or commercial tourism establishments, such as hotels and motels, holiday units, and caravan parks. In 1990/91, almost 30% of all Victorian domestic tourist activity, based on the use of these establishments, took place in the non-metropolitan coastal zone. The proportion of accommodation nights spent was highest for caravan parks (35%), followed by holiday units

(23%), and hotels and motels (35%). Mallacoota Shire Caravan Park, for example, accounts for 64% of the total holiday accommodation within Mallacoota.

High concentrations of tourists occur in coastal towns with extensive foreshore camping areas or other types of accommodation catering for large numbers of people. Some 100 coastal towns and localities provide different types of accommodation ranging from camping areas, through bed and breakfast (including a farm stay or a grand colonial home), to four-star motels. Cape Bridgewater, for example, provides only two cottages and one lodge. Port Fairy by contrast has 28 different accommodation facilities, including cottages classified by the National Trust. Camping areas in popular coastal parks, such as Wilsons Promontory during peak periods, are managed on ballot or reservation systems. In addition, a number of private holiday houses on the coast are often rented out during peak periods.

Tourist attractions

Attractions are an implicit part of tourism. They are based on both natural and cultural features, such as rugged coastline, beaches, interesting rock formations, marine mammals or birds, museums, historic buildings, port areas, and shipwrecks. The following description deals only with examples of what is commonly understood as 'commercial attractions' - that is, natural or cultural features promoted by the tourism industry and provided with special facilities like self-guided walks or animal-viewing platforms.

Physical attractions

Many facilities and attractions are available along the Great Ocean Road and the rugged Shipwreck Coast which stretches between Port Fairy and Cape Otway and is known for its many (80 recorded) shipping disasters. The wrecks can be inspected by diving (see Chapter 9) or followed onshore along the Great Ocean Road using the information provided by Victoria Archaeological Survey-Shipwreck Trail brochures. A much publicised shipwreck is the 'Mahogany Ship' - some 20 unconfirmed sightings of the wreck have been made in the coastal dunes, but it has never been found. It was believed to be a Portuguese caravel and is thought to have been wrecked west of Warrnambool around 1522. A reward of $250 000, offered during late 1992 and early 1993, attracted a number of potential discoverers. The famous rock formations, the Twelve Apostles, Island Arch, Castle Rock, and London Bridge (now partly collapsed) are other well publicised attractions.

Biological features

Penguins, seals, muttonbirds, and whales are promoted as commercial attractions. In fact, public interest in animal-watching has increased enormously over the last decade.

For example, little penguins and seals are the main attractions for visitors to Phillip Island, where the Penguin Parade at Summerland Beach is the best known penguin-viewing area along Victoria's coast. Each year it attracts an increasing number of visitors, reaching nearly half a million in 1992 (Table 10.2). Half of these come from interstate (10 to 15%) or overseas (35 to 40%).



Penguin parade, Phillip Island.

Table 10.2: Penguin Parade - Number of Visitors and Income Generated

	Year ending 30 June					
	1987	**1988**	**1989**	**1990**	**1991**	**1992**
Number of visitors ('000)	396	476	477	471	469	480
Income generated ($M)	22	28	30	33	33	34

The penguins can be seen coming ashore just after dark and visitors stimulated by this extraordinary sight can learn about the biology and life cycle of penguins in the modern interpretation centre, which is a key component of the facility. The centre provides a number of educational programs as well as audio-visual information. Nearby Seal Rocks on the south-west tip of Phillip Island are home to a large

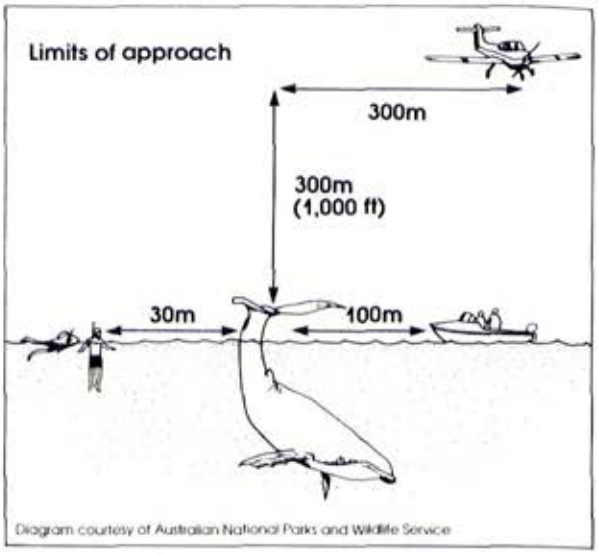
colony of Australian fur seals, which can be viewed from the adjacent Point Grant.

A framework that focuses on the interrelationship of all the island's fauna (Australian fur seals, muttonbirds, wetlands birds, and koalas) could be established. This would increase not only visitor numbers on the island but also the length of stay and yield per visitor. Such frameworks could also be developed around the other regional strengths in Victoria where over one or two days people can experience environments of great contrast.

Muttonbirds or short-tailed shearwaters form colonies, one of which occupies Griffiths Island off Port Fairy. This unique attraction draws thousands of visitors each year. A well-signposted foot track from the island causeway leads to a specially constructed viewing platform, where visitors can enjoy the viewing with minimal disturbance to the birds. From September to April the birds return at dusk and provide a spectacular sight.

Whales afford perhaps the most inspiring of all animal-watching. In Victoria, whale-watching is centred on the southern right whale on Logans Beach near Warrnambool, where in recent years 24 calves have been born or have spent the early part of their lives. A special viewing facility is provided. Although whales can also be watched from boats, aircraft, or even by swimmers, strict rules are enforced about the distances from the whales and the level of noise allowed. The regulations are depicted in Figure 10.1.

Figure 10.1: Whale Approach Regulations



Cultural features

Historic buildings are located in some coastal towns, including Portland, Port Fairy, and Queenscliff. The historic black lighthouse at Queenscliff is the only unpainted bluestone one in Australia. Other lighthouses along the coast, such as those at Point Hicks, Point Lonsdale, and Wilsons Promontory, are a source of fascination and interest and important tourist attractions in these localities. Historic stone cottages at Port Fairy are well preserved and the associated historic walk attracts a significant number of visitors. The townside wharfs service a commercial fishing fleet and increase the appeal of such towns.

Museums and information centres providing information about Australian maritime history are established in many of Victoria's coastal towns. They include maritime museums in Geelong, Warrnambool, and Port Albert, a Maritime Centre at Queenscliff, a historical museum at Port Fairy, HMAS Cerberus naval museum at Crib Point, and a lighthouse museum at Cape Schanck. Flagstaff Hill Maritime Village at Warrnambool recreates the appearance, atmosphere, and activities of an early coastal port around 1850. It contains information about Aboriginal history, whaling, sealing, European settlement, and a number of historic buildings. In addition to a church, bank, store, a harbour with a variety of carefully preserved historic vessels, and hundreds of items washed ashore or retrieved from the ships wrecked along the coastline, the Village has library, and a 100-seat theatre where a wide variety of historical and informative audio-visuals are screened.



Maritime Museum, Warrnambool.

Marine transport, boat charter, and hiring services

An obvious attraction of coastal tourism is a possibility of sea travel (sea transport is covered in Chapter 11). Sea travel can combine transport and pleasure or can be purely recreational as, for example, scenic

cruises. Apart from pleasure travel, boat charters and boat hiring services are available for recreational diving and fishing.

Three transport ferries operate around Port Phillip Bay, allowing car trips by connecting Mornington and Bellarine Peninsulas between Queenscliff, Portsea, and Sorrento. They are the car and passenger ferry 'Peninsula Princess' and two passenger ferries 'M.V. Nepean ' and 'M.V. J.J. Farnsworth'. Only the 'Peninsula Princess' runs all year round, and apart from transporting tourists is also used by commuters. To reduce the travel time and increase parking space and the capacity to carry passengers and cars, there are proposals to construct a new berth closer to Portsea and at Queenscliff and to introduce another ferry. The other two ferries operate daily between the Peninsulas from Christmas until Easter, but only on weekends for the rest of the year.

Western Port has a hydrofoil service from Crib Point to Phillip Island (Cowes) and French Island. Tourists can also travel by sea between Victoria (Welshpool) and Tasmania (George Town) in 4.5 hours by *Seacat*, a catamaran five decks high, able to take 350 passengers and 84 cars, and travelling at a speed of 35 knots. The *Seacat* operates only during summer (between December and April), while tourists can use the slower, but available year round *Able Tasman* connecting Melbourne and Launceston.

Charter services provide boats for diving and recreational fishing. Dive charter facilities in Victoria are excellent. In summer, up to 20 boats operate out of Queenscliff, Portsea, Sorrento, Rye, Dromana, Mt Martha, and Frankston. Boat-hiring for diving is also available from Geelong, Western Port, Port Campbell, and Portland. The boats are small (6—10 m), and operate on a daily basis and from 5 to 10 km off-shore. The bigger live-aboard ships of 12—15 m operate mainly from around Wilsons Promontory. They offer trips from 2 to 7 days, and may travel up to 50 km off-shore. They include the Deal and Flinders Islands of Tasmania.

Boat charters for fishing and scenic tours are provided in Port Phillip Bay, with some operating out of Geelong. Most run all year, with the peak in spring and summer and the low season in winter. The boats mostly cater for small groups on weekends (see Table 10.3).

Table 10.3: Boat Charter Services

Operator	Number of boats	Boat passenger-carrying capacity	Frequency of service	Areas of operation	Type of tours (scenic or fishing)
Williamstown Bay and River Cruises	3	8	Mainly weekends - Sept to June	Port Phillip Bay	Both
Bay or River Cruises	3	20	Mainly weekends - Nov to Mar	Port Phillip Bay (includes Hobsons Bay and Williamstown)	Both
Fishing Charters v.v	1	8	Mainly weekends - all year	Port Phillip Bay Western Port	Fishing
M.V. Revolution	1	38	4 days a week - all year	Apollo Bay Port Welshpool Port Phillip Bay	Scenic
Wilsons Promontory Fishing Services	1	14	3 days a week - Nov to April	Seaspray to Gippsland Lakes	Both
Skipper and Clipper	3	6	Mainly weekends - Oct to April	Point Wilson to Portarlington St Kilda to Mt Martha	Fishing
Oceania Cruises	3	37 (2 boats) 8 (1 boat)	Once a week - All year	Port Phillip Bay	Scenic

Note: As Gippsland Lakes are not included in the study area, the information on boating in Gippsland Lakes is not provided.

Other craft for hire are canoes, small fishing and sailing boats and sailboards. The hire of these vessels is restricted to the larger, more sheltered coastal bays, such as Port Phillip Bay, Western Port and the larger estuaries, like Mallacoota Inlet or Glenelg River.

Safety services

Facilities and services that ensure safe conduct of recreational activities are an important part of tourism infrastructure. In Victorian marine waters, Victoria Police (specifically the Water Police Squad) has the responsibility for co-ordinating all search and rescue operations. Many volunteer marine rescue organisations are involved, including, for example, Surf Life Saving - Victoria (SLS), Australian Volunteer Coast Guard, Royal Volunteer Coastal Patrol, Westernport Safety Council, Gippsland Safety Council, Ballarine Sea Rescue, Southern Peninsula Rescue Services, and Mornington Bay Sea Rescue.

Most water-safety craft are based in Port Phillip Bay, Western Port, Lakes Entrance, and the Portland area. All are staffed by volunteers. The entire coast, including Port Phillip and Western Port, has developed an extensive marine radio network to assist all mariners. One service, the Southern Peninsular Rescue Service, is further equipped with a helicopter and the Westernport Safety Service has, as part of its fleet of dedicated rescue craft, a hovercraft to rescue mariners stranded on the mudflats of the bay. In addition to volunteer groups, assistance is given by commercial fishing vessels, commercial and government ships (e.g., MSL's 'Delphinus'), the pilot service that brings ships through Port Phillip Bay heads, and media helicopters.

Surf Life Saving - Victoria (SLS), is one of the largest voluntary organisations, partly funded by the Victorian government and dedicated to ensuring beach safety. It provides patrols and beach surveillance at 28 Victorian beaches. Volunteers patrol the beaches during summer, usually from the last weekend of November to the end of March, on Saturday afternoons, Sundays, and public holidays. Professional lifeguards patrol from Monday to Saturday mornings during the peak holiday period (Boxing Day until the end of January). On average, SLS has 1200 rescues a year. Each of the beaches it patrols has a clubhouse with equipment, including first aid equipment and in-shore rescue boats with a 5- to 6-km range.

Table 10.4: Surf Life Saving Patrolled Beaches and Associated Resources

Serviced beaches	Professional lifeguards in peak periods	Radio link	Off-shore rescue boats	Four-wheel-drive
Lakes Entrance	yes			yes
Seaspray				yes
Woodside				
Waratah Bay		yes		yes
Venus Bay	yes	yes		yes
Cape Paterson		yes		yes
Woolamai Beach	yes	yes		yes
Point Leo		yes		
Gunamatta	yes	yes		
Portsea	yes	yes		
Half Moon Bay		yes		
South Melbourne		yes		
Point Lonsdale	yes	yes		
Ocean Grove		yes		yes
13th Beach		yes		
Bancoora		yes		
Torquay	yes	yes		
Jan Juc	yes	yes		
Anglesea	yes	yes		
Fairhaven		yes		yes
Lorne	yes	yes		
Wye River		yes		
Kenneth River		yes		
Apollo Bay			yes	yes
Port Campbell			yes	
Warrnambool	yes			yes
Port Fairy				
Portland			yes	



Surf Life Saving for a Summer of fun at Portsea.

Off-shore rescue boats, with a range of 8—40 km, operate only in 3 locations - Apollo Bay, Port Campbell, and Portland. Many beaches are linked to a UHF radio network and some are serviced by four-wheel-drive vehicles. The Water Police Squad often uses SLS facilities. Table 10.4 lists some of the facilities available at the beaches patrolled by SLS.

Surf Life Saving also provides surveillance services, for a fee, for a number of organised events such as triathlons or distance swims. Training is provided for a number of activities associated with life saving, first aid, rescue boat operation, radio operation, and, of course, life saving. Training manuals are also provided.

Access roads

A good road network allows most of the coast to be conveniently reached by private vehicles. Also, day bus tours operate to the coast, including Phillip Island, and along the Great Ocean Road.

Some roads follow the coastline closely - the Great Ocean Road for example. Most of the coast, however, can be reached only by feeder roads leading to coastal towns or other seaside locations. The longest sections of coast without two-wheel-drive vehicle access within 500 m of the shore, lie along Discovery Bay, Wilsons Promontory, and Croajingolong National Park. These sections make an important contribution to the diversity of recreation opportunities available along the Victorian coast.

Guided tours

Guided tours are useful for educating tourists about natural and cultural environments. Most of those provided by tourist organisations are self-guided walks, but the Department of Conservation and Natural Resources (CNR), in addition to information kits, has a number of tours guided by the rangers. Among the few such tours along the Victorian coast, sea-kayaking and coastal walks along Croajingolong National Park provide limited examples.

Over the last decade, interest in guided tours based on eco-tourism or cultural tourism has increased. Eco-tourism promotes an understanding of the scientific and ecological aspects of natural environmental features. It integrates protection of the natural environment with its enjoyment by people and increases the visitor's respect through non-exploitative

means, as distinct from the construction of large tourist-oriented developments. Currently, 4 or 5 tour operators are licensed by CNR to conduct activities on public land on the Victorian coast. In addition CNR, through around 20 to 25 park rangers, and other organisations provide coastal and marine field interpretation and education programs (described in Chapter 15), which convey the context of eco-tourism. Cultural tourism, as the name indicates, promotes an understanding of cultural features.

Promotion

The knowledge of first-time visitors is shaped by the media, recommendations from friends, and tourism information services. Therefore promotion of an area can significantly affect its level of use, and the way it is used and valued by tourists.

Promotion can affirm particular forms of behaviour that may or may not be appropriate. It may also serve to change visitor patterns, encouraging off-peak use or selectively promoting specific coastal venues, or it may provide new possibilities for holidays, such as eco-tourism. For people who return to the same place each year, tourist promotion would probably influence their activities rather than make them choose another holiday destination. Advertising campaigns have proved effective.

Some material has been produced (see the references below), but in general the information on tourism is sparse and difficult to find. It also appears that the tourism industry is underdeveloped, the range of services and facilities narrow, and the existing services often inadequate. As a result, potential tourists have very poor knowledge of opportunities. In addition, even within areas, information on local sites and activities of tourist interest is limited.

ISSUES

* provision of services, water supply and waste discharges in coastal towns
* compatibility of tourism with other uses, e.g., nature conservation
* implications of boating on water quality
* major coastal tourism developments and the issue of coastal dependence
* promotion of coastal tourism consistent with the capability of the resource

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11. TRANSPORT AND COMMUNICATION

This chapter deals with shipping routes, ports and their facilities, locations of areas developed in harbours and channels, locations of sea-floor cables, pipelines, and outfalls, and flight corridors.

SHIPPING

The major shipping routes are shown on Map 3 and navigational details on Admiralty charts, 'Sailing Directions - Victoria Including Bass Strait', and the Australian Notices to Mariners produced by the RAN Hydrographic Office. Generally the routes lie outside Victorian waters, except around major promontories such as Cape Nelson, Cape Otway, Wilsons Promontory, and Point Hicks and the approaches to the major ports, Portland, Geelong, Melbourne, and Hastings. Where shallow waters are encountered in the approaches to ports, such as in Port Phillip Bay, Western Port and Corner Inlet, shipping movements are restricted to narrow marked channels.

Various notices to mariners are issued both to protect shipping from navigated hazards and to protect sea-bed and floating installations.

Two traffic-separation zones lie off the Victorian coast and outside Victorian waters. One, 10 km wide, lies 10—20 km off Wilsons Promontory and the other 90 km off Ninety Mile Beach. In both instances ships travelling east to west must pass on the in-shore side of the zone and those proceeding west to east must pass on the outside. For the zone off Wilsons Promontory, large vessels are discouraged from entering the central area, which includes islands such as Rodondo and the Moncoeur Group. This arrangement minimises the possibility of collisions between ships in foggy conditions.

Also of relevance, an Area to be Avoided, which unauthorised ships over 200 tons should not enter, covers an area off Ninety Mile Beach from the low-water line out to about 90 km and includes the production oil wells and sea-floor pipelines.

To protect the proposed optic-fibre cable link between Victoria (Waratah Bay) and Tasmania, it is proposed to issue a Notice to Mariners that would prohibit anchoring and fishing by vessels of 20 m or greater in LOA, two nautical miles either side of the submarine cable.

PORTS

As described in Chapter 5, safe harbours were critical to the development of trade and defence of the colonial maritime economy in the early to mid 19th Century. The development of ports and shipping allowed the transport of goods and communication within the colony and with the world.

Over the last 150 years the need for the shipping of goods between ports on the Victorian coast has changed. Air transport has developed, along with a coastal road network. Cargo-handling has become more efficient, further affecting port use and the demand for port facilities. This section describes the major and minor port areas used for trade and maritime industry.

Major commercial ports

Currently, Victoria has four major commercial ports - Melbourne, Geelong, Portland, and Hastings. Trade can be described in terms of the 'trade sector' - the destination or source of cargo, be it overseas or within coastal Australia (Table 11.1) - and the type of cargo - whether containerised, liquid bulk, break bulk, or dry bulk (Table 11.2).

Table 11.1: Trade by Sector 1988/89 ('000 tonnes)

	Overseas		Coastal	
Port	Imports	Exports	Imports	Exports
Melbourne	4853	3767	2328	1530
Geelong	2112	1728	600	1273
Portland	402	1527	733	0
Hastings	105	1891	721	6256

Source: Port of Melbourne Authority (1990)

It should be noted that the landward sections of the ports of Melbourne, Geelong, and Portland lie within city boundaries and therefore outside the study area.

Table 11.2: Trade by Cargo Type 1990/91 ('000 tonnes)

	Containerised[1]	Liquid bulk[2]	Break bulk[3]	Dry bulk[4]
Melbourne	6362	2121	1131	1762
Geelong	69	3440	2219	284
Portland	0	142	0	292
Hastings	0	6687	1797	1076

Notes:
1. Containerised - shipping containers.
2. Liquid bulk includes crude oil, refined petroleum products, liquid gas, liquid chemicals.
3. Break bulk includes timber, paper, vehicles and parts, steel.
4. Dry bulk includes woodchips, fertiliser, alumina, petroleum coke, raw sugar, gypsum, cement.

Source: Port of Melbourne Authority (1991)

Major commercial ports have the following requirements:

* deep protected water in both access channels and dock areas

* flat land immediately adjacent the dock (This provides storage areas for material shipped through the port. Associated port industries, such as the refining or processing of bulk materials like oil or aluminium, also require suitable land within conveyor or pipeline reach of the port. Some materials require appropriate buffers for safe handling and storage: the Point Wilson facility in Corio Bay, for example, is dedicated to the handling of explosives.)

* proximity to markets and raw materials

Port of Melbourne - Of the four commercial ports, Port of Melbourne is the largest. It is also the largest container port in the Southern Hemisphere and in 1988 ranked 27th in the world in terms of container throughput. Port facilities are located at the mouth of the Yarra River and spread over several docks and piers.

Port of Geelong has six major cargo-handling facilities.

* Refinery Pier has four berths for handling liquid-bulk products - crude oil, refined petroleum products, chemicals, and gases.

* Bulk Grain Pier has two berths used only for the export of bulk grains such as wheat, oats, barley, and a variety of coarse grains.

* Point Henry has a single berth used only for the handling of petroleum, coke, and alumina.

* Lascelles Wharf has three berths. Two are dry bulk berths and handle fertiliser products predominantly. The third, a multi-purpose berth, caters mainly for break bulk cargoes.

* Corio Quay has four berths. One caters principally for woodchip exports and the other three for general cargo, steel, and roll-on/roll-off facilities.

* Cunningham Pier provides general cargo facilities and is also used for vessel lay-ups, for short-term visits of commercial and non-commercial ships, and for the staging of special events.

Additional facilities within the port include Point Wilson, which is used exclusively for the handling of explosives, and so public access is prohibited; and Rippleside Ship Repair Yard, a marine engineering facility that includes a slipway with a 1000-ton capacity.

Port of Portland has four major cargo-handling facilities.

* K.S. Anderson Wharf has two berths used mainly for grain export (90% of total tonnage) and also for aluminium ingots.

* Special Purpose Bulk Berth exclusively services the aluminium smelter through the transfer of imported alumina and petroleum coke.

* S L Paterson Berth - a liquid-bulk berth is used for the import of petroleum products.

* Two general Cargo Berths cater for dry-bulk and break-bulk cargoes.

Port of Hastings - Western Port is used by more than 300 merchant ships (in excess of 2500 tonnes). In 1989, most of them carried liquid fuels - with 125 carrying liquid petroleum gas and 82 carrying crude oil. The Port of Hastings operates five berths for commercial shipping. Crib Point has two berths, one for crude-oil tankers and the other for refined petroleum products. The Long Island Point berth handles crude oil and liquid petroleum gas. The BHP steel industry has



Port of Portland.

two privately owned berths, one for roll-on/roll-off vessels, the other for conventional vessels.

The deep water in the Western Entrance and North Arm of Western Port is significant for deep-draughted shipping. No other harbour on the Victorian coast and very few in Australia provide sheltered waters of such depth. Western Port's depth at the western entrance varies between a minimum of 16 m and a maximum of 30 m while the North Arm Channel has a 15.5 m draught. The cost advantages of deep-draught shipping make suitable natural harbours highly significant.

Future requirements, until 2013, for the development of the four major Victorian ports have recently been reviewed in the Victorian Ports Land Use Plan and a final report is currently being prepared. The plan recognised that, in view of the capacity available at existing facilities and the existing investment in port and related industry infrastructure, the only reason for considering the development of port facilities at a new site would be to decrease the risk associated with handling hazardous materials. However, because of the uncertainty in predicting future port requirements it was considered important to maintain options to use sites that would enable further port development in the very long term. Point Lillas in Port Phillip Bay and Tyabb in Western Port are two such sites. The Ports of Hastings, Portland, and Geelong also have the capacity for further expansion. It has, however, been possible to identify some areas within the major ports, that are not required for future port use and can be divested.

Other Port Facilities

In addition, facilities catering for commercial fishing, commercial shipping, coastal trading, the offshore oil and gas industry, and recreational boating are provided either in

association with the four major commercial ports or 14 other smaller port areas often referred to as 'associated ports' because of the administrative basis for their management. The administrative arrangements relating to their use and control are described below.

Port of Portland Facilities associated with the main commercial port include the Fishermens Wharf and Trawler Wharf, providing for 33 and 12 commercial fishing vessels respectively. In addition, 36 swing moorings and a marina with a capacity of 49 vessels cater for recreational vessels. A slip-way is also provided.

Port of Port Fairy Berthing facilities have been developed in the sheltered estuary of the Moyne River and include a large (100 tonne) and small slipway. They service a commercial fishing fleet (14 vessels) and 41 recreational boats.



Port Fairy facilities.

Port of Warrnambool A breakwater provides a sheltered basin for a commercial fishing fleet of 12 vessels.

Port of Port Campbell The port area lies within the unprotected water of Port Campbell Bay and provides no moorings. Vessels are launched by jetty crane, which 63 recreational boat-owners and 20 professional fishers are registered to operate.

Port of Apollo Bay is located at the southern end of Apollo Bay and extends from Henry Reef to Skenes Creek. Facilities consist of a harbour formed by two rubble-mound breakwaters; dredging keeps its entrance clear of sand. The harbour is the only safe haven for boats between Queenscliff and Port Fairy. It contains 25 pens, 26 swing moorings, one alongside berth, and fuelling and unloading berths. It also has a 50-tonne slipway and two-lane boat ramp.

Port of Lorne lies at the southern end of Loutit Bay. Port use is based around a concrete and timber pier, which provides deck storage for 16 boats. In 1992 this was used by four professional fishers. The Shire of Winchelsea operates two boat ramps adjacent to the pier.

Port of Barwon Heads consists of the area inside the mouth of the Barwon River. It contains six swing moorings, which are currently used by three professional fishers and three recreational boats, and three boat ramps.

Port of Queenscliff lies at the mouth of Queenscliff Creek at the southern end of Port Phillip Bay. A series of timber wharves and a sheet-pile wall provide 82 pens, 49 alongside berths, and 64 swing moorings. Currently 38 professional fishers, 8 charter operators and 141 recreational boats use these facilities. Additional facilities include two 100-tonne slipways and a boat ramp. A licensed marina is also located at the western end of the harbour.

Queenscliff harbour is regarded as the safest haven for small craft once they leave the confines of Port Melbourne. It is also the departure point for the 28-car-capacity ferry to Sorrento Pier.

Port of Port Phillip contains, in addition to the major port facilities described previously, over 60 public and private boat ramps and over 30 harbour and mooring locations. These boating facilities provide for recreational and commercial craft. Policy for their further development was outlined in the 1990 government plan for the protection and development of Port Phillip and Corio Bay - 'Making the Most of the Bay'.

Port of Anderson Inlet Anderson Inlet is comparatively shallow and facilities are few and limited to those required for recreational craft.

Port of Corner Inlet and Port Albert includes the eastern section of Corner Inlet and the adjacent Nooramunga area. Port facilities have been developed at a number of locations including Port Franklin, Port Welshpool and Port Albert. Facilities are also provided at Yanakie and Barry, McLoughlans, and Manns Beaches.

Barry Beach was used as the main construction and launching facility for the heavy

engineering works for the platforms now operating in the Gippsland oilfield. Only the slip facilities remain as testament to this use.

Port Welshpool services: the *Seacat*, a catamaran car-ferry service operating seasonally between Victoria and Tasmania; the offshore oil industry; and minor coastal trade, which is expected to increase. Facilities include 11 pens, 10 swing moorings, 30 alongside berths, double ramp, and slipway.

Port Albert has 34 pens, 65 swing moorings, 27 alongside berths, a slipway, and launching ramp.

Other facilities in the area include swing moorings at Manns Beach (12), Yanakie (80), Robertsons Beach (5) and McLoughlans (5).

Port of Gippsland Lakes includes most of the waters of the Lakes. Facilities developed at a number of locations throughout service the recreational and commercial needs of lake-users. Extensive port facilities at Lakes Entrance service the recreational and commercial users of the adjacent coastal waters.

Lakes Entrance is Victoria's largest commercial fishing port. It also provides facilities for vessels servicing the off-shore oil and gas industry and for minor coastal trade. The actual entrance is maintained by constant dredging, but can prove hazardous, particularly for those without local knowledge. At least two boat ramps are provided at Lakes Entrance.

Other areas - the Snowy River and Mallacoota Inlet have recently been degazetted as 'associated ports'.

At Marlo, at the mouth of the Snowy, the main facility, the Marlo Jetty, has alongside mooring for 3 or 4 craft only. The Snowy River bar is often shallow; alternative sea access is available at launching facilities at Cape Conran.

Mallacoota Inlet contains jetties at Gypsy Point and Karbethong and a wharf at Mallacoota. The Inlet also has launching ramps. These facilities service the needs of the commercial abalone-fishers and recreational boaters. Conditions over the bar at Mallacoota are highly variable and local knowledge of its condition is important. Boats may be launched directly on the ocean side of the bar at Bastion Point

Table 11.3: Waters Declared as Associated Ports (April 1993)

Responsible authority	Area
Port of Portland Authority	Port Fairy, Warrnambool, Port Campbell
Port of Geelong Authority	Apollo Bay, Lorne, Barwon Heads, Geelong, Queenscliff
Port of Melbourne Authority	Melbourne, Port Phillip, Western Port, Anderson Inlet, Corner Inlet, Port Albert, Gippsland Lakes

CHANNEL OR HARBOUR DREDGING AND SPOIL DISPOSAL

Harbours or access channels used by commercial or recreational vessels may require dredging to create and maintain the channel to sufficient water depth. Reduction in water depth through siltation often occurs where: the harbour structure traps previously mobile sand; the harbour is located at a river mouth and fills with sediment deposited by the river; or the channel or harbour infills as a result of sand movement.

Dredging also requires the disposal of spoil, preferably to areas where it will not re-enter the dredged area, or where it would naturally end up if it had passed through the area. Map 4 shows the major sites of spoil disposal.

The history of dredging and spoil disposal and future dredging requirements have recently +been reviewed for the 1992 Victorian Protocol and this section is based on that review. Chapter 4 discusses aspects of the environmental impact of dredging and Chapter 14 its use in beach-renourishment programs.

Port of Portland The port has natural deep-water access from shipping lanes and does not require navigational channels. Dredging has been confined to within the harbour to provide for the turning basin and deep water adjacent to each wharf and is expected to continue for the next 10 years at least. Up to 50 000 cu.m each year can be dredged.

Historically, spoil disposal occurred within the harbour to reclaim land, and ongoing dredging has enabled spoil to be used for further reclamation of the No. 2 Quarry area.

The material dredged from the main breakwater is a fine-grained sand and has been disposed of either by pumping ashore for beach renourishment or at an off-shore disposal site. Sand is accumulating on the eastern side of the main breakwater at an estimated rate of 50 000 cu.m a year. Sand by-passing operations have been initiated and will be necessary every 4—5 years.

Port of Port Fairy Maintenance dredging of the Moyne River is carried out regularly to maintain navigable waters for fishing vessels. At present the removal of about 20 000 cu.m of fine sand each year ensures a depth of 2.7 m

Approximately 20% of the material is pumped onto the beach at Campbell Street. The remainder is pumped onto Eastern Beach to renourish the beach adjacent to the training wall. Some minor reclamation is also carried out in the Griffith Island causeway.

Port of Warrnambool Maintenance dredging within the mooring basin and the approach to the boat ramp at Warrnambool harbour have been conducted at irregular intervals. Prior to 1992 the area was last dredged in 1987, when 17 000 cu.m of sand was removed.

In the past, the sand was pumped ashore for beach renourishment. Recently this practice has been discontinued with material now pumped to an off-shore disposal site 300 m north of the breakwater.

Port of Apollo Bay An average of 80 000 cu.m of sand is dredged from the harbour entrance every year. All material is disposed of on the northern side of the lee breakwater. The shoreline progradation and dune accretion can be expected to continue as long as this practice continues.

The option of emptying a sand trap at the Point Bunbury groyne to reduce the sediment load drifting along the breakwater towards the entrance is being considered.

Port of Melbourne Since the turn of the century, the main shipping channel and the lower Yarra River have been dredged to allow the safe passage of ships in and out of the Port and to accommodate the increasing beams, draughts, and tonnage of vessels.

The 'Rip' and South and West Channels The entrance to Port Phillip Bay has, since 1908, been blasted, but currently there are no plans to carry out further blasting works here. Minor dredging works may be considered in the future to remove shallow areas near the edge of the shipping channel.

South Channel is the main one, catering for approximately 80% of the commercial shipping movements within the Bay. In the past, regular dredging was carried out to maintain the necessary depths, chiefly near the Deep Draught Channel and the South Channel Cut. Maintenance dredging involves the removal of at least 60 000 cu.m of material every 2 years and mainly recycles the sand within the sand-banks. South Channel is currently being realigned.

Since 1985, depths at West Channel have apparently stabilised at 5 metres. Even though shipping demands for the use of West Channel have increased, no requirement to maintain greater depths has yet become apparent. However, in the near future, the need for increasing the depths by 0.5 to 1 m may arise.

Material raised from the southern part of Port Phillip Bay is disposed of in two locations, namely east and west of South Channel.

Port waters on the Yarra River River dredging within port waters has varied over the years in direct relation to demands and development of the Port. Between 90% and 95% of the 400 000—500 000 cu.m of the dredged material is silt. Currently the redevelopment of the Holden Dock and the establishment of a new berth will generate 440 000 cu.m of material, part of which will be disposed of in the Bay. Future capital works by the Port of Melbourne and AMECON, a private ship-builder at Williamstown, may require dredging.

Historically, material from the northern part of Port Phillip Bay was disposed of in several locations, but since the 1940s one location approximately 8 sq.km in the north-central area of the Bay has been used. This area is 14 to 20 metres deep and is regularly surveyed.

Tidal waters of the Yarra and Maribyrnong Rivers, upstream of the port waters, have been dredged - 11 km of the Yarra and 10 km of the Maribyrnong. Annual dredge volumes were 40 000 cu.m for the Yarra, which was disposed of in the Bay, and 30 000 cu.m for the Maribyrnong, which was disposed of on land. These dredging operations were reviewed in the 1989 *Value Management Study on Dredging in the Yarra and Maribyrnong Rivers*, after which dredging ceased.

Corio Bay Dredging commenced in 1854. Since then it has continued, mainly to deepen, widen, and align the main channels and provide for their maintenance, and, for the last 30 years, the expansion of port facilities, especially at Point Henry.

Dredging will be required on an irregular basis in the future, for capital works such as changes to channel depth and width. Should the development of Port Lillias proceed early next century, a new approach channel will be required.

Should the development of Point Wilson proposal (as an alternative to the current Coode Island storage facility) proceed, considerable dredging as part of the capital works would be required. The Port of Geelong Authority has used four spoil grounds in Corio Bay and the Geelong Arm, located: west of Point Henry; east of Point Henry; west of Clifton Springs; and adjacent to Kirk Point.

Queenscliff Dredged material is used for rebuilding the eroded beach section between Sand Island and Swan Island or pumped into deep waters to replenish the sediment supply available for longshore drift.

Western Port Between 1963 and 1970, dredging of the shipping channels associated with the establishment of the BP Refinery and Esso Long Island Plant was undertaken in the North Arm channel. The material removed was deposited in a spoil ground located 3 km north of Tankerton Jetty between Middle Spit and French Island. The same spoil site is now utilised during maintenance dredging here. This is undertaken as required, on average at 2 to 3-year intervals, involving approximately 6000 cu.m a year. Most of the material dredged is a medium sand.

When the dredging associated with the establishment of the Esso facility at Crib Point was undertaken in the late 1960s and completed in 1970, the spoil was deposited east of Tortoise Head on the south side of French Island. This site has not been used since.

A disposal site located some 3 km south west of Grossard Point on Phillip Island was used in maintenance dredging operations in 1975 and 1976, but is no longer used.

Other areas in Victoria Material moved in these smaller dredging operations is mainly sand. It is used for beach renourishment or is moved as part of sand by-passing operations and includes entrances to port areas in Corner Inlet, Port Welshpool, and Port Albert, and at the mouth to Lakes Entrance.

SEA-FLOOR CABLES AND PIPELINES

Cables and pipelines may be located across the floor of the sea, bays, and estuaries. They may be laid either directly on the sea-floor or buried. Where they come on-shore through the surf zone, they must be buried.

Cables are used for data communication or the transfer of electricity. Pipelines across the coastline may carry petroleum products - for example, from the off-shore oil and gas production wells in Gippsland Basin to shore - or carry waste to ocean outfalls, or sea-water as the medium for on-shore mariculture. Land-based installations may or may not be buried.

The location of cables and pipelines may have implications for other uses such as conservation, anchoring of vessels, trawling, the placement of new cables or pipelines, and visual amenity.

SUBMARINE COMMUNICATIONS LINKS ACROSS BASS STRAIT

Telecommunication links

Such links across Bass Strait were of vital importance to Tasmania (Tulip 1988). The first telegraph cable between Parker River at Cape Otway and Low Head (Tasmania), via King Island, was laid in 1859. Its first break occurred within a few weeks, and following other defects it was abandoned in 1861. In 1869, a second cable was laid, between Flinders Beach (Victoria) and Low Head. A major break in this one occurred in 1884. Further cables were laid from Flinders Beach to Low Head in 1872, 1885, and 1898 and finally a pair of them were laid in 1909, some of which remained in operation until the 1930s. A submarine telephone link was finally established from Apollo Bay via King Island in 1936 and continued operating until 1979 when it was abandoned.

It should be noted that these cables were all laid directly on the sea floor, as the technology to lay buried submarine cables was not available until the 1970s.

At present, two separate microwave radio systems provide communication links between

Table 11.5: Submarine Cables, Pipelines, and Outfalls

General location	Specific location	Purpose
PIPELINES		
Ninety Mile Beach	Dolphin Monotower to shore	300 mm diameter pipeline carrying oil. There is also an associated 100 mm pipeline carrying fuel gas from shore to the Perch Monotower via the Dolphin Monotower.
Ninety Mile Beach	Barracoota A platform to shore. Two pipelines come on-shore approximately 10 km apart.	450 mm and 150 mm diameter pipeline carrying gas and oil
Ninety Mile Beach	Snapper Platform to shore	600 mm diameter pipeline carrying gas
Ninety Mile Beach	Marlin A platform to shore	600 mm diameter pipeline carrying gas
Ninety Mile Beach	Halibut A platform to shore	600 m diameter pipeline carrying oil
Port Phillip Bay	Altona to Mordialloc	Buried gas pipeline constructed in 1972
CABLES		
Otway Coast	Parker River (Cape Otway) to King Island	Telegraph cables - 1859; abandoned 1861
Mornington Coast	Flinders Beach to Low Head	Telegraph cables laid between 1869 and 1909 (abandoned)
Otway Coast	Apollo Bay to King Island	Telephone cable - 1936; abandoned 1979
OUTFALLS		
Portland Area	Nelson Bay	Ocean outfall
Port Fairy	South coast of Griffith Island	Ocean outfall just below low tide
Warrnambool	600 m west of Thunder Point	Ocean outfall discharging just below low tide
Apollo Bay	Black Beacon, Marengo about 3 km south-west of Apollo Bay	Ocean outfall. Discharges just below low tide.
Lorne	Just north of Sony Creek, 3 km from Lorne	Outfall discharging at about low water mark
Anglesea		Ocean outfall
Black Rock		Ocean outfall
Boags Rocks	Near Gunnamatta Beach	Ocean outfall, located below low water at the edge of the rock platform
Cowes		Submerged ocean outfall 120 m off-shore
Wonthaggi	Wonthaggi	Ocean outfall
Leongatha	Venus Bay	Ocean outfall
Foster		Submerged ocean outfall 1 km from high tide mark and 400 m beyond the mangrove fringe
Toora	1.3 km south-east of Toora	Pipeline discharge 250 m from high tide into a channel cut through the mangrove fringe
Port Welshpool	Outfall pipeline at the eastern side of Port Welshpool breakwater to Lewis Channel	Ocean outfall
Yarram	23 km east of Yarram	Discharges just above low tide
Ninety Mile Beach		Saline Waste Outfall Pipeline
Ninety Mile Beach		Latrobe Valley Ocean Outfall

Source: Department of Energy and Minerals, Environment Protection Authority, Telecom



Submarine pipeline inspection.

communication links between Tasmania and Victoria. These systems will be at their maximum capacity, with available technology, in 1995. To provide capacity beyond the year 2000, Telecom has proposed a submarine optical-fibre cable link, which would come on-shore at Sandy Point—Waratah Bay.

Power cables

The possibility of an undersea cable power link between Victoria and Tasmania has been investigated on several occasions.

A 1991 study (State Electricity Commission of Victoria and Hydroelectricity Commission of Tasmania) demonstrated that such a link - Basslink - was technically feasible, and a number of reports have been released, (listed in the references). The following cable landing sites have been identified:

* Ninety-Mile Beach (south-east end)
* Cape Liptrap (east and west)
* north-west of Cape Paterson (Wonthaggi)
* just west of Inverloch
* south-east end of French Island
* western side of Western Port near Tyabb
* western side of Western Port just north of Flinders

Forecasts based on 1991/92 demand levels give the optimum timing for commissioning Basslink at about 2000-01.

However, the optimum time is sensitive to a number of factors, which are regularly reviewed to determine how changes to them may affect timing.

Pipelines

Sea-floor pipelines are located in two areas.

* Along Ninety Mile Beach they provide a link with the off-shore oil and gas platforms. Here the pipelines are laid directly on the sea-floor and are generally covered or partially covered with sediment, depending on seasonally variable sea-floor currents.

* Across the north-east end of Port Phillip Bay a buried gas pipeline was installed in 1972 between Altona and Mordialloc.

OUTFALLS

In general, most of Victoria's 17 outfalls discharge to just below low-tide mark and consequently have a relatively short submerged length. They may be buried or exposed in the beach zone. The discharged material is discussed in Chapter 12.

FLIGHT CORRIDORS

Several aerodromes and landing strips have been developed within 1—2 km of the coastline, and aircraft overfly the Victorian coast and coastal waters for domestic and international travel, freight transport, and military and sight-seeing purposes. Aerodromes include those at Portland, Avalon, Point Cook and Mallacoota. Landing grounds are located at: Marengo, eastern end of Phillip Island, the north-western end of French Island, north-western end of Wilsons Promontory, just north of Port Welshpool, and Marlo.

Of relevance to this investigation is the requirement for air space and how this use may affect coastal uses, especially the conservation of wildlife such as birds and whales. Few restrictions limit the use of airspace, and flight corridors and routes are defined by the shortest distance to the destination airport, with the following exceptions.

* Routes for single-engine planes are chosen to minimise the distance over water. Those from Melbourne to Tasmania lie either along the coastline via Wilsons Promontory and the off-shore islands or via Cape Otway and King Island
* Airspace may be restricted, for safety or military purposes, around civil and military airports and gunnery ranges. For example, the restricted access around the Sale base crosses the coast between Jack Smith Lake and Loch Sport, and here the permitted route through the area is above the beach (at 500 ft); the area affected by gunnery practice to the south-west of Flinders, also has restrictions.

Administration of airspace for aviation is a Commonwealth government responsibility. To assist with the protection of wildlife, charts published by the Civil Aviation Authority provide the following notice.

> 'All Victorian and Tasmania coastal areas and inlet waterways are important breeding and nesting sites for bird and animal wildlife; to minimise the traumatic effects of low-flying aircraft on colonies, wildlife services have requested that overflying aircraft maintain a minimum height of 1000 ft above ground level in these areas, whenever possible'.

ISSUES

* potential pollution from oil or chemical spills and waste carried or generated by ships
* land for port and port-related development
* the use of anti-fouling agents and the introduction of exotic species
* hazardous materials facilities
* dredging and spoil disposal
* siting of cables and pipelines and implications for other uses
* transport corridors, particularly flight corridors, in relation to significant wildlife

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12. WASTE DISCHARGES

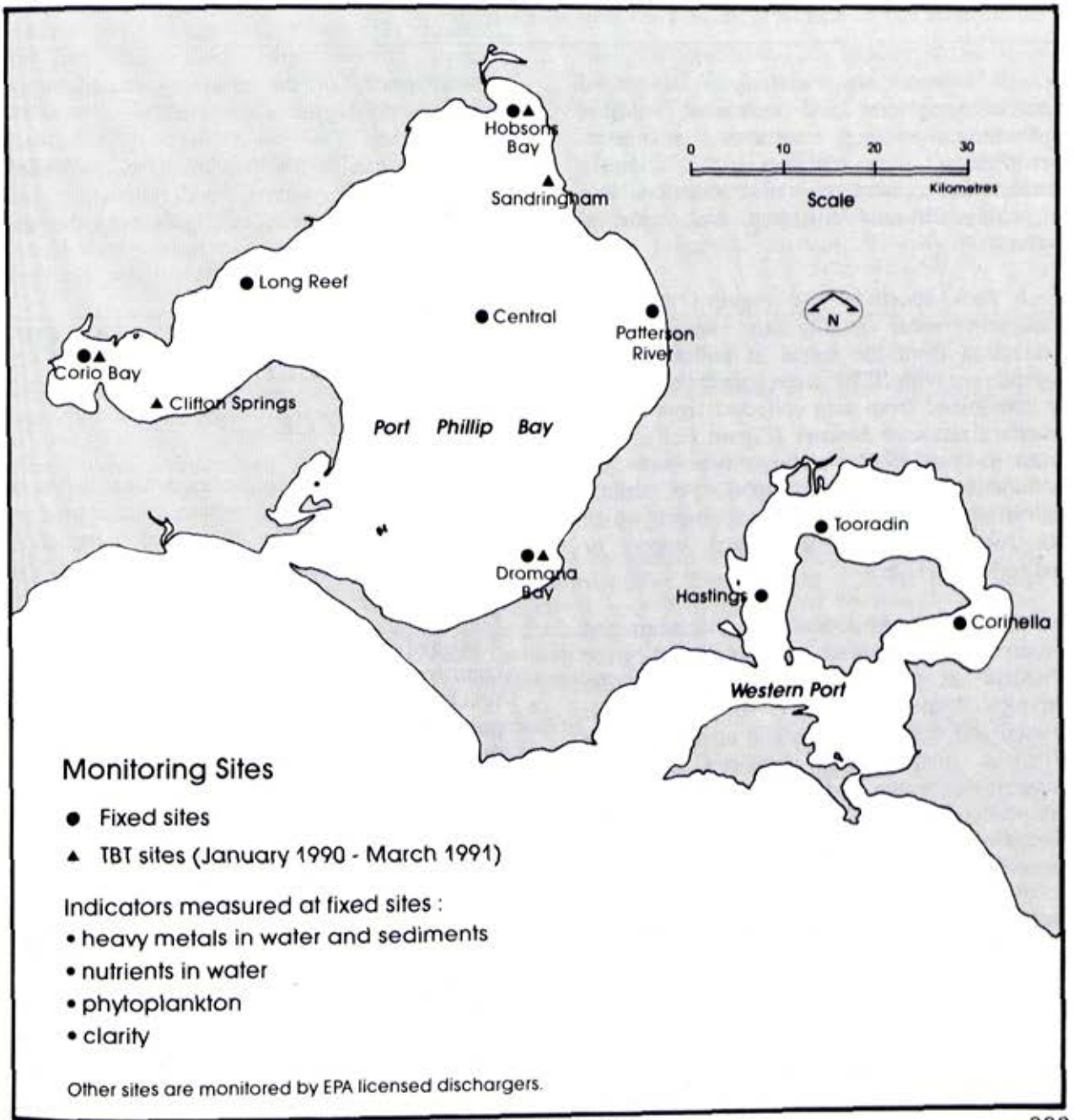
Many of the values of Victoria's coast are closely linked to the environmental quality of this area, particularly the water quality. 'Beneficial uses' are defined in State7 Environment Protection Policies (SEPPs) as

> 'a use of the environment or any element or segment of the environment that is conducive to the public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges, emissions or deposits'.

They include for water, activities such as swimming, navigation and shipping, fishing, industrial uses such as salt production and cooling water, and maintenance of natural aquatic ecosystems.

Three SEPPs have been declared for the coastal waters of Victoria, Port Phillip Bay, Western Port, and 'Waters of Victoria' (WOV) (see Chapter 18). The last one applies to all surface waters in Victoria except where varied by separately declared policies. The WOV policy divides these into five segments, including a coastal segment, which includes all the State's marine territorial waters. The policies identify the 'beneficial uses' of the environment to be protected in each segment. Those for the

Figure 12.1: Environment Protection Authority Monitoring Sites



Box 12.1: Heat, suspended solids, and organic wastes and nutrients

Very high water temperatures are lethal to fish and other aquatic organisms. Both temperature changes and elevated water temperatures may affect the growth and reproduction of some organisms.

Suspended particles may affect fish and other aquatic organisms in the water by: reducing the amount of light in the water available for plant growth and thereby reducing the supply of food for other organisms; clogging and damaging sensitive tissues such as gills or other respiratory surfaces; or smothering organisms that live on or in the sea-bed.

Organic wastes comprise degraded plant and animal matter and other biological products. Their further breakdown releases nutrients (nitrogen and phosphorus compounds) essential for the growth of marine plants (seaweed, seagrasses, and phytoplankton). The excess of nutrients encourages eutrophication - rapid growth of plants, which may then become a nuisance (for example, algal blooms). Massive die-off of the plants occurs and bacterial decomposition depletes the available oxygen supply. As a consequence, dissolved oxygen may decrease to a level low enough to kill fish and other aquatic organisms. The depletion of oxygen may also lead to anaerobic processes such as the generation of the odorous hydrogen sulphide. High levels of nutrients can also cause excessive growth of epiphytic algae (algae that grow on the leaves of other plants). Epiphytes have been known to kill seagrass by smothering.

Although excess nutrients increase plant production, their exact role in initiating algal blooms is not well understood. Some algal blooms include species that produce biotoxins. Marine molluscs such as mussels can take up the biotoxins and the resulting contaminated seafood can be highly dangerous to people. In addition, the biotoxins may be harmful to shellfish and other aquatic species.

coastal segment are maintenance of natural aquatic ecosystems and associated wildlife, swimming, boating, aesthetic enjoyment, production of molluscs for human consumption, commercial and recreational use of edible fish and crustacea, and industrial water use.

Each such beneficial use requires a certain minimum water quality and hence needs protection from the threat of pollution. The compliance with SEPP water quality objectives is determined from data collected from EPA's marine fixed sites network (Figure 12.1). The coast is particularly under threat from the pollutants resulting from population, urban, industrial, and agricultural development, which are released directly to coastal waters or indirectly via rivers.

In 1988, the Ministry for Planning and Environment completed 'A Coastal Policy for Victoria' as part of the State Conservation Strategy. Under this policy, which covers all coastal and estuarine areas and embayments in Victoria, marine and estuaries of high conservation value and habitats important for the production of fisheries resources are to be identified and, if necessary, set aside as protected areas.

POLLUTANTS AND THEIR IMPACTS

The impact of a pollutant on the marine environment depends on: the type of pollutant; the pollutant concentration and load; and the characteristics of the receiving waters - for example, the degree of wave action.

Pollutants can be grouped as: heat, suspended solids, organic wastes, and nutrients; and toxicants, radioactivity, and pathogens (see the boxes).

SOURCES AND PATHWAYS OF POLLUTANTS

POINT SOURCES

These are identifiable inputs where waste is discharged to receiving waters from a pipe or drain. The term 'waste' is defined as including 'any matter prescribed to be waste and any matter - whether liquid, solid, gaseous, or radioactive - which is discharged, emitted or deposited in the environment in such volume, constituency or manner as to cause an alteration of the environment'. With few exceptions, point source waste discharges are controlled by the Environment Protection Authority (EPA) through works approval and licensing systems. The licence for each input specifies the quality and quantity of the waste permitted to be discharged at a particular location.

Sewage-treatment plants are the major point source discharges to Victoria's coastal waters. Sewage is discharged to the marine environment either with no treatment or with primary or secondary treatment. The higher the level of treatment, the better is the quality of effluent.

Primary treatment involves the removal of solid material in settling ponds. This reduces levels of suspended solids, organic wastes and toxicants.

Secondary treatment - a biological process - involves the further removal of organic waste and toxicants using enzyme-activated sludge tanks and trickling filters. Waste may be chlorinated before discharge to reduce the level of pathogens.

Tertiary treatment removes nutrients, but it is not used to treat Victorian coastal discharges.

Major licensed discharges to open Victorian coastline

There are 17 licensed discharges directly to open Victorian coastline (Map 4). From west to east, they are: Portland sewage discharge, Port Fairy, Warrnambool, Apollo Bay, Lorne, Anglesea, Black Rock, Boags Rocks, Cowes, Wonthaggi, Leongatha, Foster, Toora, Port Welshpool, and Yarram discharges, Saline Waste Outfall Pipeline (SWOP), and Latrobe Valley Ocean Outfall (LVOO).

Varying amounts and types of effluent enter coastal waters from these. Most of the outfalls discharge relatively small volumes of effluent. Toora and Foster discharge into marine parks and are to be phased out when practicable in accordance with Clause 32 of WOV. Only two of the 17 discharges are from industrial sources. Leongatha discharges milk waste into the surf zone at Venus Bay, and SWOP discharges saline waste-water that contains metals from the Loy Yang power station (McKenzie and Goudey, 1991).

Boags Rocks discharges the highest volume (200 000 megalitres a year) of these licences. It receives a large percentage of Melbourne's sewage waste (35%), the rest being directed to the Werribee Treatment Complex. The waste is treated to a secondary standard at the South Eastern Purification Plant located at Carrum. It is then transported by a 56 km pipeline to the discharge point just below low tide located near Gunnamatta beach to the east of Cape Schanck.

Biological studies on the effects of the Boags Rocks outfall on marine biota have shown losses of intertidal brown algae, particularly *Hormosira banksii*, and their replacement by ephemeral green algae (see Chapter 4). This has resulted in a change of habitat favouring an increase in intertidal snails, but also a reduction in their diversity (Manning 1979).

Box 12.2: Toxicants, Radioactivity, and Pathogens

Toxicants - substances that cause death or adversely affect the life processes of aquatic organisms - are classified into two groups:

Non-persistent toxicants include ammonia, chlorine, sulphides, most surfactants, biocides such as tributyltin, and cyanides. While toxicants of this type do affect aquatic organisms, in time they evaporate, break down, or transform into relatively harmless substances.

Persistent toxicants include heavy metals, petroleum and halogenated hydrocarbons, and some pesticides. These may cause immediate death, or at lower concentrations, cause chronic effects. Chronic effects range from metabolic changes affecting reproduction and growth to gross morphological variations. Persistent toxicants may accumulate and remain in sediments for long periods of time. Physical disturbance of the sediments by storms or dredging may re-mobilise the toxicants into the water column. Chemical changes - for example, oxygen depletion - can also result in their release from the sediments.

Persistent toxicants can be bioaccumulated (concentrated by organisms) or biomagnified (concentrated up the food chain). They do not have to reach toxic concentrations in water to be bioaccumulated by marine organisms and, as a result, to have major impacts on the environment or pose significant health risks to consumers of seafood. Bioaccumulation rates vary and depend on the type of toxicant and organism. For example, fin-fish accumulate mercury more readily than shellfish.

Radioactive wastes include solids, liquids, and gases produced in the manufacture and use of radioactive material. In Victoria, hospitals, research institutes, and industry use radioisotopes only in small amounts and radioactivity is not considered to be a problem in Victorian waters.

Sewage and wastes from animals and animal-processing industries can contain very high numbers of micro-organisms such as bacteria and viruses. Some of these organisms are pathogens; that is, they can cause severe illness in humans exposed to them by contact with the water or through eating seafood harvested from contaminated waters. The bacterium *Escherichia coli*, or *E. coli*, is used as an indicator of faecal contamination (and hence, potential pathogen contamination) in coastal waters.

The patterns of algal change are common around many outfalls in south-eastern Australia and large brown algae tend to decrease in abundance (Brown *et al.* 1990). Another biological effect is the appearance of large numbers of a small spionid worm *Boccardia proboscidea* (Holmes 1987). The presence of this worm is thought to indicate high nutrient loads.

Black Rock discharges the second highest volume of domestic and industrial waste (20 300 ML a year) to a high-energy coastline. This outfall serves a population equivalent of about 180 000 people in Geelong and surrounding districts. The waste is passed through a milliscreen before being discharged via a submerged pipeline, 1.2 km in length. Diffuser ports increase dispersion and dilution of the effluent. The submerged pipeline came into operation in March, 1989, replacing an intertidal discharge. Following closure of the intertidal outfall, gastropod populations decreased, *B. proboscidea* disappeared, and nine species of brown algae appeared (brown algae were absent during the intertidal discharge). It has also been suggested that subtidal kelp and seagrasses increased.

A 1991 Department of Conservation and Environment study suggested that surfactants in Black Rock effluent were responsible for the decline of the coastal tea-tree (*Leptospermum laevigatum*) in the Barwon Heads area. During this study the Black Rock discharge was upgraded from the intertidal to the submerged outfall. The study suggested, but did not prove, that the extension reduced surfactant deposition.

Sewage discharges to Port Phillip Bay

The Werribee Treatment Complex (WTC), on the north-western shores of Port Phillip Bay, treats 65% of metropolitan Melbourne sewage, using land filtration, grass filtration, and lagooning. The treated waste-water is discharged into the Bay via six licensed drains, at a yearly rate of 170 000 ML. Under certain conditions, increased chlorophyll-*a* and total phosphorus concentrations in the Bay (indicating increased primary production and increased nutrient concentrations) may indicate the potential for eutrophication (Axelrad 1978).

Annual nitrogen load to the Bay is about 7800 tonnes, about 50% from the WTC and the rest from the Yarra and Maribyrnong Rivers, other streams, atmospheric inputs, and groundwater inputs.

Industrial discharges to Port Phillip Bay and Western Port

Industrial effluents in Port Phillip Bay are discharged to Corio and Hobsons Bays.

Shell's petrochemical refinery at Corio Bay discharges, after treatment, industrial cooling water; its licence allows the inclusion of some hydrocarbons, nutrients, suspended solids, sulphide, and *E. coli*. All process and domestic waste from the refinery is discharged to sewer. Also in Corio Bay, the Phosphate Co-operative - PIVOT - phosphate refinery is licensed to discharge cooling water that contains low levels of fluoride compounds, suspended solids, and total phosphorus. Alcoa, located at Point Henry in Port Phillip Bay, is licensed to discharge cooling and process water containing suspended solids, fluoride, phosphorus, and chromium.

The Newport D Power Station, located in the Hobsons Bay region of Port Phillip Bay, is licensed to discharge cooling water containing chlorine, ammonia and iron.

Western Port receives industrial discharges from BHP (formerly Lysaght), Esso, and BP.

BHP's industrial cold-steel rolling works located in the north of Western Port has a licence to discharge effluent that can contain phosphorus compounds, surfactants, and low concentrations of zinc.

Esso Australia Pty Ltd at Long Island point, near BHP, may discharge effluent that contains numbers of pollutants including surfactants, phosphorus compounds, and sulphides.

The BP refinery, located at Crib Point, is licensed to discharge effluent with ammonia, sulphides, phosphorus compounds, surfactants, and phenol, but has not discharged any effluent for a number of years. Mobil and Shell currently have plans to submit a works-approval application for a new storage and to increase its capacity of the existing storages. The BP licence would then be transferred to those companies, and amended. The proposal at this stage is to have no discharge to water, but to irrigate land.

NON-POINT-SOURCE DISCHARGES

Non-point sources of pollution (run-offs) refer to inputs that occur over a wide area and are generally associated with particular land uses,

Box 12.3: Some Persistent Toxicants

Heavy metals such as mercury, cadmium, chromium, zinc, and copper are acutely toxic to marine organisms. The valency state of the element affects its toxicity - e.g., arsenic III is more toxic than arsenic V. Bacteria in sediments may change metals from non-toxic inorganic precursors to organic highly toxic forms - e.g., mercury to methylmercury.

Halogenated hydrocarbons are produced specifically (e.g., polychlorinated biphenyls, PCBs) or as a by-product of various processes (e.g., as a result of chlorine disinfection of organic effluents). Halogenated hydrocarbons are found in pesticides, synthetic rubber, aerosol propellants, and pulpmill effluents. Many of these compounds bioaccumulate and may irreversibly damage genetic material.

Petroleum hydrocarbons consist of aromatic and aliphatic hydrocarbons. Aromatic hydrocarbons are, in general, toxic and fairly resistant to biological break-down. A number of them, such as benzo(a)pyrene have been classified as carcinogenic (Norden *et al.* 1978). By comparison, aliphatic hydrocarbons are less toxic and more readily broken down. The toxicity of aromatic hydrocarbons increases with volatility. The volatile benzene and toluene are highly toxic to fish and other marine life (Miller and Connell 1979).

In addition to effects common to other persistent toxicants, oil hydrocarbons cause tainting of seafood, making it unfit for human consumption, and direct smothering of marine organisms, particularly birds. Coating by oil may cause suffocation or interference with movements to obtain food or escape predation.

A large one-off exposure to oil is likely to have acute affects on marine organisms; chronic effects occur after frequent exposures over extended periods of time. Small quantities of hydrocarbons are continually being released from outboard-motor fuels, small spillages, and discharges from refineries.

as opposed to individual point-source discharges. Often the run-off enters waterways through drains, or rivers and streams.

Such pollution is more difficult to control than that from point sources. In urban areas the provision of reticulated sewerage systems and adequate street cleaning are important measures, while farming communities must adopt soil conservation practices and the controlled application of pesticides and fertilisers if pollution problems are to be minimised.

Victoria's coastal zone contains a handful of licensed discharges to land. The following list summarises these discharges.

* O'Connor's Abattoirs of Warrnambool have treatment lagoons at Levy's Point.

* Alcoa has a landfill site at its plant at Point Henry (near Geelong) that is within 1 km of the coastal zone. It is a general-refuse, above-ground tip. Until 1982, a licensed tip, operating in a separate area of that landfill site used to dispose of 'pot-liner' - that is, carbon that contains significant amounts of fluorine and cyanide. In that year, a study of an adjacent wetland found slight leaching of fluorine and cyanide through the tip wall. Consequently, a cut-off wall was built and the site clay-capped, which successfully curbed any further leaching, according to regular monitoring information reported to the EPA. The tip-site was replaced in 1982 by a site in Moolap (just over 1 km from the coast). This secure, long-term storage facility is built on a geologically stable foundation, and is properly managed and regularly monitored. Alcoa operates good internal waste-minimisation processes, such as mulching wood and recycling steel, and has internal bins for staff to recycle bottles and aluminium cans.

* Werribee Sewage Treatment Complex has treatment lagoons within the coastal zone.

* Mobil is submitting an EPA works approval for land irrigation at Crib Point. Contaminated storm-water from the tank farms will be used for irrigation.

* Wonthaggi—Inverloch Water Board irrigates all its sewage effluent to land during summer at Inverloch.

* BHP in Western Port, is currently looking at an option of irrigating industrial waste-water and sewage effluent to land. Its licence is currently being reviewed and options investigated.

* At Wilsons Promontory, CNR's evaporative lagoon system, designed as an infiltration basin, is within 1 km of the coast.

* At Lakes Entrance, the Tambo Water Board dispose of Lakes Entrance Sewage Treatment Scheme waste-water by recycling it to the golf course.

Urban sources

In metropolitan Melbourne, sewage is disposed to sewers and conveyed to the Werribee Sewerage Farm or the South Eastern Purification Plant at Carrum for treatment. Many country towns contain similar sewerage systems and treatment works. However, some newer suburbs and urban fringe areas have no reticulated sewerage system available, so sewage is discharged to septic tanks. Seepage and surface run-off of septic tank effluents are major forms of non-point-source pollution of streams in these areas, increasing nutrient and bacterial levels.

Other forms of non-point-source pollution in urban areas include rainfall run-off (storm-water) from street surfaces contaminated with car oil, lead from petrol, zinc from corrugated iron sheeting, litter (including plastics), dust, the faeces of animals, biocides used in the garden, and soil and sediment run-off from construction sites (erosion). Illegal sewerage connections to storm-water drains are an added source of pollutants. In the metropolitan area, the storm-water system acts as an emergency overflow for the sewerage system and this can result in contamination during intense and/or prolonged storms.

Storm-water run-off may contain similar concentrations of contaminants to those in point-source discharges. Nutrient and heavy metal concentrations may be similar to those in secondary-treated sewage (ABS 1982); suspended-solid levels can approach those of untreated sewage; and fluctuating levels of bacteria and pathogens may be higher than in treated sewage.

Litter transferred by street flushing, rain, and wind into the drainage system and then into the waterways and the Bay, where it accumulates, can also be considered as a form of non-point-source pollution. Recognised sources of litter are: pedestrians, motorists, unsecured loads, domestic garbage (put out for collection, commercial refuse collections, loading and unloading operations, and construction sites.

Melbourne Water estimates that 180 000 cu. m of rubbish ends up in the city's waterways each year, of which litter traps and booms collect less than 5%. The figure is based on 0.3 cu. m of rubbish per kilometre per day in the Melbourne metropolitan region, including Port Phillip Bay and all waterways, (it includes items such as dumped car bodies).

In 1988 it cost Victorians more than $50 million to control and minimise litter. A similar survey is currently under way and the data strongly indicate that the figure for 1991/92 will be much greater.

The amount of rubbish generated outside of Melbourne is unknown, but its effects - particularly those of plastic - are well recognised.

Polystyrene foam used for packing material, plastic cups, bags, bottles, strapping bands, and six-pack holders have all been responsible for damaging marine life. Surface-sea-feeding birds are especially vulnerable because they mistake plastic particles for food. In Hawaii, 90% of albatross chicks examined had plastic particles in the upper digestive tract. These cause ulcers in some birds; moreover they fill the birds up with indigestible material. Plastic pellets have also been found in the gut of a variety of fish; turtles are easily deceived by plastic bags, which they mistake for jellyfish, their main food source, and can choke to death when they try to ingest these. In recent months, biologists at the Phillip Island Penguin

Box 12.4: Some Non-persistent Toxicants

All types of surfactants - anionic, cationic, and non-ionic - may adversely affect marine biota. Anionic and cationic surfactants are constituents of commercial detergents and household cleaning products and therefore common in municipal effluents. Non-ionic ones are used for industrial purposes such as wool-scouring, but are also being increasingly used in commercial detergents.

Anionic and cationic surfactants break down readily into less toxic forms. The non-ionic are persistent and break down in the marine environment at a slow rate and into more toxic metabolites (Miossec and Bocquene 1984). However, it is difficult to study them, because accurate measurement methods have yet to be developed. In general, cationic surfactants are not as toxic as the others (Lewis 1991).

Surfactants, in addition to their toxicity, are of special concern in coastal foreshores. Their presence is thought to increase the penetration of salt spray into the leaves of coastal vegetation, which may cause die-back.

Reserve have found penguins washed up on the beach tangled in plastic rings - six-pack holders discarded by drinkers.

Ropes and nets discarded at sea damage boats as well as marine organisms. Ropes can end up around boat propellers; plastic sheets can re-emerge to block water intakes. Lost fishing nets (ghost nets) can drift around the ocean for years. Those made from synthetic materials are light, strong, invisible underwater in some cases, and last longer than those made from hemp, flax or cotton.

As well as fish, ghost nets catch birds and marine mammals, including dolphins, seals and whales. In one example recorded in the North Pacific, a 15 km net caught 350 sea-birds. Diving birds are particularly vulnerable. A survey of dead or entangled gannets on North Sea beaches found that 29% had been caught in fishing gear. Whales, seals, and dolphins around the world have been injured by ghost nets.

Agricultural land use

Agricultural non-point sources of pollution include pesticides, herbicides, fertilisers, animal manure, and soil washed into streams in rainfall run-off. Stock given access to streambanks may foul the water and accelerate erosion.

Forestry land use

Intensive forestry operations such as clear-felling may contribute to non-point-source pollution of streams by increasing soil erosion and sediment run-off. The run-off may also contain fertilisers and biocides.

LANDFILLS AND GROUNDWATER

Rubbish tips, commonly known as landfills, occur throughout Victoria. Over the past decade the EPA has been tightening controls to overcome problems such as litter, odour, noise, dust, and vermin, and the harder-to-control contamination of groundwater. Known (but perhaps not all) landfills in the coastal zone include licensed municipal tips located at Warrnambool, Torquay, Anglesea, Corio, Port Campbell (now closed), Apollo Bay, Port Albert, Mallacoota, Marlo, Foster, Port Welshpool, and Port Fairy (not licensed).

Leachate from the contents of landfills may contaminate nearby groundwater, and this is very difficult to detect and rectify. It is therefore essential to assess the sites' suitability for containing wastes.

Groundwater pollution can also occur from agricultural, industrial, and domestic sources. Agricultural contaminants include pesticides, herbicides, and agricultural fertilisers. Industrial waste, if not disposed of correctly, may produce a leachate high in chemical compounds and trace metals. If the site does not adequately contain the percolated leachate, groundwater contamination may occur. Leakage from industrial pipelines or storage vessels or accidental spillages of hazardous materials may cause further problems, as the leaked pollutant may enter soils and leach through to the groundwater via rainfall.

The available information regarding contamination of groundwater does not permit comprehensive regional assessments, but some areas of high contamination can be identified.

In the case of Port Phillip Bay, monitoring by the EPA and the former Department of Conservation, Forests and Lands has shown that levels of toxicants in sediments and biota are generally higher in the northern section than elsewhere. This is attributable, at least in part, to the levels of toxicants in the streams that flow into that segment of the Bay. However, the contribution made by direct discharges off-shore from contaminated groundwater is less clear.

The Newer Volcanics discharge up to about 4000 ML of groundwater a year directly into Port Phillip Bay and a significantly greater volume into streams draining the volcanic plains. A large proportion of the discharge comes from the zones of high-level pollution underlying the western metropolitan area. The toxicant load in the discharged groundwater depends on the degree of attenuation within the aquifer. The available data from the monitoring bores located just inland from the coastline suggest that substantial attenuation of heavy metals does occur. In these southern bores the concentration of metals is close to the 'back-ground' concentrations of groundwater found to the north of the industrial zone. Of the measured parameters, only the concentration of dissolved solids remains elevated.

Contaminated groundwaters in the Newer Volcanics underlying the western metropolitan region probably contribute significantly to contamination of adjacent parts of the surface streams, but do not appear to discharge

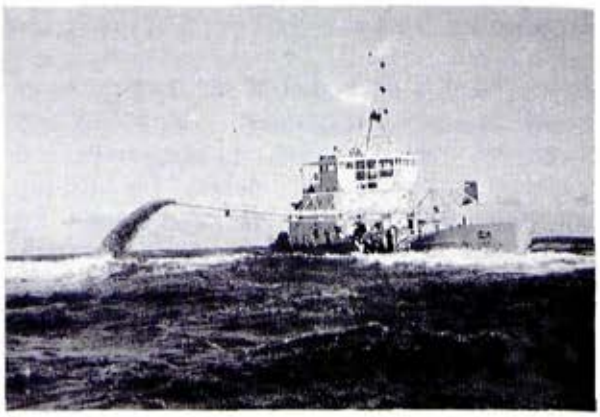
significant quantities of toxicants directly to the Bay. It must be stressed, however, that this tentative conclusion can be substantiated only by the implementation of a systematic regional monitoring program (Leonard 1992).

DREDGING

The coastal and estuarine waters of Victoria support numerous beneficial uses that have economic, cultural, and recreational importance. 'Maintenance of natural aquatic beneficial uses' and 'Navigation and shipping' are both protected uses in these waters. To maintain ports and harbours, and to create new shipping and boating facilities, it is necessary to dredge areas and to dispose of dredged material. Dredging and disposal operations, by their very nature, are likely to adversely affect aquatic ecosystems in some way; in some cases they may put the integrity of particular aquatic communities at significant risk or may mobilise contaminants . At the same time, the benefits resulting from use of coastal and estuarine waters for commercial and recreational vessels are considerable.

The State Environment Protection Policy (SEPP) (Waters of Victoria) states (paragraph 41) 'Dredging, construction, river management, reclamation, nuisance weed control measures, spoil disposal and other works must be carried out in a manner which causes minimal disturbance of land and animal habitats. Where practicable dredged spoil shall be disposed of on land above high water mark clear of floodways and flood-plains (as defined by an average flood recurrence interval of one hundred years)'.

In 1992, the Victorian government developed a 'Trial Dredge Protocol' which aims at providing guidelines for achieving maximum environmental protection when planning and conducting dredging operations. It consists of a series of recommendations, and is not mandatory. However, by adopting the 'protocol' a dredging agency acknowledges its willingness to minimise the environmental impact of its activities. The protocol was developed by a working group with representatives from government agencies and the three port authorities. If it is eventually adopted by each port authority and Melbourne Water, it will cover virtually all dredging operations. Its guidelines cover activities such as evaluating proposals for and technical aspects of dredging and disposal (including to land).



Disposing of dredged spoil off Lakes Entrance.

The protocol recognises a number of 'real-world' situations, for which special consideration must be given:

* some operations, because of their limited size, known impact, or other factors, should not require the detailed assessment generally recommended

* proponents and relevant agencies may disagree in interpreting environmental data

* serious shortages limit the amount of scientific data available, particularly in the field of sediment criteria

* if a proponent proceeds with a proposal despite clear (and sometimes agreed) indications of environmental uncertainties or hazards associated with the proposals, the way(s) in which the guidelines are not being met will be made public.

EFFECTS OF VESSELS ON THE VICTORIAN MARINE ENVIRONMENT

The major impacts of vessels on the Victorian marine waters are introduction of exotic species from ballast water, accidental oil spills, and leaching of tributyltin (see Box 12.5).

Introduction of exotic species from ballast water and other sources

Ballast water, taken on board unloaded ships to improve their stability, may contain a variety of aquatic organisms. If the ship is berthed in shallow water, or in deeper water disturbed by dredging or wind or wave action, then harbour sediments and the organisms within may also be pumped into the ship. De-ballasting takes place when the unloaded vessel reaches a new

port and plans to take on cargo. Marine organisms may also be transported on the hulls of ships (Jones 1991).

The major commercial ports in Victoria are vulnerable to the introduction of exotic marine biota from de-ballasting. At present there is an agreement by convention (not a regulation) that no discharges of ballast water occur in Port Phillip Bay. Nevertheless, several species of exotic marine organisms are thought to have arrived in Victorian waters from the ballast water of foreign ships.

Exotic marine species may have adverse impacts on the beneficial uses. Biological impacts include the introduction of disease, parasites, and toxins to, and hybridisation, predation, or competition with native species. Exotic species may also have physical effects such as fouling marinas (Jones 1991).

Box 12.5: Biocides

Biocides are substances produced to kill pest and fouling organisms. Some (e.g., synthetic pyrethroids and tributyltin) are active for only a few weeks while others (e.g., organochlorines and their toxic break-down products) persist for decades. Organophosphorus biocides are generally of intermediate persistence.

Tributyltin (TBT), commonly used as an additive in antifouling paints to protect the hulls of boats from the growth of fouling organisms such as barnacles and algae, is recognised as the most acutely toxic substance deliberately introduced into the marine environment (Maguire 1987). Its reported effects on aquatic organisms range from direct lethality to gross behavioural and morphological alterations, such as changes in reproduction, sex, and growth, and biochemical and haematological effects. Molluscs appear to be the most sensitive organisms followed by crustaceans and fish (Rexrode, 1987).

Apparently TBT does not biomagnify at higher trophic levels (Laughlin 1986). It is broken down by bacteria, fungi and phytoplankton, and in marine waters has a half-life of about 10–15 days (Seligman *et al.* 1986). Estimates of half-lives in sediments tend to be longer - e.g., 162 days (Stang and Seligman 1986).

The EPA introduced regulations from June 1989 limiting the scale and use of TBT-based paints. Regulations prohibit the use of these paints on boats 25 m or less in length, as well as on piers, moorings, and other marine and estuarine structures. The *Agriculture Chemicals Act* 1958 has limited the sale of TBT-based paints to cases where written permission to purchase is obtained from the EPA. To assess effectiveness of these regulations, the EPA has introduced monitoring of TBT (see Figure 12.1).

A number of known exotic species have established themselves in Victorian waters and are assumed to be imported via ballast water discharge or attached to the hulls of ships. They include the fish striped goby (*Tridentiger trigonocephalus*), the yellow-fin gody (*Acanthogobius flavimanus*), crustaceans (*Carcinus maenas* and *Cancer novaezealandiae*), molluscs (*Theora lubrica* and *Musculista senhousia*), polychaete worms (*Boccardia proboscidea, Pseudopolydora paucibranchiata, Saballa spallanzanii* and *Styola plicata*), and seaweeds (*Polysiphonia brodiaei* and *Sticryosiphon soriferus*).

Few studies have considered the impacts of introductions of exotic species on natural communities, but evidence is mounting that introductions continue to occur and that they have the potential to pose a significant threat to the survival of native flora and fauna throughout the world, including parts of Australia.

Cord grass (*Spartina townsendii*), an introduced plant affecting intertidal habitats has been discussed in Chapter 4.

Now established in Western Australia and recently recorded in Port Phillip Bay, the Asian mussel (*Musculista senhousia*) is potentially harmful as it has the capacity to significantly alter the biota and movement of soft sediments through its mat-building activities.

The introduction of toxic algae - mainly the planktonic algal group, dinoflagellates - is of concern due to the adverse effects they can have on the marine environment. They can affect marine organisms including wild and cultured mussels, and can cause serious health problems for consumers of seafood. Toxic dinoflagellates can induce paralytic, diarrhoeic, and neurotoxic shellfish poisoning. They may also adversely affect marine organisms by physical damage (usually to the gills), oxygen depletion, direct action of toxins, and possible indirect effects of toxins in the food chain.

Toxic and non-toxic dinoflagellates (or their benthic resting spores) may be spread in ballast water. *Alexandrium catanella, A. tamarense, A. minutum*, and *Gymnodinium catenatum* have been identified in Victoria.

In July 1992, *G. catenatum* was reported at Lorne - the first time this species had been recorded in Victorian coastal waters. About the same time, the west coast from Portland to Lorne experienced a bloom of *A. tamarense*.

Oil Spills

The 2000 tonne oil spill by 'Oceanic Grandeur' in Torres Strait in 1970 provided the impetus for establishing a national plan for combating oil spills in Australia. Most reported oil spills in Victorian waters, however, are associated with ship activities in ports. They are noticed immediately and dealt with according to the 'National Plan to Combat Pollution of the Sea by Oil'. Most are small and easily contained. Others, in high tidal streamflow ports such as Western Port, are more difficult to control. Of the reported 500 spills in Australian waters, for the two periods of 1972—79 and 1982—83, only two - one of 800 and the other of 130 tonnes - exceeded 30 tons (BTCE 1991).

Spills in open waters are much more difficult to follow up. Those sighted by aircraft may turn out to be cloud reflections or shadows on the sea surface or floating algal blooms, and location may be difficult to confirm. Although reports from ships are more reliable, it may still take considerable time before the personnel and equipment can be transported to the site. Unsighted and/or unreported spills also occur, as evidenced by the occasional oiled little penguins coming ashore, recorded over the years by staff og the Phillip Island Penguin Reserve.

The National Plan to Combat Pollution of the Sea by Oil has been designed to cope with spills of up to 1000 tonnes, and the newly established Australian Marine Oil Spills Response Centre has increased the capability of response to 10 000 tonne spills. Funded by the oil industry, the Centre was officially opened in Geelong in June 1992. A recent report (BTCE 1991) examining the risk associated with major oil spills indicated a 48% probability of one occurring in Australian waters in the next 5 years. On the basis of the shipping traffic measured at 82 waypoints round the Australian coast during the period 28/10/89 to 4/8/90, one of the highest-risk areas identified was Bass Strait - particularly Wilsons Promontory, with 3300 passages including 450 tankers.

An oil spill has an environmental impact directly proportional to its size, but other equally significant factors are distance from sensitive areas, the type of oil, and prevailing sea and weather conditions. For example, a small-volume off-shore spill may have considerable impact if a strong wind carries it to an area sensitive to oil, especially if it is difficult-to-disperse waxy crude oil.

In the 10 years since 1982 there have been only two medium-size oil spills in Victorian waters: a 1988 Portland harbour spill of 180 tonnes and a spill of unknown volume in 1990 in the vicinity of Cape Otway. The Portland spill caused death of 23 birds and warnings were issued to local recreational fisheries about the potential hydrocarbon tainting of fish. In addition, Crown land was used to dispose of 30 tonnes of contaminated oil.

Of 300 birds recovered after the Otway spill, only 65 could be released to the wild following rehabilitation. Apart from two retained in captivity, the remainder died at or after the spill. Moreover, it is estimated that the number of birds recovered represented only 10% of those affected.

Small and environmentally comparatively benign spills in popular areas can incur large costs in clean-up operations. For example, cleaning up the 2000 litre spill on Paradise Beach cost the Victorian government $320 000. Generally, the costs incurred due to environmental impact, although not immediately apparent (it make take months or years before they manifest themselves), are usually much greater and have much longer-lasting impact.

POLLUTION STATUS OF THE COASTAL ZONE

ESTUARIES

An estuary is a semi-enclosed coastal body of water that has a free connection with the open sea; it is thus affected by tidal action, and within it sea water is mixed with fresh-water from land drainage (Odum 1971). Examples are river mouths, some coastal bays, and tidal marshes. Estuaries are often affected by excessive nutrients and sediment inputs from streams. They may also be influenced by shoreline developments and by urban, industrial, and agricultural pollution from point and non-point sources.

The main pollution problems are inappropriate land use resulting in siltation, and increases in the discharge waste to the water as a result of

recreational activities. Boating and other recreational uses are polluting estuaries with hydrocarbons (from fuel), with organic wastes (from on-board toilets), and with litter.

Glenelg River

In the north-west of Discovery Bay is the estuary of the Glenelg River. Reports by the former Soil Conservation Authority indicated that 44% of the surrounding catchment had land degradation problems causing an increase in the silt load in the river's lower reaches. This increase has adversely affected the Glenelg, with its already high silt loads.

Lake Connewarre

Lake Connewarre is surrounding the largest area (3300 ha) of native vegetation remaining on the Bellarine Peninsula. Damage to vegetation and the influx of weeds associated with grazing present the most significant problems in several parts of it. Engineering works that alter hydrology of some areas adversely affect the vegetation (Yugovic, 1985).

Nooramunga, Corner, and Shallow Inlet

During the early 1900s the catchment areas of Corner Inlet, Nooramunga, and Shallow Inlet were cleared of almost all native vegetation. In 1984, the then Fisheries and Wildlife Division of the National Parks Service established that the land-clearing, drainage of swamps, and overgrazing of surrounding land increased siltation of the estuaries and decreased their water depth.

Sydenham Inlet

Sydenham Inlet, in East Gippsland, has undergone increased sedimentation, primarily caused by the deposition of sediments by the Bemm and Little Rivers, and the gradual deposition has reduced the average water depth to less than 2 m. The possible effects of increased sediment deposition may be detrimental to benthic estuarine flora and fauna of the Inlet (Brown and Lavery 1977).

Tamboon, Wingan, and Mallacoota Inlet

Estuaries such as those of the Tamboon and Wingan Rivers and the larger Mallacoota Inlet have significant inputs of fresh water. They attract large numbers of tourists, but sewage waste generated from tourist facilities adversely affects the estuary ecosystem (DCFL 1985).

BAYS AND INLETS

Port Phillip Bay

The Bay is a shallow marine basin, has a surface area of 2000 sq. km and a narrow entrance to the ocean at its southern end. It drains a large urban, industrial and agricultural catchment area (9800 sq. km) with a population of 3 million people. Many activities in the catchment affect the Bay. Its major fresh-water inputs are the Yarra River and its tributary the Maribyrong, the Werribee Sewerage Farm Complex, Patterson River, Mordialloc Creek, and Kananook Creek. The pollution that the rivers carry to the marine environment is mainly from diffuse sources. For example, it is estimated that 40 000 tonnes of sediment enters the Bay each year from the Yarra River. A number of smaller rivers and creeks, storm-water drains, and effluent discharges also enter the Bay environment (MMBW and FWD 1973).

Pollution history - Port Phillip Bay was initially subject to a large number of direct industrial discharges. In the past, wastes were also released directly into the rivers and streams that flow into it. For example, some years ago discharge of effluent containing cadmium into Corio Bay caused contamination of the sediments (Fabris 1983). Although the discharge stopped in 1974, trace metal contamination in sediments of the area is still apparent (Nicholson *et al.* 1990). Now, most wastes are treated to reduce, remove, or neutralise contaminants either at specialised commercial facilities or via the sewerage system.

Present Status - Shellfish, particularly mussels, have been used to indicate areas of metal and hydrocarbon contamination (Fabris *et al.* 1985; Burns and Smith 1977).

Concentrations of metals in the mussels have changed little since measurements began in the 1980s. Mussels from Corio Bay and Hobsons Bay are still the most contaminated, as the MSL established in 1986. However, the present concentrations do not necessarily reflect the recent input of pollutants, but may instead result from metal accumulation in sediments from inputs of previous decades. Similarly, the petroleum hydrocarbon concentrations in the mussels have not changed significantly over the past decade. Those in mussels from northern Corio Bay are still the highest in the Bay (Parry 1988, Fabris *et al.* 1990).

As EPA monitoring (Saunders and Goudey 1990) shows, growth of phytoplankton, as measured by chlorophyll-*a* concentrations, has increased in Port Phillip Bay. The condition of the Bay does not appear to have significantly declined over the past years. However, increased concentrations of nutrients and chlorophyll-*a* are of concern and may contribute to algal blooms. Three toxic dinoflagellate blooms of *Alexandrium catenella* - in January 1988, January 1989, and January 1992 - have been recorded recently in the northern part.

Levels of TBT in the water, sediments, and biota in 1988/89 were considerably higher than levels known to have sublethal effects on aquatic organisms (Daly 1990). Continued monitoring of waters in 1990 failed to demonstrate any significant decline in TBT levels following regulations restricting its use in 1989.

Although not currently used, PCBs occur in Port Phillip Bay in areas closest to industry and high population density (e.g., in-shore Corio Bay and the mouth of the Yarra). Their concentrations in mussels were of the same order as those found in other industrialised centres overseas and, as such, were considered significant (Richardson and Waid 1980).

The EPA has calculated that effluent discharged via the WTC during 1990 contained approximately 91 tonnes of surfactant, with an unknown impact on the Bay environment.

Petroleum hydrocarbons and organochlorines have been detected in flathead fish collected throughout the Bay, but particularly high levels were found in the Geelong Arm and Corio Bay. These substances are also found in the sediments.

Swan Bay

Swan Bay is located immediately north of Queenscliff on the western shores of Port Phillip Bay. It is a shallow tidal marine area, partly enclosed by spits and barrier islands, with significant ecological, recreational, and aesthetic values. It is contaminated with heavy metals, particularly in the southern, more urbanised, area (DCE 1991).

Most of its catchment is used for cattle- and sheep-grazing and some intensive farming to produce potatoes, peas, oilseeds, and cereals. Most of the land has a history of fertiliser application, with the addition of biocides such as dieldrin on the more intensively cropped areas. These compounds, therefore, have the potential to contaminate Swan Bay, although the use of dieldrin is no longer permitted.

Leaching of nutrients into the Bay, particularly in areas of limited exchange of water, could result in eutrophication and smothering of seagrass by epiphytic algae. Storm-water seepage and overflows from septic tanks are other potential sources of pollution. Swan Bay is at some risk from oil spills, being in close proximity to the heavy shipping traffic passing through Port Phillip Heads.

Western Port

This has a catchment of approximately 3000 sq. km, with major towns and industries located along its western side and smaller townships scattered throughout the catchment.

Pollution history - As discussed in Chapter 4, seagrass beds of *Heterozotera tasmanica* and *Zostera muelleri* declined in Western Port between 1973 to 1984, the greatest reductions (about 90%) occurring in areas formerly dominated by *H. tasmanica*.

The loss of seagrass, as discussed in Chapter 4, may have been caused by a number of factors but no conclusive cause or causes were identified.

Present status - The waters of the eastern area, near Corinella, have at times exceeded biological and chemical objectives of SEPP for Western Port. The Corinella site receives inputs from several streams entering the Bay, and it has been suggested that agricultural run-off to these streams is an important source of increased phosphorus and suspended solid levels found there.

Portland Bay

In 1979, a technical report from the CSIRO Division of Applied Geomechanics revealed that the construction of Portland Harbour in 1956—58 had resulted in the erosion of beach for 4 km along the coast and a deposition of sediments a further 6 km east.

VICTORIAN OPEN COASTLINE ENVIRONMENT

Preliminary studies undertaken on the effects of sewage and industrial outfalls on the marine environment have supported the view that effluent discharge may have localised effects in

the areas of discharge (Holmes 1987). Victoria's 17 coastal outfalls have the potential for such adverse effects, particularly those discharging untreated or primary-treated effluent, which has acute toxicity for marine life (McKenzie and Goudey 1991).

All the discharges contain low levels of persistent toxicants such as heavy metals, petroleum hydrocarbons, phenols, and non-ionic surfactants and relatively higher levels of anionic surfactants. These toxicants are a potential problem in the coastal zone because organisms can accumulate some of them directly or indirectly through the food chain. Some can also accumulate in the sediments.

Of the 17 licensed ocean outfalls discharging to Bass Strait, only nine are treated to a secondary level. A recent study ranked 12 of them according to their potential to affect the marine environment (McKenzie and Goudey 1991). The study confirmed the greater potential impact of untreated or primary-treated effluent, ranking the discharges in order of priority as Black Rock, Warrnambool, Portland, Leongatha, Port Fairy, Yarram, Apollo Bay and Lorne (same ranking), Anglesea, Wonthaggi, Cowes, and Port Welshpool. The EPA has developed an action plan to deal these discharges.

Water authorities with ocean outfalls not meeting the requirements of the 'State Environment Protection Policy - Waters of Victoria' will be required to upgrade their treatment works to provide effluent of secondary-treatment quality or discharge their wastes to land by 1997. Although the Policy permits a lower standard of treatment, scientific information shows that primary-treated effluent does not meet its toxicity requirements. Discharge to land is the preferred option, but this may not always be feasible and should not prejudice other parts of the environment (e.g., land disposal should not degrade groundwater resources).



Warrnambool submerged outfall.

EPA and DWR staff met with all non-complying authorities by the end of October 1992 to discuss the ocean outfall report, SEPP requirements, upgrading plans, where appropriate, and proposed licence amendments. The government requires authorities to prepare reports on treatment and preferred disposal options, and will expect comprehensive public participation in the assessment of the options and the selection of those preferred. These reports will be required by the end of December 1993, to allow for implementation by 1997.

The EPA may require interim upgrades to provide improved effluent quality pending completion of the final works.

Several water authorities listed in the ocean outfall report are already taking steps to upgrade the quality of effluent being discharged to Bass Strait - for example, the Geelong District Water Board (Black Rock and Anglesea); the Alberton Water Board (Yarram) expects to cease discharging to the ocean by March 1993. Other authorities, such as at Warrnambool, are well advanced in the public consultation phase of reviewing disposal options.

The Black Rock and the Warrnambool discharges together represent 85% of the population served and discharge volume. Both of these systems are at an advanced stage of planning for upgrading with additional facilities already in hand, completion of which over the next few years will achieve an 85% reduction in the potential for environmental damage.

The lower-ranked discharges are in various stages of planning or upgrading, ranging from investigations of options (Portland, Port Fairy, Lorne, Leongatha) to actual construction or planned construction of facilities (Yarram, Anglesea). Although these present a lesser potential for environmental damage, they have local significance.

EFFECTS OF LANDFILLS ON THE COASTAL ZONE

Leaching from landfills is not considered a significant source of pollution to Port Phillip Bay, or to other areas of the coastal zone. The filtration process associated with seepage would probably prevent any significant volume of toxicants reaching the marine environment,

and the wave energy and dilution factors associated with that environment would minimise the impact of any groundwater input of contaminants.

ISSUES

* ongoing and future monitoring of marine waters, sediments, and biota
* eutrophication and algal blooms
* ocean outfalls
* accumulation of heavy metals and hydrocarbons in marine sediments and organisms
* pollution of marine environments from diffuse land sources
* the effect of increased urbanisation and population on waste discharges

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13. DEFENCE

Defence is a use of the coast that has evolved with changing technology. As explained in Chapter 5, during the 19th Century coastal ports serviced naval vessels and guns were installed along the shore around port entrances to protect them from seaward attack. At this time it was not possible to see beyond-the-horizon, making cliff-top vantage points of strategic military importance. With new technology, particularly aircraft, providing for beyond-the-horizon operations, the strategic importance of the coast has changed. Partly as a result of this historical legacy and to provide for ongoing needs several coastal areas are currently used for defence purposes; Map 3 shows the main areas of Commonwealth land. Defence is the responsibility of the Commonwealth government and is administered by the Department of Defence. The following material is derived from a *submission to the Council from that* Department.

The Australian Defence Force (ADF) comprises three services: Navy, Army, and Air Force. In carrying out its functions, the ADF must maintain a presence in, and have access to, Australia's territorial coastal zone. All three services operate or use facilities within the coastal zone for training, research, and the transit of vessels. Activities and facilities within the zone include:

* airfields, naval bases, and other shore facilities
* ship-, aircraft-, and shore-based weapons training
* clearance diving teams and/or special forces personnel engaged in beach clearance or underwater demolitions operations
* underwater surveillance
* research and surveys of the coastline and coastal waters
* coastal surveillance
* weapons ranges

The ADF also has non-defence functions within the coastal zone, such as coastal surveillance, fisheries protection, and search and rescue.

Major defence properties that occur within 1 km of the Victorian coast and are larger than 3 ha are:

* Fort Queenscliff
* Point Wilson - explosives area
* Point Cook - RAAF base and small-arms gunnery range
* Portsea - training centre
* West Head Flinders - gunnery range
* Crib Point - HMAS *Cerberus*

DEFENCE PROPERTIES

The ADF land contains features of natural and cultural significance, for which the ADF is responsible. Three examples identified as having natural and cultural heritage significance, - HMAS *Cerberus*, Point Cook, and Fort Queenscliff - are summarised below. Each of them has aspects classified by the National Trust and listed on or nominated for the Australian Heritage Commission's Register of the National Estate.

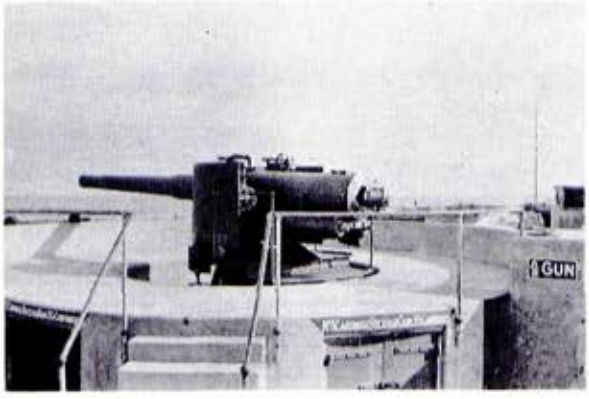
HMAS *Cerberus* - located at Crib Point, Western Port - is primarily used as a naval training facility. Its historical heritage values include buildings classified by the Trust and listed on the Register. Moreover, the naval establishment lies within the Sandy Point Landscape Conservation Area which is similarly classified by the Trust and has been nominated for the Register. It also contains one of the few remaining substantial blocks of relatively undisturbed native vegetation on the Mornington Peninsula. Public interest in access to the beach around Sandy Point is currently being considered in the development of a management plan for the area.

Point Cook RAAF Base comprises an area of approximately 343 ha abutting Port Phillip Bay. Development has been largely restricted to the western portion of the base. A shallow saline lake known as RAAF Lake occupies the north-eastern quadrant. The central third of the base is developed as an airfield apron, with concrete and grass aircraft runways and taxiways, while the south-eastern quadrant

remains largely undeveloped and comprises modified coastal sand barriers.

The entire base is included in the Point Cook Estate Landscape Conservation Area, which is listed on the Register of the National Estate. The Point Cook wetlands, listed under the Ramsar Convention, are particularly important as waterfowl habitat. The salt-marsh found on the base has regional faunal significance due to its potential as habitat for the orange-bellied parrot. Historical heritage values include buildings classified by the National Trust, a number of which have been nominated for the Register.

Fort Queenscliff, located on the Bellarine Peninsula, is home to the Australian Army's Command and Staff College. It contains fortifications of significant historical importance. The heritage values of the area include Queenscliff fortifications and the Queenscliff Conservation Area, both of which are classified by the Trust and listed on the Register.



Historic defence facility - Fort Pearce gun emplacement, Point Nepean.

The establishment is steeped in military history. It mounted the first substantial attempt to defend the entry to Port Phillip Bay, and subsequently was the centre of major fortifications of the Heads. The fort is the tangible remains of part of this defence system, with its 19th century layout largely intact. With continuous military use for more than 120 years, the area also illustrates the rapid evolution of military engineering during the late 19th and early 20th centuries.

LEGISLATION

The maintenance and, in some instances, enhancement of these natural/cultural heritage values involved obligations and responsibilities under Commonwealth legislation. Two Acts, *Control of Naval Waters Act* 1918—78 and the *Defence Act* 1903, are important for environmental management of defence land and for defence responsibility within the coastal zone.

The *Control of Naval Waters* legislation is used to regulate or prohibit activities that may be detrimental to Department of Defence use of the coast. The *Defence Act* 1903 provides a mechanism for declaring of defence areas as public areas and allows for the establishment of regulated control of public access and the appointment of rangers. In particular, the impact areas of defence firing ranges cannot, for safety reasons, be made available for public use. This Act also provides for declaration of public land, with the consent of the State authority responsible for its management, as a military training area. No public land in Victoria is currently designated for military training purposes, however.

In respect of defence airfields, regulations establish zones around airfields where various height restrictions apply to the erection of structures.

PLANNING AND MANAGEMENT CONSIDERATIONS

Historically, the ADF have managed their respective coastal properties in consultation with federal, State, and local government departments or authorities and, where appropriate, have sought the services of CSIRO and other expert organisations. The following issues relate to ADF activities that occur within the coastal environment or arise from current or past uses.

Facility disposal In accordance with Commonwealth government policy, the Department of Defence is pursuing a series of asset disposals that include properties along the Australian coastline. In Victoria, consideration is being given to reducing a number of activities currently conducted at the RAAF Williams base or transferring those activities to other locations.

Pollution Some defence activities use equipment that has significant potential to generate a variety of pollution. Policies and standing orders have been developed as safeguards against this. The forms of pollution and their implications are discussed in Chapter 12. Noise pollution is of particular relevance. ADF produces Australian noise-exposure forecasts for its airfields and some weapon ranges, as a guide to assist State and local government planning authorities and thereby

minimise noise impacts on surrounding communities.

Unexploded ammunition occurs at several locations along the coast. For example, the presence of ammunition required restrictions on public access to sections of Point Nepean National Park. In off-shore areas a number of localities are considered dangerous due to unexploded depth charges (RAN Hydrographic Service 1993): three discrete areas within Port Phillip Bay in water depths of 25 m have a combined area of about 3 sq. km; and along the open coast three small ones (less than 2 sq. km) lie outside Victorian waters. The latter lie about 70 km south-west and 30 km to the east of Wilsons Promontory, and 20 km south of Lakes Entrance.

Firing practice and exercise areas Warnings with to regard these areas are given in *Weapons Practice Warnings* or *Notice to Airmen*. General areas along the Victorian coast are listed below but do not include restrictions in the use of air space or around military or civil air-fields.

* Westernport, an area to the south-west of Cape Schanck and one around and to the south-west of Flinders that are used for military flying and gunnery purposes.
* Point Grant - military flying
* Point Nepean - firing
* Hanns Inlet - radar flares
* Point Cook - small-arms practice

ISSUES

* the extent to which shoreline facilities are still required given advances in defence technology
* continuation of restricted access to parts of the coast

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14. COASTAL ENGINEERING

The collective term coastal engineering encompasses most of the engineering activities related to works along the coast. Key elements are water movements along the coast, the interactions between moving water and loose beach and sea materials, and the hydrodynamic forces exerted by waves and currents on various structures. Specific activities include:

* foreshore protection by utilising beach renourishment, or structures such as groynes and seawalls
* protection of backshore areas such as dunes and cliffs
* projects for boating facilities such as jetties, boat ramps, harbours, and channels
* sand-bypassing across channels and obstructions
* dredging for channel capital works and maintenance
* monitoring of the coastline for change

Coastal engineering is a relatively recent profession; until about 30 years ago, few major projects in Victoria had any coastal engineering input. As a result, in many cases, undesirable changes to the coastline have occurred particularly in Port Phillip Bay, that require ongoing effort to reduce effects.

On largely undeveloped coastlines, coastal engineering involves designing and implementing projects so as to minimise possible changes to the coast, or advising on likely changes. In practice, artificial changes to the coastline frequently involve an ongoing maintenance expense and effort, and society needs to recognise this fact and allocate responsibilities when approving works.

Naturally occurring coastal processes such as the transport of sediments by currents and waves along the coast are ongoing. However, it is frequently not recognised that the coast is a very dynamic area, and continues to evolve.

Sand transport by a current component parallel to shore is called littoral transport. The current may arise from tides, obliquely approaching waves, in some cases river currents. Sand transport may also occur in the on-shore—off-shore direction, and is usually due to the difference between the actual beach slope and the equilibrium beach slope corresponding to the given wave and current conditions. On the Victorian coastline, sediment transport occurs mostly by littoral processes.

In both cases, the distinction needs to be made between actual sediment transport and capacity. Sediment transport assumes ample availability of sediments, whereas the latter term is the theoretical amount of sediment that the waves and current can move.

In general most of the beaches of Port Phillip Bay and Western Port are subject to erosion and recession of the coastline, and hence there is a high requirement for beach-protection works. Erosion is typically due to two causes: natural recession; and/or recession due to artificial interference.

Many areas of the Bay show little evidence of artificial interference, yet the coastline is inexplicably receding. Such natural recession rates are often difficult to estimate due to a lack of survey data, of other information, or of resources.

By far the greatest need for intervention arises from human interference to the coast. In such cases, the object of remedial works is often to re-establish the *status quo* or minimise interruption to the coastal processes.

AMOUNT AND DIRECTION OF SEDIMENT TRANSPORT

Sediments are transported generally according to the storm conditions, on the scale of a single storm lasting for days. For example, a southerly storm within Port Phillip Bay will tend to drive sediments northward along the eastern shoreline of the Bay, whereas an easterly storm on Ninety Mile Beach will drive them generally westward along the beach.

Short-term sediment transport is superimposed over seasonal trends, which in Port Phillip Bay means net southerly transport in summer and net northerly transport in winter. These are very generalised trends only, and particular areas may exhibit different characteristics.

At Swan Island, evidence suggests that a much longer term trend may involve large variations in sediment transport quantities between about 100 000 and 500 000 cu. m per annum over a 30 year cycle.

On the open coast, there is much less information on coastal processes and sediment transport rates. In general, the west coast trend is for net easterly littoral transport as a result of predominant south-westerly weather. Investigations show annual movements of about 50 000 cu. m at Portland, and about 80 000 cu. m at Apollo Bay. In the central zone, no quality estimates of sediment transport rates are available. On the Ninety Mile Beach, investigations indicate very large transport rates of about 1 million cu. m, with probably a net transport east.

Boating facilities

Boat harbours may interfere with natural coastal processes by providing a barrier to sediment transport and trapping sediments inside the quiet water of the harbour confines. Within Port Phillip Bay, the three large boat harbours at St Kilda, Brighton, and Sandringham segment the coast by providing semi-impassable barriers to the natural movement of sand by waves along the coast. Their impact has been to strip sand from the beach adjacent to the open lee side of each harbour, exposing the seawalls to wave attack and undermining their foundations. The remedy has been to artificially renourish the beaches at Middle Park and Brighton, and soon the Hampton beach, thus protecting the structural assets and creating a recreational resource.

On the open coast, Portland Harbour has interrupted the littoral transport of sand and cumulatively trapped about 1.5 million cu. m over the last 30 years. This has resulted in severe erosion of the downstream coast, where rock walls have been constructed to stop the erosion in the Dutton Way area, but further east the shoreline recession continues. Passing the accumulated sand east, by dredger and trucking, will help control future siltation of the harbour and reduce downstream erosion.

Boating channels such as those within Port Phillip Bay at Mordialloc, Carrum, Frankston, Werribee, and Queenscliff are often maintained by dredging to provide a minimum depth. Being deeper than the adjacent coast, they tend to act as a partially effective trap for sediment moving along the coast.

Good practice requires that the dredged material be bypassed to the downdrift side, so as to minimise interruption to the coastal processes. For example, dredged material from Mordialloc Creek is deposited on the adjacent southern beach to help maintain this part of the coast.

FORESHORE PROTECTION

Protection generally involves either beach renourishment or structures built to protect coastal facilities; each form may provide a recreational resource.

Beach renourishment

This involves placing a large amount of sand on the eroded beach, generally to stop wave action further degrading the coast. A successful program is a large project and involves a number of skills. These include: off-shore field investigations to find suitable sands; analysis of samples for grain size and other characteristics; coastal-process investigations for stable alignments and sand gradings; design of anchor structures to retain the beach; extension and/or diversion of drains; appointment of a suitable dredging contractor; contract administration and supervision; and planning approvals and liaison with interested parties. Sand is usually obtained from off-shore, but, where this is not possible, has been sourced from either a quarry or an area of natural accumulation.

The eastern metropolitan beaches of Port Phillip Bay have been mainly selected for beach renourishment because of the need to address artificial erosion areas there, and the value of the renourished beach as a recreational resource (see Table 14.1). The Port of Melbourne Authority (PMA) has acted as contractor to carry out the renourishment works on behalf of the government, which provides the funds. In recent times, a decline in funding has slowed the beach renourishment program, so major projects may need to extend over a longer period.

In terms of maintenance, most of the beaches have required no, or very minor, internal redistribution of sand, and the life of the renourished beaches has exceeded initial predictions and in this context can be considered a successful means of providing foreshore protection. Dredging operations must comply with the Trial Dredge Protocol (see Chapter 12).

Table 14.1: Beach Nourishment Programs - Port Phillip Bay

Beach location	Date	Cost[1] ($'000)	Length of beach renourished (m)	Volume ('000 cu.m)	Borrow area[2]
Rye	1975	225	1800	150	Rye
Middle Park	1976	310	900	120	Middle Park
Mentone	1978	340	1800	127	Mentone
Aspendale	1979	390	800	150	Aspendale
Sorrento	1980	120	800	40	Sorrento
Parkdale	1981	446	1100	65	Parkdale
Williamstown	1982	103	600	29	Middle of the Bay, Brighton
St Kilda	1982	415	700	70	St Kilda Harbour
Altona	1982	140	300	11	Quarry
West Rosebud	1982	90	1000	27	Rosebud, Tootgarook
Elwood	1983	200	800	34	St Kilda Harbour
Brighton, Park St	1984	310	500	40	Aspendale
Blairgowrie	1984	143	900	34	Sorrento Channel
Geelong	1984	126	500	10	Queenscliff Beach
Rosebud, 3rd Ave	1985	125	1500	35	Rosebud
Watkins Bay	1984	81	400	10	Mordialloc, Middle of the Bay
Portarlington	1986	205	1400	35	Portarlington, Pt Richards
Brighton, New St	1987	440	1100	115	Aspendale, Mordialloc, Brighton
Altona	1989	300	400	12	Quarry
Eastern Beach	1990	350	500	15	Quarry
Werribee South	1990	200	700	25	Werribee

Notes:
1. Costs are basically for materials only.
2. Borrow areas are offshore, except where indicated.

Source: Port of Melbourne Authority 1993

Foreshore protection and management

A significant activity of the PMA is to undertake foreshore protection works. Coastal engineering input comprises advice, designs, consultation with interest groups, and assessment of likely impacts and effects resulting from proposed works. Typical applications involve using seawalls, groynes, revetments, and sand redistribution to prevent cliff undercutting and to protect eroded shorelines and assets such as roads, car-parks, buildings, etc.

Groynes

These structures built across the beach to trap littoral sand are designed to cause build-up on their updrift side, usually at the expense of the downstream side, which tends to erode. Careful design may result in the groyne trapping some sand, while allowing some natural leakage around the structure to minimise downstream erosion. McCrae Beach carries an example of a successful groyne field, but in many instances groynes have not worked, typically because of failure to recognise a very low or highly variable littoral transport rate. For example, the complete lack of littoral transport combined with a vertical seawall in the Lonsdale Bight area has prevented these groyne fields being of any use.

Where drains discharge to the beach, and beach renourishment is planned, it is usually necessary to extend the drain at great expense, whereupon the extended drain forms a groyne.

Groynes are used for management purposes at Portland and Apollo Bay, to trap sand upstream of harbour entrances. The trapped sand is periodically passed downstream by trucking.

Groynes are commonly made of timber or rock, and rock-rubble mound structures are fairly common.

Seawalls

Historically, many seawalls were built in Port Phillip Bay as a means of providing employment during the depression of the 1930s. In recent times, they have essentially been built as a last resort, or where it is impractical to consider other alternatives. For example, the severe erosion at Somers beach in Western Port threatened services and houses.

Along the northern shore of Phillip Island, seawalls built near the high-water level have arrested erosion of the primary dune, without much detrimental effect on the remaining coast.

The use of seawalls has declined because of high cost, possible limiting of public access to the beach, detraction from the visual amenity of the coast, possible construction problems in the wet or difficult circumstances, and the generally detrimental effect of the structure on the downstream coast. A seawall generally transfers the erosion zone downstream, and it is not uncommon to have locally amplified erosion where the wall ends, which may eat inland and even threaten the end of the wall.

Where the sea is capable of reaching the wall, reflected waves may tend to cause additional erosion and scour in front of the wall, as well as overtopping and spray behind it. Therefore, in general walls should not be vertical, so as to minimise these effects.



Rock and timber seawall, Somers.

Seawalls are normally constructed in timber, steel, concrete, rubble mound rock, or dynamic rock design.

Revetments

While revetments resemble seawalls in many ways, the term tends to be applied to containment structures generally on land, or a stabilising structure on a river-bank.

Reclamation

This involves raising the land level to above high-tide level, and generally constructing some form of revetment around the perimeter. The fill material for the core can come either from a land source or from the sea, by dredging. Reclamation works are generally undertaken to increase the amount of flat near-coast land for projects such as:

* artificial islands as dredge-spoil-disposal sites or bird-breeding habitats - for example, Sand Island, Queenscliff lagoon
* boating facilities, like Westhaven Marina in Western Port, St Kilda Marina, and St Aubins Way boat ramp and car-park
* canal developments such as the proposed Bayside Development at the northern end of Port Phillip Bay
* commercial port operations such as the additional wharfage or transport operations - for example, Webb Dock.

Monitoring

Monitoring of the coastline should be a key element to provide information for coastal management and planning. The value and the need for ongoing monitoring of the coastal environment 'to enable refinement of conservation and management practices and the design of remedial programs' are recognised in the Victorian government's 1988 coastal policy.

Very little systematic monitoring of key elements such as waves, winds, tides, currents, sediments, and beach profiles has covered the whole Victorian coastline. The following list shows its extent.

* The PMA carried out a program to take beach profiles and sediment samples at selected sites along the coast, and did this for 4 years, while resources were available.

* Limited and generally very short-term information comes from specific projects, such as waves, currents, winds, and tides.

* A comprehensive 'mapping' of the Victorian coast aims at identifying sites particularly vulnerable to a possible rise in sea level.

Currently, lack of resources prevents any systematic monitoring of the outer coast or the Bays.

THE BEACH PROFILE

In practice, coastal engineering considers the coast as extending over a wide zone from the landward base of the dunes to the seaward limit of the active beach.

The beach profile is dynamic and responds to the ambient wave climate. During quiet weather it tends to flatten as sand is transported up the beach from the sand bars. Conversely, during storms the beach profile is cut more steeply as sand is moved off-shore to the bars.

Typical beaches range from steep slopes of about 1:12 (for example, at Somers), through about 1:20 for Port Phillip Bay, to very mild slopes of 1:100 or more (at Lorne, for example).

The upper part of the beach profile can be built up during times of high tide and become dry at low tides. On-shore winds can transport this sand further inland to form dunes. During storm periods, especially with elevated water levels, wave run-up and occasional breaking waves reach the base of a dune and cause erosion of its toe. During the longer quiet weather periods, sand moves up the beach profile and replaces that removed by storms. This natural cyclic process is particularly evident in relatively undisturbed areas such as the Ninety Mile Beach, where storms can remove wide areas of beach overnight, and then over periods of weeks the beach is rebuilt.

Where possible, it is desirable that this natural fluctuation in the beach profile be allowed to occur. Unfortunately, in many areas



Marram grass.

inappropriate development has occurred, with inadequate, setback distances, and it is necessary for coastal protection works to be undertaken.

Problems can occur when seawalls effectively isolate the dunes from the beach, and the beach is eroded by storm action. As there is no reserve of sand available from the dunes, the wave action will tend to further lower the beach profile, and possibly the adjacent coast, leading to net erosion. Unfortunately, this is a common occurrence, due to inadequate knowledge of coastal processes at the time, lack of monitoring information, and in some cases inappropriate development permitted by responsible authorities. An example is the residential housing development on the primary dune at Port Fairy, which required rock to be placed at the base of the dune to prevent its further erosion.

Sand dunes are sometimes breached as a result of extreme storm events. Examples occur on the Ninety Mile Beach, where two 'blowholes' approximately south-east of Paynesville were probably primarily caused by extreme floods in catchments to the Gippsland Lakes. This dune system provides only a narrow barrier between the saline lakes and the sea. A modern-day breach of the dune barrier would result in massive salt-water ingress into the lakes, with a significant impact on their ecology.

Sand dunes are relatively fragile because they are composed of sand, the slopes are generally steep, and only the surface is bound by vegetation. Damage can be caused by trampling by people and livestock, vehicles, clearing, and burning of vegetation. Loss of vegetation and creation of access tracks create potential fail areas where the wind can further add to erosion of the dune.

Destabilisation of sand dunes is undesirable and may result in breaches, sand accretion on adjacent land, waterways, and roads, loss of scenic amenity, loss of habitat, changes to flora and fauna, and disturbance to sites of cultural significance such as Aboriginal middens. In potential problem areas, it is essential that responsible authorities have and implement appropriate land management policies to safeguard against degradation of sand dunes.

Where damage has occurred, remedies include revegetation, fencing to prohibit access, creation of fenced access tracks, chained timber ladder-type structures to stop sand being carried down slopes, brush matting surfaces, and sand-trapping fences. Damage and potential damage to sand dunes is widespread, affecting virtually every popular duned coastal area to some degree.

Sand dunes that are naturally mobile and devoid of vegetation occur both on the land and in the sea. Land examples include dunes greater than 20 m high at Tamboon Inlet, Discovery Bay and Cape Howe. In the sea, examples include the 3 m high mobile sand dunes commonly found in the shipping channels in the Great Sands area of Port Phillip Bay, and in Western Port. Movement and growth of these dunes cause ongoing problems in regard to maintenance of the shipping channels for declared depths. Dune movement is currently uncovering the wreck of the William Salthouse and causing damage to it.

Box 14.1 Dune Stabilisation Programs

Programs have been implemented at numerous locations along the coast to stabilise mobile sand dunes that have been: inundating agricultural land, coastal vegetation, roads, and car-parks; threatening to engulf buildings; reducing the amenity for visitors; and making life unpleasant for house-owners affected by wind-blown sand. Locations of major reclamation projects include Cape Paterson to Kilcunda, Cape Woolamai, Seaford, Mornington Peninsula's ocean coast, Point Lonsdale to Anglesea, and the Discovery Bay Coastal Park.

Removal of the underlying causes of instability such as grazing by stock and rabbits and uncontrolled access by people and their vehicles is essential before attempting a stabilisation program. In many cases natural revegetation will occur once the causes have been removed. However, usually it is necessary to assist re-establishment of protective vegetation.

Modification of the unstable sand surface is sometimes necessary. This may require dune re-shaping - to remove projections that create turbulence or to form a desired dune profile - or the construction of sand-trap fencing to reform a dune or reduce the movement of sand.

Temporary surface stabilisers including brush (cut limbs of trees and shrubs) and straw pinned down by netting are very effective but costly. Natural revegetation will often follow without further treatment.

Primary stabilisers become necessary where large areas of sand are involved. Marram grass (*Ammophila arenaria*), a native of the coasts of Europe and North America, was introduced into Victoria in 1883 by Baron von Mueller. It proved to be the most useful and cost-effective primary stabiliser and in the past was extensively planted along the Victorian coast. It establishes readily from stems and its ability to grow up through depositions of incoming sand allows it to survive burial more successfully than other species. Most large-scale areas of mobile dune requiring treatment have now been stabilised, and today the emphasis has moved to the use of temporary surface stabilisers and native species in preference to marram grass. Hairy spinifex (*Spinifex sericea*), the most useful of the native sand-binders, is established here by planting rooted cuttings.

Once primary stabilisation is achieved, it may be necessary to promote permanent stability by establishing secondary and tertiary stabilisers such as coast wattle (*Acacia sophorae*), common boobialla (*Myoporum insulare*), and coast beard-heath (*Leucopogon parviflorus*). This can be achieved by broadcasting seed, or planting cuttings or seedlings.

ISSUES

* implications of reduced funding for coastal protection works and maintenance of existing structures, control of beach and cliff erosion (which in turn impinge on public safety and protection of coastal infrastructure)

15. EDUCATION AND RESEARCH

Community interest in the marine environment and in the processes that shape our coastline has grown significantly in recent years. Television programs and articles in popular magazines have helped to develop this interest and provided community expectation to be able to visit, see, and learn first hand about the marine environment. Seal-, dolphin-, and whale-watching is particularly attractive and people in general are interested in visiting areas with abundant marine life (for example, Popes Eye in Port Phillip Bay). There is also significant interest in programs that cover human occupation and use of marine areas and coastal resources, including Aboriginal history and maritime shipping history recorded in the historic ports and documented by shipwrecks.

EDUCATION

Managers of marine and coastal areas, scientists, and other individuals and groups interested in the marine environment recognise the need for areas suitable for education. A well-informed public can understand and appreciate the values, diversity, and sensitivity of coastal and marine environments and the consequences of different uses.

Formal education courses at primary, secondary, and tertiary levels contain programs on marine biology. Secondary school students, for example, are required to learn about marine environments as part of ecosystem studies in Year 12. Tertiary institutions provide a range of courses and subjects dealing with the marine environment. In addition, a number of organisations and groups offer various forms of semi-formal training to school students and the general public. In most cases, they use areas located in marine and coastal parks for their on-site education programs.

Education programs mainly use rocky shore platforms, mudflats, and mangrove and estuarine environments. The majority of school programs, however, are conducted on rocky shore platforms because these are easily accessible and display an abundance of marine life in a relatively small area. Most education facilities are adjacent to major population centres around Port Phillip Bay.

Many tertiary institutions use coastal and marine areas for a variety of courses including botany, zoology, geography, geology, and environmental science and many students, both graduates and post-graduates, undertake specific projects or research associated with marine and coastal areas. Sites used in the past have included Port Phillip Bay, Western Port, and Mallacoota and Andersons Inlets.

The Victorian Institute of Marine Sciences (VIMS) maintains Marine Studies Centres at Queenscliff and Tooradin. These provide a number of programs, including field studies for students (for example, the sand dune revegetation program), teacher training programs, and holiday programs for the general public (comprising snorkelling trips, rockpool walks, and marine biology cruises). The Centres are very active and service a large number of people. For example, in 1992 the Queenscliff one expected to run 200 marine biology cruises and 5500 field studies for 19 500 primary and secondary students.

Once a year the Australian Marine Education Society, a voluntary group, holds a 'Seaweek' on various marine conservation topics, such as marine parks or marine pollution. Some commercial scuba-diving groups organise, jointly with teachers, science-snorkelling trips for secondary students. Government and scientific organisations such as the Marine Science Laboratories, the Environment Protection Authority, and most universities have open days for the general public, during which they provide displays and information on the marine studies they conduct.

A number of schools regularly use marine areas for geography or biology studies. In addition to accessible field sites, the schools need facilities to prepare for and finalise their field work, including specialised scientific and other equipment (laboratories, slide-projectors, writing boards, etc). Facilities can be provided by school classrooms - for example, Point Gellibrand Girls Secondary College in Williamstown, visitor centres like that at the Phillip Island Penguin Parade, VIMS or other specialist centres, and other public and private establishments such as yacht or life-saving clubs.

The Department of Conservation and Natural Resources provides marine field interpretation programs in most of its coastal national parks



Marine interpretation conducted by a CNR ranger.

and marine parks. Those for schools - designed in conjunction with teachers to fit the school curriculum and conducted throughout the year - usually consist of about 1 hour rock-pool rambles. The programs for the general public are slightly longer and include rock-pool rambles, night activities, and other walks. They are advertised and usually conducted during summer and school holidays.

An education centre, located at Wilsons Promontory, offers school courses that include studies of the marine environment. It has a full-time teacher, a classroom, and appropriate equipment; for example, a television camera linked to a microscope can display freshly collected marine specimens. The centre is a convenient location for field-work associated with a variety of marine habitats. It is also used for a joint VIMS and Museum of Victoria venture - which involves a weekend training program about the marine biology and ecology of Wilsons Promontory for secondary teachers. So far, about 1000 teachers have completed this program.

In addition to formal and semi-formal programs, education about the marine environment may be achieved through interaction with it during a variety of recreational activities such as, for example, walking, Nature study, fishing, swimming, and snorkelling.

Marine and coastal areas are an important resource in educating the community about aspects of Australia's history. Sites of local Aboriginal occupation provide information about their lifestyle and the resources they used. Such sites can teach the community a great deal about many issues pertaining to the coast. Similarly, 19th and 20th Century sites reflecting occupation and activities, can provide insights into the more recent history of Victoria. Historic sites and the locations of shipwrecks, along with maritime museums (such as the one at Flagstaff Hill in Warrnambool), provide a great deal of information that is valuable for public education.

A series of educational guides provide information on shipwrecks along the western coast of Victoria and a Historic Shipwreck Trail has been established. In addition, some educational institutions run tours of the coast specifically to look at shipwreck sites.

Education of a less formal but equally important nature relates to a wide range of recreation activities. Many sporting clubs and other organisations provide training and educational programs utilising the coastal environment and, over time, large numbers of people can pass through these. Examples include fishing, scuba-diving, boating, and surf life-saving.

RESEARCH

Most forms of research require access to the environment being investigated and this certainly applies to research associated with marine and coastal areas. It may be compatible with a wide range of other activities, but in some instances has specific requirements that make it incompatible. For convenience, it is divided into pure research and applied research, but some overlap between the two does occur. Pure research increases the basic knowledge of the environment being studied, while applied research concentrates on the development and use of the biological, physical, or cultural resources comprising the particular environment.

Pure research

Pure research deals predominantly, but not exclusively, with relatively unmodified systems. It provides information on:

* the biological (such as, taxonomy, biodiversity, community structure, life history) and physical (climatology, chemical oceanography, sedimentology, hydrodynamics, etc.) components of the environment

* interactions between the biological and physical components (for example, predator—prey and interspecific relationships, habitat—organism interactions)

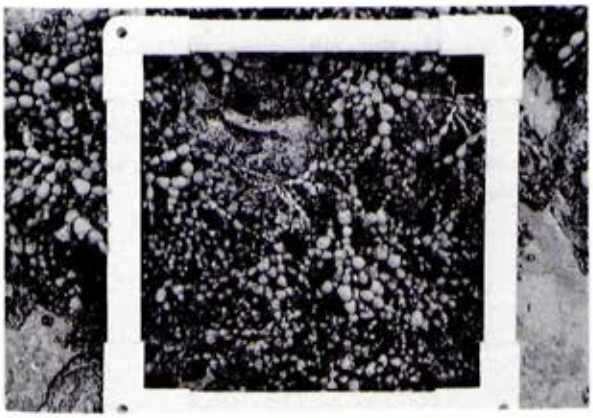
* the possible outcomes if balances are altered due to natural or human impacts (for example, habitat modification, predator removal, water-quality decrease, impact of a natural disaster or intended manipulation)

Such research usually requires relatively large areas, unmodified by humans, in order to provide an understanding of naturally occurring systems. This is particularly important for marine areas, where the movement of water with its associated chemical and biological components can have far-reaching effects. A pollution incident, for example, may have significant effects at a great distance from its occurrence.

As with the terrestrial environment, the scale of data-collection depends on the level of detail required.

Much less is known about the marine than the terrestrial environment because of its vastness, difficulty of study, and greater biological diversity. For example, only 45% of commonly occurring benthic marine macro-invertebrates can be identified at species level. The diversity of infauna in Bass Strait is exceptionally high (353 species within 1.2 sq. m in East Gippsland) - apparently higher than has been found anywhere in the world. The macrofauna of southern Australia is also largely endemic. As biogeographical information is generally lacking, large numbers of areas need to be investigated to adequately characterise biodiversity of Victorian marine waters.

Characterisation of an area requires both spatial and temporal sampling (including seasons and years). For example, a minimum of 3 years was considered necessary to describe the basic environ-mental characteristics of Jervis Bay and East Gippsland Coast, and 25 years of research into the causes of outbreaks of the crown-of-thorns starfish on the Great Barrier Reef have yet to produce clear answers.



Researching density of Neptune's necklace - a brown algae - at Mt Martha beach.

In summary, to gain adequate basic knowledge of marine environment, we need to investigate large areas, essentially unmodified by humans, over long periods of time.

Applied research

Covering both natural systems and those modified by human use, applied research may cover:

* the optimum means of producing a commodity (for example, a commercial species in a mariculture venture)

* identification and extraction of a resource (commercial fishing - finding the best location, and sustaining the resource through stock assessment; oil exploration; dredging for ports)

* assessment of the impact that human activities such as waste discharge have on the environment (effects of pollutants such as TBT, nutrients, organochlorines, impact of introduced species on indigenous species, effects of sediment disturbance)

Although the two types of research have different aims, they will overlap in their requirements for access to the marine and coastal environment and in the sort of information they generate. For example, an applied research project for a commercial fishery may, as a by-product, provide information on the distribution of other organisms. A study of the fish - blue grenadier, for instance - revealed a number of interesting facts about the distribution of its food species. It is important, however, to remember that applied research will centre only on areas or resources relevant from a resource use point of view and that it draws heavily on pure research in, for example, taxonomy.

A significant body of both pure and applied research on the marine environment has been conducted by people from academic and other institutions. However, as indicated elsewhere in this report, many gaps in the information remain and will require further work. Non-government groups and organisations such as the Marine Research Group also conduct research along the coast and, as such, make an

important contribution to our knowledge. A large number of unpublished reports and theses about the coast have been produced, but the information contained in them is difficult to find, mainly because no comprehensive listing is available. A forthcoming book (Bird 1993 in press), will contain references to both published and unpublished work on coastal geomorphology, geology and biogeography.

Chapter 4 summarises research activities including those conducted by the Victorian Institute of Marine Sciences and the Marine Science Laboratories.

The cultural resources associated with the coast also provide significant opportunities for research relating not only to history but to past climates and changes in coastal geomorphology, for example.

Most of the declared 'historic shipwrecks' have scientific research potential, as their fabric and contents are able to answer specific archaeological questions about the past, particularly when the nature of their voyage and the date of wrecking are comparatively well known. Shipwrecks may also add to scientific knowledge about the behaviour of submerged material. The *City of Launceston*, for example, has been identified as having potential to help understand corrosion rates in metals underwater. Shipwreck sites create their own micro-environment and many also contain rare or unique species. The *Clarence* in Port Phillip Bay is the habitat of a rare fish.

Midden sites can answer complex questions about Aboriginal diet and seasonal patterns of use on the coast, while sealing and whaling sites can tell about the first non-Aboriginal settlement there. The presence of these sites and their contents is the only detailed evidence available.

Cultural research, which is primarily based on documentary analysis, can move out from archives and libraries (of which quite a few are located on the coast) to use the physical features of the coast to understand the past. There are significant benefits in visiting the actual areas where events occurred in order to enhance the quality of such research.

Monitoring

The monitoring of essentially unmodified coastal areas and marine waters is often considered a prerequisite for various commercial developments such as the proposed East Gippsland pulp mill. The information gained, in addition to providing base-line data for future impact monitoring, provides basic understanding of the existing environment.

At present virtually all the monitoring of the marine environment is related to pollution. The need to monitor the environment to document historic trends and identify indicators as they relate to culturally induced changes is internationally (GESAMP) and nationally (OR2000 - National State of the Marine Environment Report) recognised. However, this is not, as yet, undertaken in any comprehensive way in Victoria.

ISSUES

* community education about the significance and appropriate use of the marine and coastal environment
* provision of signs as an education tool
* ongoing and future research needs

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16. OTHER USES

The previous chapters in Part III have described the major coastal uses, but other uses, although minor, are also of importance.



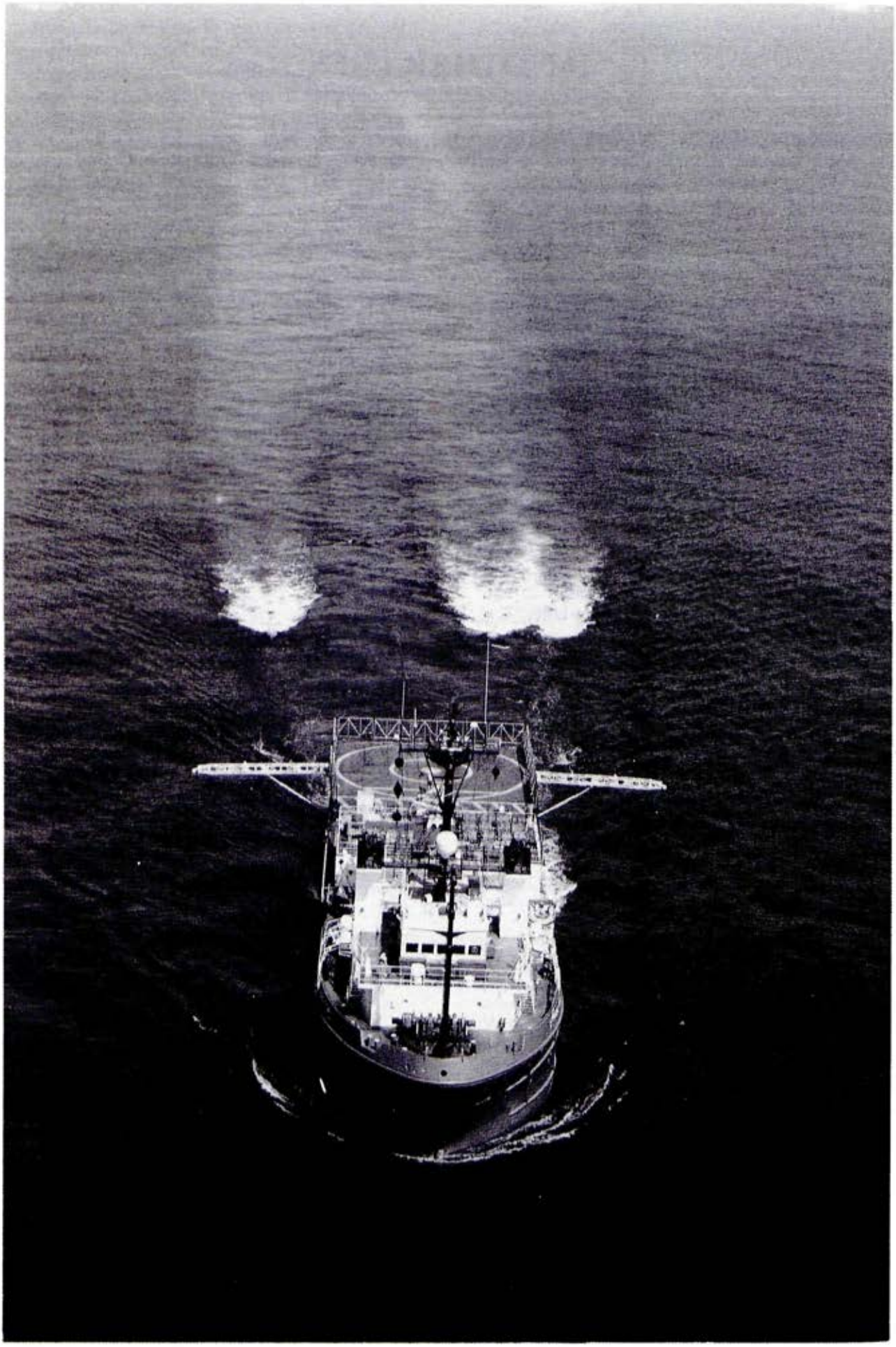
Boat houses - Safety Beach.

Clubs and individuals may be licensed to use coastal public land. Surf life saving clubs, for example, are organised around coast-based activities, which justifies the use of foreshore areas. In that instance, specific Coastal Management and Coordination Council policy covers the provision of coastal lands., However, many other club-based activities located on foreshore land neither require nor are enhanced by the foreshore location. For example, rifle ranges, golf-courses, race-courses, bowling clubs, may have facilities that occupy small areas of public land - often in or near urban centres, thus providing ease of access to their members.

Coastal land has a history of other uses, such as grazing, and permissive occupancies for holiday-fishing, bathing boxes, boat sheds, and other purposes. Where these have conflicted with land-use goals, they have been removed or phased out.

ISSUES

* use of foreshore areas for non-coastal dependent activities



Seismic exploration by the Pacific Titan - Bass Strait

PART IV
SOCIAL AND ECONOMIC CONTEXT

17. SOCIAL AND ECONOMIC CONTEXT

This chapter discusses the available socio-economic data for the Victorian coast and describes some socio-economic concepts that could be applied to the planning and management of coastal lands and marine waters.

THE SOCIO-ECONOMIC FRAMEWORK OF THE COAST

Economic data available for the Victorian coast comprise information on tourism, commercial and recreational fishing, oil, and other mineral extraction, and are described in the relevant chapters of this report.

Social data usually include information on occupations, preferences for various activities, and distribution of wealth, but such data specific to the coast are not readily extractable from the general Victorian information. Some will become apparent during the submission stage of the investigation. The only information readily available is population distribution (see Tables 17.1, 17.2, and 17.3). Population data have been compiled by the Resource Assessment Commission for selected (coastal) statistical divisions and statistical local areas, and from the 1991 Victorian Year Book.

Population along the coast is increasing much faster than in the rest of Victoria. Between 1971 and 1991 it increased by 62%, compared with 21% for the State as a whole. The predicted population for the year 2000 indicates a similar trend: an increase of 17% for the coast compared with 8% for the rest. Thirteen per cent of Victorians (excluding Metropolitan Melbourne) and 80% when it is included, live on the coast. Most people (88% in 1986) are concentrated in the ten largest coastal urban centres. Long stretches of coast, such as Croa-jingolong, Discovery Bay, and the Otways, have none or very few people. The high concentrations over relatively small areas, especially around Melbourne, and the relatively higher increase of coastal population may have considerable implications for future land use. The development of Melbourne's south-east growth corridor, for example, is likely to have profound implications for land use in the Westernport catchment.

Many positive social and economic outcomes stem from the increased activity generated by coastal development, including the growth of new and important industries such as tourism and mariculture, and the decentralisation of some commercial and light industrial activities, particularly those associated with the building and construction industry. More people than ever before have chosen to live near the coast and in doing so have greater access to many coastal resources and facilities.

The social and economic fabric of the major population centres along the coast varies greatly. As indicated above, it is very difficult to establish socio-economic profiles for these centres using existing statistical data, but some general comments and comparisons can be made.

Major activities associated with coastal population centres outside Melbourne and Geelong include agriculture, fisheries (including mariculture), tourism, recreation, industry and commerce, and petroleum production. Other activities include support services, such as schools, medical facilities, and other community needs.

Many coastal towns and settlements across Victoria have undergone significant change in recent years in response to changing social and economic conditions, but the degree and nature of the changes differ markedly. Moreover, the range of activities and their relative significance to the local, regional, and State economies varies enormously, as indicated by four examples - Portland, Warrambool Mallacoota and Marlo.



The urban areas of the Mornington Peninsula stretching north from Arthurs Seat.

Table 17.1: Coastal Population

Statistical division (SD)	Statistical local area (SLA)	Population 1971	Population 1991	Gross change[1] 1991/1971	Per cent relative change[2] 1991/1971	Per cent of SD change accounted for by coastal SLA[3]
South Western	Portland	15 000	17 000	2 000	18	154
	Port Fairy	2 000	2 000	-	2	2
	Belfast	2 000	1 000	2 000	-14	-14
	Koroit	1 000	1 000	-		
	Warrnambool	26 000	32 000	6 000	27	404
	Heytesbury	8 000	7 000	-1 000	-10	-50
	Coastal	**54 000**	**61 000**	**7 000**	**13**	**412**
	South Western SD	**96 000**	**98 000**	**2 000**	**2**	
Barwon	Otway	4 000	4 000	-	-	-
	Winchelsea	4 000	5 000	1 000	20	2
	Barrabool	3 000	10 000	7 000	185	12
	South Barwon	27 000	41 000	14 000	52	27
	Queenscliff	3 000	3 000	-	11	1
	Bellarine	19 000	41 000	22 000	119	43
	Geelong	18 000	13 000	-5 000	-27	-9
	Newtown	12 000	10 000	-2 000	-15	-3
	Geelong West	17 000	13 000	-4 000	-22	-7
	Corio	41 000	56 000	15 000	37	29
	Coastal	**147 000**	**195 000**	**48 000**	**33**	**94**
	Barwon SD	**166 000**	**218 000**	**52 000**	**31**	
Melbourne	Mornington	14 000	3 000	16 000	110	3
	Cranbourne (A)	16 000	71 000	55 00	335	11
	Hastings	9 000	29 000	20 000	222	4
	Flinders	16 000	37 000	21 000	136	4
	Coastal	**55 000**	**166 000**	**111 000**	**202**	**23**
	Melbourne SD	**2 503 000**	**2 991 000**	**489 000**	**20**	
East Central	Phillip Island	2 000	5 000	3 000	192	9
	French Island	200	60	-140	-70	
	Pakenham (part in Melb SD)	13 000	31 000	28 000	142	49
	Bass	4 000	5 000	1 000	31	3
	Wonthaggi	4 000	6 000	2 000	69	7
	Coastal	**22 000**	**47 000**	**25 000**	**112**	**67**
	East Central SD	**30 000**	**67 000**	**37 000**	**123**	
Central Gippsland	Woorayl	9 000	11 000	2 000	20	7
	South Gippsland	5 000	6 000	400	8	2
	Alberton	6 000	6 000	400	6	1
	Rosedale	5 000	9 000	4 000	73	13
	Coastal	**25 000**	**32 000**	**6 000**	**25**	**23**
	Central Gippsland SD	**118 000**	**145 000**	**27 000**	**23**	
East Gippsland	Sale	10 000	19 000	3 000	32	22
	Bairnsdale	12 000	18 000	6 000	47	37
	Tambo	6 000	10 000	4 000	73	27
	Orbost	6 000	7 000	300	4	2
	Coastal	**35 000**	**49 000**	**14 000**	**39**	**87**
	East Gippsland SD	**49 000**	**65 000**	**16 000**	**32**	
TOTAL COASTAL (excluding metropolitan Melbourne)		338 000	550 000	211 000	62	
TOTAL STATE		3 502 000	4 244 000	741 000	21	
COASTAL AS % OF STATE (excluding metropolitan Melbourne)		10	13			
TOTAL COASTAL (including metropolitan Melbourne)		2 786 000	3 375 000	589 000	21	
COASTAL AS % OF STATE (including metropolitan Melbourne)		80	80			

Notes:

1. Gross change: 1991 less 1971 figures.
2. Relative change: $\frac{\text{Gross change}}{\text{1971 figures}}$ (%)
3. $\frac{\text{Gross change}}{\text{Relative change}}$ (%)

Source: RAC (based on ABS statistics) and rounded to nearest 1000.

Table 17.2: Projected Coastal Population

Statistical local area	Projected population	
	1992	2000
South Western Statistical Division		
Belfast (S)	1 000	1 000
Heytesbury (S)	8 000	7 000
Port Fairy (B)	3 000	3 000
Portland	20 000	21 000
Warrnambool	34 000	37 000
Coastal	66 000	70 000
Statistical Division	106 000	110 000
Barwon Statistical Division		
Barrabool (S)	10 000	12 000
Bellarine (S)	45 000	34 000
Corio (S)	59 000	64 000
Geelong (C)	13 000	12 000
Geelong West (C)	15 000	14 000
Newtown (C)	10 000	10 000
Otway (S)	4 000	4 000
Queenscliff (B)	3 000	3 000
South Barwon (C)	44 000	48 000
Winchelsea (S)	5 000	6 000
Coastal	207 000	227 000
Statistical Division	231 000	252 000
Melbourne Statistical Division		
Cranbourne (S)	74 000	112 000
Flinders (S)	42 000	50 000
Hastings (S)	30 000	37 000
Mornington (S) Pt A	32 000	37 000
Pakenham (S) Pt A8 000	8 000	11 000
Coastal	187 000	247 000
Statistical Division	3 145 000	3 400 000
East Central Statistical Division		
Bass (S)	5 000	6 000
French Island	70	70
Pakenham (S) Pt B	22 000	28 000
Phillip Island (S)	6 000	7 000
Wonthaggi (B)	7 000	8 000
Coastal	39 000	49 000
Statistical Division	61 000	74 000
Central Gippsland Statistical Division		
Alberton (S)	7 000	7 000
Rosedale (S)	10 000	12 000
South Gippsland (S)	6 000	7 000
Woorayl (S)	13 000	15 000
Coastal	36 000	40 000
Statistical Division	155 000	167 000
East Gippsland Statistical Division		
Bairnsdale	19 000	21 000
Orbost (S)	7 000	7 000
Sale (C)	14 000	15 000
Tambo (S)	11 000	13 000
Coastal	51 000	56 000
Statistical Division	68 000	75 000
TOTAL COASTAL	586 000	689 000

Source: RAC (based on ABS statistics) and rounded to nearest 1000, except for French Island.

Portland is the only deep-sea port between Port Phillip Bay and Adelaide and, as such, is a focal point for the export and import of produce to and from the area known as the 'Green Triangle', which includes south-west Victoria and south-east South Australia. The city, with about 11 000 people (1986), boasts the Alcoa Aluminium Smelter (a major employer), which has broadened the economic base and complemented existing activities in meat-processing, particle-board manufacture, fertiliser works, wool stores, fishing (trawl, lobster, and abalone), and service industries. Portland has a comprehensive shopping centre and a full range of community services, and caters for tourists with a variety of accommodation - hotels, motels, guest-houses, and caravan parks.

Warrnambool, a flourishing city of some 23 000 people (1986), is regarded as the regional commercial centre for western Victoria. It is fortunate to have several major industries including the Nestlé Milk Condensing Plant, the Fletcher Jones organisation, and Warrnambool Textiles. Kraft Foods and Murray Goulburn operate important cheese and milk processing and packaging factories nearby. Dairying, sheep, and fat cattle production are an important aspect of the regional economy. The city has excellent shopping facilities, a full range of community services, and a large range of accommodation for the many tourists who visit the area each year. A major attraction that has provided the city with national recognition is the annual appearance of the southern right whales. The many other attractions and events for tourists, include the Flagstaff Hill Maritime Museum.

In contrast to the two cities described above, many of the smaller coastal towns have a narrower economic base.

Table 17.3: 1986 Population - Ten Largest Urban Centres, Victorian Coast

Urban centres[2]	Population[1]
Melbourne	2 645 000
Geelong	126 000
Warrnambool	23 000
Portland	11 000
Ocean Grove–Barwon Heads	9 000
Hastings	5 000
Lakes Entrance	4 000
Queenscliff	4 000
Torquay	4 000
Port Fairy	3 000
	2 834 000
Total coastal (including metropolitan Melbourne[3]):	3 223 000
Urban centres as % of coastal:	88

Notes:
1. All data rounded to nearest 1000.
2. Source: 1991 Victorian Year Book.
3. Source: RAC (based on ABS statistics).
4. Data have been drawn from different sources and therefore some inconsistencies occur.

Box 17.1: Effects of Coastal Zone Use

Changes in coastal zone resource use are most evident in the dramatic increase in the number of people living, working, and recreating in such areas. The effects on coastal zone resources are:

* urbanisation
* habitat depletion
* pollution
* competition for and conflict about resources

These changes have resulted in:
* land previously used for rural purposes being subdivided and converted to urban and semi-urban purposes
* many new developments concentrated along a narrow belt of coastline and inshore marine areas
* increased reservation of coastal lands and waters for preservation and recreation purposes
* access to coastal zone resources generally increasing (for example, through provision of more roads and other infrastructure)
* much greater use of the non-metropolitan coastal zone for long term occupancy (residence) that has increased demands on resource managers, particularly State and local governments
* increased intensity of resource use

Economic consequences

Changing patterns of land use and population growth in the non-metropolitan coastal zone have had a number of important economic effects:

* The traditional economic bases (farming, mining, fishing) of many parts of the coast are progressively changing to urban-oriented economies. Many development pressures have arisen through the process of urbanisation.
* Some economic development opportunities have been foregone; but new economic opportunities have been created; for example, some areas with economic potential have been set aside in public reserves, while the tourism potential in many parts of the coastal zone are being realised, and others are being investigated.
* Underpricing in the use of important resources, for example, water for consumption and waste disposal, and land for development.
* The costs of coastal management and development have increased, including the costs of providing for infrastructure, services and management by all spheres of government. As a consequence:
  - State and local authorities have had to increase their borrowings to meet infrastructure and management costs
  - most decisions relating to land development have not been taken in the context of meeting the full costs of development
  - increased demands have been made on developers to meet the costs of managing impacts

Social consequences

There have been significant social consequences of rapid urbanisations and the changing pattern of land uses on the coast in some places including:

* Growth in demand for social services and infrastructure in dispersed locations.
* Reduced quality of experience in some uses of coastal resources.
* Increased access to coastal zone resources for recreational use in some areas, decreased access in others.
* Loss of the aesthetic quality of some natural environments.
* Replacement of traditional activities, with consequent job changes and losses.
* Changing demographic structures, in particular the concentration of specific age groups in specific localities (for example, retirement centres and new growth centres).
* Demands by particular groups for exclusive-use rights over coastal resources (for example, for tourist developments in some areas).

Ecological consequences

There is evidence of widespread and growing community concern about the ecological effects of coastal development and about the ecological impacts associated with population growth. Among the impacts are the following:

* Loss of coastal habitats, especially wetlands, through development and associated infrastructure provision, as well as from agriculture.
* Degradation of many coastal habitats, including dunes and beaches, wetlands, and estuaries, due to increased pressure from human activities.
* Introduction of exotic plants and animals.
* Increasing soil erosion and associated soil loss.
* Increased risks to some endangered and commercial species.
* Significant direct, indirect, and cumulative effects that are poorly understood.
* Declining water quality of rivers, inshore waters, wetlands, and the ocean as a result of urban, industrial, marine-based, and agricultural pollution.

The long-term economic, social, and environmental costs of these changes have not yet been identified or evaluated in a comprehensive way.

Source: Resource Assessment Commission (1992b)

Mallacoota, a small town of around 800 people in far East Gippsland, relies heavily on tourism and commercial fishing (predominantly abalone). In summer, the town population swells to about 7000—8000 with the influx of tourists. The only significant secondary industry is an abalone-processing plant that exports canned produce, mainly to Japan. As with numerous small coastal towns, Mallacoota is experiencing an influx of retired people who find it an ideal place to settle.

Marlo, also in far East Gippsland, sits at the mouth of the Snowy River and relies heavily on agriculture and fishing for its economic well-being, but it also appears to provide an attractive residential location for people working in nearby Orbost. Tourism is only a minor contributor to the economy of the town.

Other coastal towns, such as Torquay, Rye, and Rosebud rely on tourism to a significant extent, but also act as dormitory suburbs for people working in the nearby cities of Geelong and Melbourne.

The socio-economic framework of many coastal cities and towns is therefore complex and has numerous links both within and beyond the study area. For example, the economies of many towns rely on agriculture, which is conducted in the surrounding hinterland. Some towns derive a significant proportion of their economic well-being from fishing but, again, a proportion of this activity is carried out beyond Victorian waters and thus also beyond the scope of the present investigation.

During the next stage, the Council will be developing proposed land-use recommendations for public comment. As part of this task, it will gather information that provides a broad picture of the socio-economic structure of the coast, against which to assess the implications of any of those recommendations. Some of the techniques that can be used in such assessments are discussed below.

METHODS OF SOCIO-ECONOMIC ASSESSMENT

As its primary function, the Land Conservation Council makes recommendations on the balanced use of land and, in the case of this investigation, the associated marine environment. In doing so the Council is aware of the need to balance local, regional, State, and national interests as well as those of present and future generations.

The concept of 'intergenerational equity' is relevant to this task and involves satisfying the needs of present generations without compromising the ability of future generations to meet their needs. In relation to natural resources this means that some resources need to be conserved or used wisely to allow future generations to make decisions about their use.

The concept assumes that future generations will use resources in a thoughtful, careful, and sustainable way. The size of the future populations that will rely on the resources they inherit is important and unpredictable. The principles underlying sustainability are that:

* the renewable resources are used at a regeneratable rate

* non-renewable resources are used prudently and efficiently and a surplus is created for developing and substituting technologies that use renewable resources (for example, use of the surplus from the oil industry to develop affordable solar power)

* biological diversity is maintained

Another relevant concept is 'Ecologically Sustainable Development'. As noted by the Working Group Chairs of the Ecologically Sustainable Working Groups (Anon. 1992):

> 'The policy challenge is how to achieve the necessary integration of economic development and ecological sustainability. What is important is the understanding that as a broad principle there is no necessary conflict between economic and environmental goals, and indeed that both have to be pursued simultaneously and in harmony in an economic development process that is ecologically sustainable.'

In 1992, the governments of the Commonwealth, States, and Territories and the Australian Local Government Association concluded their 'Intergovernmental Agreement on the Environment', in which all parties agreed on the need for:

> 'the effective integration of economic and environmental considerations in decision-making processes, in order to improve community well-being and to benefit future generations...'

In making balanced land use recommendations, the Council often has to decide between

competing uses for public land, satisfying three broad society goals: economic, social, and environmental.

Options for resource uses, and the potential losses and benefits associated with these uses, are explored and assessed in terms of economic, ecological, and social goals. The analyses conducted span many disciplines, including economics, ecology, and sociology, in an effort to better integrate considerations relating to both natural and human systems.

Differences arise within and between disciplines in terms of focus, analytical techniques, assumptions, and policy prescriptions. They are often the source of confusion and frustration in resource-use debates. Nevertheless, they mirror the extraordinary complexity of the real world and the approaches that different disciplines have taken in analysing such complex relationships. They emphasise the need to consider the wide range of values that may be associated with particular resources and their uses, as well as the losses and benefits that may be incurred through particular choices.

All values associated with resource-use options can be considered within the loss—benefit framework. This framework not only incorporates the traditional form of cost-benefit analysis (CBA), which assesses those uses of a resource that have commercial or potential commercial value, but also emphasises the importance of losses and benefits identified in environment and social impact-assessment procedures and recognises the presence of uncertain and unquantifiable losses and benefits. Thus, CBA does not seem to differ from the loss—benefit analysis.

Cost—benefit analysis, as applied to issues considered by the Council, resembles more a loss-benefit framework. It is a systematic assessment of costs and benefits of alternative land uses. Its aim is to select land uses with the highest net benefits to society (satisfying the economic, social, and environmental goals). The costs and benefits are expressed in a common - monetary - scale of measurement, and often include values, which may be easy or difficult to price.

Easily priced values are those that are usually expressed in money terms and are market commodities; for example, a benefit may be profit from a commercial fish sale and a cost, may be that incurred in cleaning up an oil spill.

For hard-to-price, sometimes called 'unpriced', values, a dollar value is difficult to determine with any accuracy and therefore needs to be estimated. For example, an estimated cost could be associated with altering the marine environment by assimilation of human wastes. An estimated benefit could be willingness to pay for recreation experience, or existence of certain marine habitats, landscapes, and biodiversity.

Cost—benefit analysis is well suited to easily priced values, but much more difficult to apply to unpriced ones. Some of the inherent problems involve discounting of natural resources; valuation of 'free' public goods, such as clean air and water, soil, plants, and fish; and valuation of other unpriced commodities, such as ecological values (including biodiversity), existence (spiritual) and aesthetic values, and uncertainty, substitution, and irreversibility issues.

The following discussion of techniques used in socio-economic assessment is derived from *RAC Research Paper* No. 7 (Resource Assessment Commission 1992c). Readers are directed to this paper for greater detail.

While the loss—benefit frame of reference is a workable and useful way of structuring the analysis of resource-use issues, clearly in some circumstances even assessment techniques that recognise the existence of multiple goals will be inadequate. No technique can express, aggregate, weigh, and compare the values of all the losses and benefits associated with alternative resource uses, or adequately provide for different and changing value systems. Thus, no methodology eliminates the need for governments to make final judgements in relation to resource-use options. This situation is unlikely to change, despite the further development of techniques that inform and assist policy-makers.

A range of techniques have been developed to identify the nature and extent of resources, their current and potential uses, and associated values, the aim being to provide more accurate values or to establish values for 'difficult to price' commodities to enhance the cost—benefit analysis approach. Examples include **econometric modelling**, which involves the application of mathematical and statistical techniques to economic data to analyse the behaviour of consumers, producers, markets, and economies, and in particular to assess the likely impact of changes in economic variables. **Input—output models** seek to represent the

intersectoral flows of products in an economy; they assume that linear relationships exist between the economic variables modelled.

General equilibrium models are based on input—output models, but may provide for the existence of non-linear relationships between many economic variables; that is, they seek to simulate the resource reallocation that may occur as a result of changes in demand through factors such as price changes and improvements in technology.

Environmental-domain analysis uses existing data on environmental attributes (altitude, terrain, climate, and geology, for example) together with classification techniques to identify and map the different types of environments that occur in a region. These types are called 'environmental domains'; knowledge of their distribution, together with some biological distribution data, may then be used, among other things, to predict the distribution of plants and animals in the region and to assess the design of systems of nature reserves. The biophysical classification of marine and coastal environments, being developed by the Council and the Department of Conservation and Natural Resources, is attempting to provide this kind of information.

Population viability analysis is a mathematical modelling tool used to predict the fate of a species' population over time under a particular set of circumstances, or to compare the effects that different resource uses or management regimes may have on it. Other techniques include financial analysis of specific projects, the application of recreation opportunity spectrum analysis, and conservation reserve design analysis.

A variety of other techniques have been developed to attempt to derive an assessment of community values, attitudes, and preferences. Some of these may be termed economic techniques, in the sense that they measure the values and preferences expressed by consumers, sellers, or producers in markets or, when markets do not exist (as in the case of amenity, option, and preservation values), in surrogate or simulated markets. Markets, particularly those operating efficiently, provide useful data on the value that society ascribes to resources and their uses. Many values that can be used in benefit—cost analysis can be inferred from market data.

When conflicts occur between development and conservation aims, values associated with conservation may be compared with the net benefits from development in two ways. The development benefits may be used to calculate a threshold value that the community would have to pay to forgo development and preserve the natural environment. Alternatively, an attempt may be made to measure environment values directly in monetary units. In principle, it should then be possible to determine whether development or environment preservation yields the highest net benefits. Attempts to derive monetary estimates of environmental values can use the **travel cost** and **contingent valuation** methods. Each of these methods is based on a number of important assumptions: that individuals are willing and able to indicate their preferences in monetary form; that community values depend on the sum of the values of all individuals; and that values derived by these measures can be compared with those obtained from market behaviour. Some individuals and groups do not accept that these assumptions are realistic and query the usefulness of information derived through these techniques.

The **travel cost method** is used to measure the recreation value to consumers of sites where entrance or use fees are either non-existent or low. It relies on observing people's behaviour: the costs of travelling to a site, such as a national park, are assumed to be a proxy for the value associated with visiting the site. A sample is taken of visitors to the site in question. Costs of travel are estimated according to the cost per trip reported by respondents. Total willingness to pay for use of the site is imputed by simulating the effects of variations in the cost of travel on the extent to which the site is used, thus allowing a total demand function to be estimated. The travel cost method is well established and employed in many countries. When properly applied it is a reasonably reliable and robust technique for quantifying the recreation use value of a resource. The method works best when visitors travel from a wide range of distances.

Contingent valuation attempts to measure in monetary terms values that are not revealed either directly in markets for goods and services or indirectly in surrogate markets. Commonly called 'preservation' values, these comprise the value to people of simply knowing that an area or ecosystem exists, the value of retaining the option to 'use' the area or its contents in the future, and the value to the present generation of passing something on to the next.

The technique employs surveys to create a hypothetical market for the benefits people derive from the environment. Usually a sample of people are asked how much they would be willing to pay to preserve or improve the level of environmental quality, or how much they would be willing to accept in compensation for losses, contingent on a set of economic circumstances. For example, people may be asked how much they would be willing to contribute to a fund to purchase forests to be preserved.

It is necessary to exercise great care in applying the method, particularly in collecting data and in applying statistical techniques to derive values from it. The principal goal is to eliminate bias from the exercise. Bias can arise from many sources. For example, respondents may attempt to distort the results; information about options may be presented incorrectly or unclearly; respondents may give answers they think will please the interviewer; the questionnaire may not be perceived to be real or relevant; or the suggested mechanism for payment may result in unrealistic responses. There are different ways of formulating questionnaires and analysing data, which are designed to minimise the effects of bias arising from these sources.

To help ensure the reliability of surveys used it is desirable to design the questionnaire in conjunction with focus groups and to conduct pilot surveys prior to carrying out the survey itself. In its present state of development, the technique cannot provide results that are sufficiently precise to incorporate into or compare with value estimates of the net benefits of development from cost—benefit analyses.

When land-use recommendations are being considered, there is a need to aggregate information and consider options according to a few relatively simple decision rules: it may be necessary to attach weightings to the criteria deemed to be appropriate in evaluating options. Provided their limitations are recognised, some techniques are particularly useful for these purposes, and include both cost—benefit analysis and multi-criteria analysis. Social impact analysis (which provides insights relating to the evaluation of resource-use options by individuals and groups within communities potentially affected by resource-uses) and scenario analysis can be useful tools for decision-makers, in view of existing uncertainty about the future.

Cost-benefit analysis (CBA) refers to both an approach to resource-use decision-making, whereby the costs and benefits of alternative resource-uses are measured and compared, and the set of techniques that permit this assessment. It is based on standard welfare analyses used in economics. These assume: that individual preferences, as revealed in markets, should be taken into account; that they should be weighted according to the existing distribution of income; and that social preferences can be determined by summing the weighted preferences of all individuals comprising society.

In CBA, costs and benefits are assessed in monetary units, and the key decision variable is the present value of net benefits - that is, the value now of the difference between the stream of revenues and costs arising during the life of the project, program, or policy. The 'best' resource-use alternative, in the sense of the most economically efficient alternative, maximises the present value of net benefits. The main steps in the CBA process are described below.

* Determine the scope and aims of the analysis.
* Identify the constraints (financial, distributional, environmental, and so forth) on meeting the aims to ensure that all alternatives examined in the analysis are feasible.
* Identify alternatives to be examined.
* Identify costs (capital expenditures, operating and maintenance costs, labour costs, opportunity costs, harmful effects on other parties, and so forth) and benefits (value of outputs, avoided costs, productivity savings, health, social or environmental benefits, and so forth).
* Quantify/evaluate costs and benefits, including adjustment of private costs and benefits into social ones - that is, costs and benefits that reflect losses and benefits to the economy as a whole, rather than to individual persons or groups. For example, estimates of 'shadow' prices may be required when market prices do not reflect the true opportunity cost of using a resource, and taxes on outputs would be included as a benefit.
* Calculate net present value - that is, total benefits less total costs occurring in each time period, discounted to present values.
* Apply sensitivity analysis - that is, calculate the net present value using different assumptions about key determinants of costs and benefits.

Box 17.2: An Assessment of the Impact of the 1990 Oil Spill Near Cape Otway

Identified sources of costs of the oil spill

Economic - commercial loss to hoteliers/restaurant-owners; commercial fishery losses; clean-up cost; cost of preventative measures
Social - loss of recreation to beach users, sightseers, anglers
Environmental - immediate ecosystem damage: impact on sea-birds, penguins, fisheries resource, plankton, life in intertidal zone; long-term ecosystem damage; irreversible damage

Observed and estimated physical ecosystem damages

Observed - 226 dead and 66 ill penguins and 9 other dead sea-birds, some damage observed in intertidal zone
Estimated total number of killed penguins - 3616, based on recovered birds representing 10% of total impact.

Approaches considered for valuation of environmental loss

Replacement cost of rearing penguins - based on cost available from Phillip Island for hand-rearing fledglings while parents at sea.

Potential revenue associated with the ecosystem [based on the revenue received from Phillip Island Penguin Parade (PP)] - average future PP revenue across all Phillip Island penguins and apply to the lost penguins.

Future conservation expenditure associated with the ecosystem - based on the Victorian Government's willingness to pay to maintain population recruitment, or the population at Phillip Island or in Victoria.

(Note: the above three approaches are limited and include only penguins, which form an extremely small part of the valued ecosystem.)

Willingness to pay - the amount people are prepared to pay (information found by survey) to protect the environment from an oil spill.

Action

Legal action by government is in progress on two fronts.

Commonwealth Department of Public Prosecutions - Action under Commonwealth legislation Section 9.1 of the *Protection of the Sea (prevention of Pollution from Ships) Act* 1983. The judge concluded that the spilled oil resulted in the environmental damage and the company and the ship captain were deemed to be responsible.

Department of Conservation and Natural Resources - Under Tanker Owners Voluntary Agreement Concerning Liability for Oil Pollution, the Department has submitted a claim for $1.8 million for:
death of penguins; death of other wildlife; costs of restoring replacing/natural resource;
economic loss.

Source: Department of Conservation and Natural Resources.

* Consider equity issues (identify groups or communities that lose or gain from the project or program) and 'intangibles' (costs and benefits that cannot be assessed in monetary terms).

In practice, CBAs have been principally concerned with readily identifiable impacts, leaving other considerations, including losses of ecological or social values, to be considered separately by decision-makers - for example, by separate environmental impact analyses.

Thus, the values appearing in a CBA represent only some of those that may be relevant to the use of a resource. This is particularly true when techniques that recognise and seek to measure community values - that are not expressed directly in markets - are not widely accepted.

The main disadvantage of CBA is that it reduces the significance of each option for resource-use to a single indicator: the present value of net benefits. It also heavily discounts costs and benefits that are expected to occur over a very long period. Whether this matters depends principally on whether the project or proposal under consideration uses natural resources that may affect the opportunities available to future generations.

In decision-making it is often necessary to take into account considerations other than those that may be incorporated in cost—benefit analyses of development proposals - for example, the distribution of the associated costs and benefits among different groups within society, and various ecological issues. Policy-makers may thus require a method of comparing options that assesses such options in terms of more than one criterion and also shows why some options may be superior or inferior to others under prescribed assumptions.

Multi-criteria analysis (MCA) is such a technique. It may be viewed as a set of

procedures designed to identify and organise information relevant to various steps in the decision-making process. It begins with specifying options to be examined and the criteria deemed to be of importance in evaluating them. The advantages and disadvantages of each option are compared by using a 'table of effects'. Each effect is measured in a common unit across all options, using quantitative or qualitative indicators. Weightings for each criterion may be introduced, indicating the relative importance of each effect to the analyst or the analyst's client.

The need to specify the appropriate criteria and provide decision weights is a practical limitation of the technique, since subjectivity is inevitably involved. All methods of evaluation involve some subjectivity; MCA simply makes assumptions transparent. By performing sensitivity analysis within a multi-criteria framework, the analyst can test the robustness of preferred options, and information can be provided on the factors that have a critical effect on the ranking of options. Trade-offs can be assessed according to multiple criteria rather than just a single indicator.

Because it permits the combining of criteria based on different units of measurement, MCA can be an instructive tool in considering natural resource-use issues. It can take into account the complex mixture of economic, social, and ecological losses and benefits that resource-use issues inevitably involve, and the different assumptions about weightings that analysts and decision-makers may wish to give to different aims. To be useful, MCA requires a level of data about resource uses and their impacts that may not often be available.

When developing its proposed land use recommendations for Victoria's marine and coastal areas, the Council will have to identify the most appropriate techniques with which to evaluate social, economic, and environmental information. The example in Box 17.2 gives some insight into the issues that can be involved in assessing the implications and values of certain uses in the marine and coastal environment. This example is for illustrative purposes only.

ISSUES

* methods and appropriateness of valuing all natural resources in monetary terms

* appropriateness of techniques for the integrated assessment of economic development and ecological sustainability

* changes in coastal population and implications for coastal land uses

* social and economic significance of marine and coastal environments

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PART V

ADMINISTRATIVE AND LEGISLATIVE CONTEXT

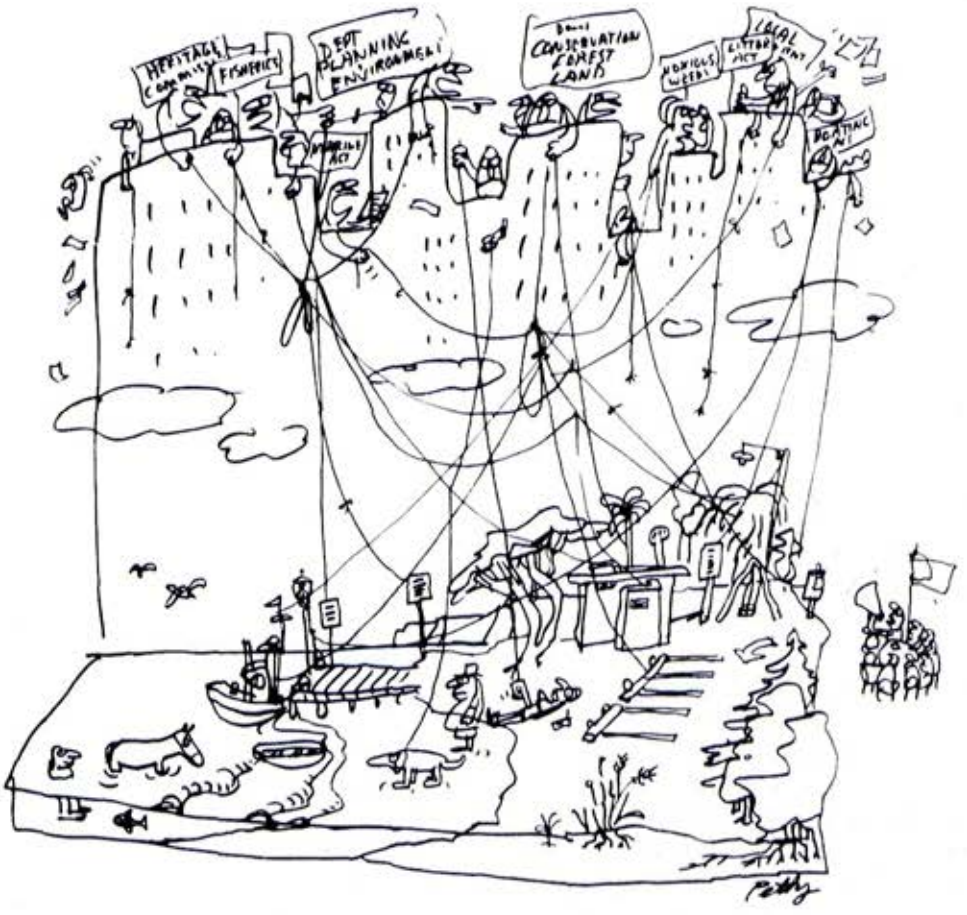
18. ADMINISTRATIVE AND LEGISLATIVE CONTEXT

This chapter discusses the administrative arrangements, land uses and policies, and strategies and management plans that provide a framework for the consideration of future recommendations and the way in which they may be implemented.

LEGISLATION AND MANAGEMENT

Non-government groups - industry, conservation, and recreation organisations - are taking an increasing interest in legislation and management covering Victoria's coast and how these may affect their members. The apparent complexity is a cause for social comment, as shown in the following cartoon. The challenge to government is therefore to provide a clear outline of those arrangements. This is not as easy as may first appear. Often conflict arises between keeping the 'rules' to a minimum and yet having sufficient rules to protect all interests, and between having self-regulation or government regulation through various recreation or industry codes and sufficient penalties for those who do not follow them. Within the coast jurisdictional divisions seldom match the underlying biophysical reality of the area being managed, as illustrated in three examples: Western Port, Bass Strait, and migratory waders. The focus of these examples is to illustrate the differences in scale and complexity of the jurisdiction covered, rather than necessarily describe current or potential arrangements.

Western Port Figure 1.3 in Chapter 1) shows the many and varied inputs to the coast. For this bay, inputs come from the rivers that drain the surrounding catchment and the two entrances - one to the west and one to the east of Phillip Island. It is recognised that river inputs should be managed on a catchment basis, but rarely do the catchment boundaries match municipal boundaries, the bases of local



(Reproduced by permission of Bruce Petty.)

government. Within the bay, different activities - for example, the discharge of waste from on-shore sources, effects of dredging and spoil disposal, and mariculture ventures - may affect water quality. These activities may involve different government and non-government interests. Consequently, co-ordination is required across the catchment, across the bay and between the two groups. **Bass Strait** can be recognised as a major biophysical zone bounded by Victoria, Tasmania, and the edge of the continental shelf. Commonwealth, Victorian, and Tasmanian interests are all represented within it. Those sections of the sea floor over which the two States have title join off Wilsons Promontory. Migrating fish may move through the entire area and may be caught in waters controlled by one State while the home ports for the boats involved may be in another. Oil- and gas-fields cover extensive parts of the region and proposed optic fibre and electricity cables would cross it.

Migratory waders Some birds, through their annual migration, have life-cycle requirements that cover thousands of kilometres. For their survival they therefore depend on the maintenance of wetland habitats and on protection from capture (or being harvested at a sustainable yield) in several countries. Within any particular country these issues may be the responsibility of different sectors of government, or controlled by regional or local authorities. Consequently the birds' conservation depends on international, national, and local co-operation. The aims and priorities of these three tiers may not always coincide.

Responsibilities for the planning and management of the Victorian coastal area and its resources are divided to varying degrees between the Commonwealth, Victorian, and local Governments, but primarily fall to the last two of these. They must make a wide variety of decisions - on matters including land use planning and development control, subdivision, building controls, provision of basic services and infrastructure, and other management functions.

The Commonwealth and States both have management obligations in the off-shore area. The States have title to the sea-bed within 3 nautical miles of the coast (beyond the 'baseline') and associated legislative powers within the area (*Coastal Waters (State Powers) Act* 1980; *Coastal Waters (State Title) Act* 1980). Under the Off-Shore Constitutional Settlement, which came into effect in 1983, co-operative arrangements between the State and Commonwealth have been agreed in relation to petroleum, minerals, fisheries, and marine parks and reserves. The boundary of the 3 nautical mile Victorian off-shore territory shown on the maps is for illustrative purposes only. In November 1990, the Commonwealth extended the limits of the territorial sea to 12 nautical miles, with the Victorian title to the sea floor remaining at the 3 nautical mile limit. Beyond these waters, the Australian Fishing Zone extends 200 miles seawards.

The Resource Assessment Commission (1992) reports outline the responsibilities of the three tiers of government, and only a brief outline, drawing on that material, is provided here. The examples given are for illustrative purposes only. Information is also given in a draft policy (DASET 1992).

Commonwealth government

Under the Australian Constitution, the Commonwealth Government may only enact laws with respect to matters listed in the constitution. In Section 51, this covers the key elements of lighthouses, light ships, beacons, and buoys, fisheries in Australian waters beyond territorial limits, and external affairs.

Under Section 96, the Commonwealth can also potentially influence management of the coast through its power to grant financial assistance to the States.

Examples of Commonwealth legislation introduced to meet external affairs obligations are:

* *Protection of the Sea (Civil Liability) Act* 1981
* *Protection of the Sea (Powers of Intervention) Act* 1981
* *Environment Protection (Sea Dumping) Act* 1981
* *Protection of the Sea (Prevention of Pollution from Ships) Act* 1983

Other key Commonwealth legislation that applies to the coast zone includes:

* *Environment Protection (Impact of Proposals) Act* 1974
* *Australian Heritage Commission Act* 1975
* *Fisheries Act* 1952
* *World Heritage Properties Conservation Act* 1983

Box 18.1 - Coastal Areas Covered by the Ramsar Convention

Port Phillip Bay (western shoreline) and Bellarine Peninsula - covering at least 7000 ha, including the coastline from Skeleton Creek to Point Cook

- Werribee Sewerage Farm
- The Spit State Wildlife Reserve
- Coastline from Point Wilson to Limeburners Bay
- Swan Bay Marine Reserve
- Mud Island Marine Reserve and State Wildlife Reserve
- Lake Connewarre State Wildlife Reserve

Western Port - covering approximately 52 330 ha

Corner Inlet - covering 51 500 ha in the Corner Inlet and coastal island complex east to Bruthen Creek.

Gippsland Lakes - covering approximately 43 050 ha, including Clydebank Morass, Macleod Morass, Blonde Bay, Jones Bay, Heart Morass, Sale Common, Dowd Morass, and Lakes Wellington, Victoria, King, Bunga, Tyers, and Reeve.

Only the Commonwealth government can conclude international treaties, agreements, and conventions. Such arrangements are of relevance to this investigation where they relate to areas, flora and fauna, and activities and management; examples are given below.

Areas - The Ramsar Convention provides for the protection of wetlands of international importance especially for waterfowl habitat. Four of the ten Victorian wetlands covered by the agreement occur along the coast and are described in Box 18.1.

Flora and fauna - The Japan—Australia Migratory Birds Agreement (JAMBA), and China—Australia Migratory Birds Agreement (CAMBA) protect migratory birds other than waterfowl and these are listed in Appendix IV.

Activities and other management arrangements - The International Convention on Pollution from Ships (MARPOL) seeks to prevent pollution from disposal of oil, noxious liquids, harmful packaged substances, and garbage from ships of all sizes, including recreational craft.

At the recent UNCED Conference (June 1992) Australia endorsed Agenda 21, including a chapter on ocean and coastal issues in which coastal 'States' (that is, Australia) made commitments to the integrated management and sustainable development of coastal areas and the marine environment as well as preventing degradation of the marine environment.

Victorian Government

The State Government has wide-ranging responsibilities for the use and management of Crown land and its resources, and for the planning arrangements for private land.

Statutes, by necessity, cover specific activities or resources and consequently the coast is covered by a wide range of Victorian legislation. Box 18.2 shows how this legislation applies to the coast, while Table 18.1 outlines the aims of provisions of the various Acts. There is some uncertainty with regard to the application of some statutes and this will only be resolved through the development of case law.

For example, legislation used to establish marine parks and reserves - the *National Parks*, *Fisheries*, and *Crown Land (Reserves) Acts* - does not always allow for appropriate regulation of activities within these areas, especially when an activity is licensed under another Act. To cite one case, as a result of a Supreme Court decision in 1987 arising from an action brought by licensed commercial abalone fishers, it became evident that commercial fishing could not be excluded using the *National Parks Act* 1975 and regulations alone.

It is also not possible in a marine reserve to regulate tourist operations such as charter boats) using the *Fisheries Act* 1968.

At a broader level, in 1991, Supreme Court action brought by commercial scallop-fishers determined that the *Fisheries Act* provides no head of power to prohibit commercial fishing on broad conservation grounds.

As a consequence of legislative inadequacies, the recently declared Bunurong Marine Park was reserved using a mosaic of legislation, which - while effective - is confusing to implement. This highlights the need to review the existing legislation used to protect marine areas to ensure that it meets the needs and aspirations of the managers and users of such areas.

Box 18.2: Principal Victorian Legislation for the Coast

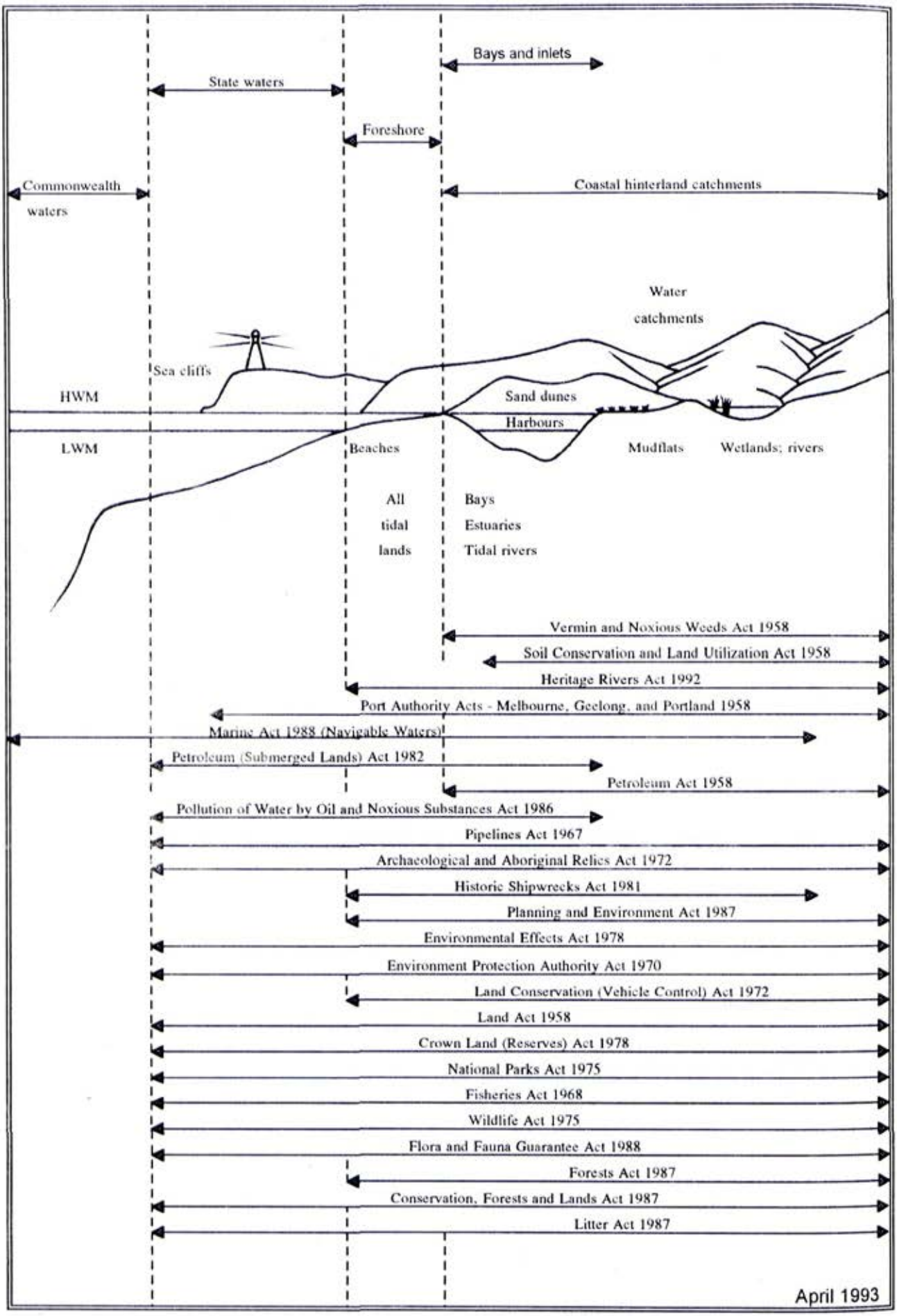


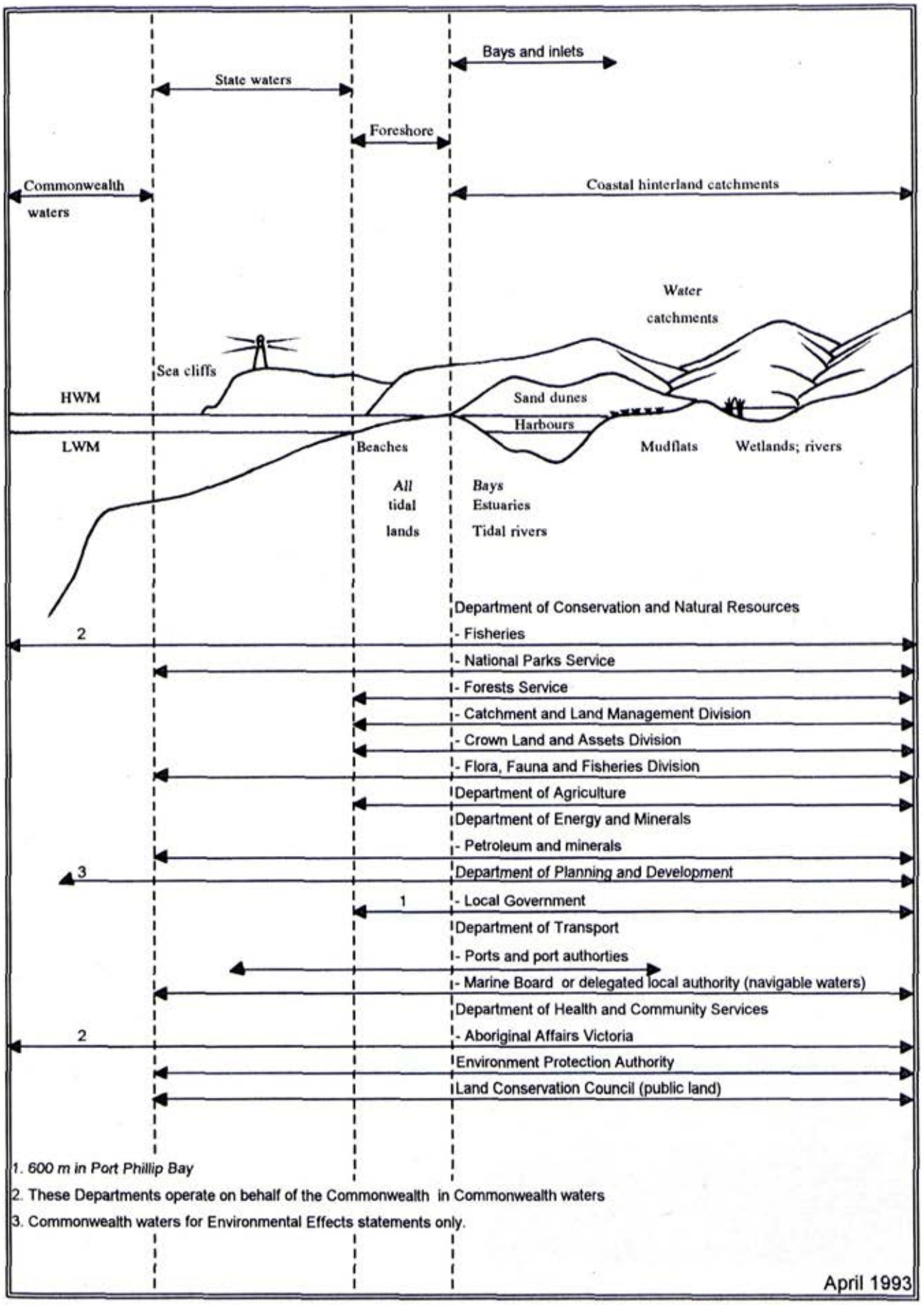
Table 18.1: Principal Victorian Legislation for the Coast

Act	Aim	Responsible agency
Archaeological and Aboriginal Relics Act 1972	Provides for the recording and protection of archaeological sites and Aboriginal relics.	DHCS
Conservation, Forests and Lands Act 1986	Provides for land management codes of practice and other administrative arrangements for Crown land.	CNR
Crown Land (Reserves) Act 1978	Provides for the management of reserved Crown land. It specifies conditions for the use and lease of Crown land and the establishment of committees of management; establishes the Coastal Management and Coordination Committee, which advises the Minister for Conservation and Natural Resources on development works on all coastal Crown land (excluding Port Phillip Bay, national and State parks, and land vested in port authorities), and is empowered to develop management plans and reserve land for the purpose of environment protection.	CNR
Environment Protection Act 1970	Establishes the Environment Protection Authority. Outlines its powers, duties, and responsibilities and makes provision for the protection of the environment.	EPA
Environmental Effects Act 1978	Provides for 'public works' reasonably capable of having a significant effect upon the environment to be subject to an environmental effects statement.	DPD
Extractive Industries Act 1966	Provides for the issue of licences and leases and safe operating standards for extractive industry; the rehabilitation of land affected by extractive industry; and maximising the use of the non-renewable stone resources while minimising the possible impact on the environment.	DEM
Fisheries Act 1968	Provides the legal basis for fisheries management in Victoria including: issue of commercial and amateur fishing licences, aquaculture permits, and special permits for experimental or research fishing; establishment and management of marine protected areas for conservation, scientific, educational, or recreational purposes; management and control of fisheries by regulation.	CNR
Flora and Fauna Guarantee Act 1988	Provides for Victoria's flora and fauna; that taxa except for those specified, survive, flourish and retain their potential for evolutionary development in the wild; the conservation communities; the management of threatening processes; sustainable use; and maintenance of genetic diversity.	CNR
Heritage Rivers Act 1992	Is concerned with use and protection of significant rivers.	CNR
Historic Shipwrecks Act 1981	Applies to wrecks on dryland and in internal waters (within the baseline) and allows for controls on access to designated historic shipwrecks.	DCHS
Land Act 1958	Provides for the granting of leases and licences for various uses of Crown land.	CNR
Land Conservation (Vehicle Control) Act 1972	Restricts the use of vehicles in sensitive areas, including the coastline.	CNR
Land Conservation Act 1970	Establishes the Land Conservation Council and outlines its powers, duties, and responsibilities.	LCC
Litter Act 1987	To prohibit and regulate the deposit of litter in the environment of Victoria; and provide for the enforcement of the Act.	Various
Marine Act 1988	Covers the registration of vessels and the pollution of State waters, implementation of certain international conventions, and the efficient and safe operation of vessels on State waters.	DEM

Table 18.1: Victorian legislation covering the coast (continued)

Act	Aim	Responsible agency
Mineral Resource Development Act 1990	To foster the mining industry and allow mineral exploration in an environmentally aware manner, streamline the approvals process; strengthen the emphasis on rehabilitation and improve provisions for payment of compensation.	DEM
National Parks Act 1975	Provides for the creation, protection, and management of national, State, and wilderness parks and other parks and reserves.	CNR
Petroleum (Submerged Lands) Act 1982	Regulates offshore exploration and production of oil and gas. This Act is 'mirror' legislation to the Commonwealth PSLA 1967 and operates in the area between mean low-water mark (outside the 'baseline') to the three nautical mile limit.	DEM
Petroleum Act 1958	Regulates onshore exploration and production of oil and gas and waters within the 'baseline' such as Port Phillip Bay, Western Port and Corner Inlet. Major matters covered by the Act include the: relationship between the Commonwealth and the State Acts' jurisdiction and management; issue of Exploration Permits, Retention Leases, Production Licences for Petroleum; issue of Pipeline Licences.	DEM
Planning and Environment Act 1987	Provides a framework for planning the use, development, and protection of land in Victoria. The Act has a number of aims related to environmental protection, social equity, and facilitation of appropriate development.	DPD
Pollution of Waters by Oil and Noxious Substances Act 1986	Covers the pollution of State waters.	DT
Port of Geelong Authority Act 1958	Establishes and specifies the functions and responsibilities of the Authority. The responsibility of the Authority relative to the associated ports is limited to the management of navigation.	PGA
Port of Melbourne Act 1958	Establishes and specifies the functions and responsibilities of the Authority. The responsibility of the Authority relative to the associated ports is limited to the management of navigation.	PMA
Port of Portland Authority Act 1958	Establishes and specifies the functions and responsibilities of the Authority. The responsibility of the Authority relative to the associated ports is limited to the management of navigation and port facilities and specifically excludes the adjacent land	PPA
Soil Conservation and Land Utilisation Act 1958	Enables areas to be proclaimed as water catchments and establishes appropriate land uses in such areas.	CNR
Vermin and Noxious Weeds Act 1956	Provides for the control of pest species.	CNR
Victorian Conservation Trust Act 1972	Enables the establishment of conservation covenants on land titles and the tax-deductible donation of land or money for conservation purposes.	CNR
Victorian Institute of Marine Sciences Act 1974	Establishes the Institute and provides for its mandate in marine research and education.	VIMS
Water Act 1989	Includes provision for the integrated management of all elements of the terrestrial phase of the water cycle; the protection and enhancement of the environmental qualities of water ways and their in-stream uses; and the protection of catchment conditions.	CNR
Wildlife Act 1975	Enables the establishment of controls over the taking of wildlife.	CNR

Box 18.3 Principal Victorian Resource Planning and Management Agencies for the Coast



Administrative arrangements developed by government are relevant if policy is to be implemented in a co-ordinated and cost-efficient manner. Those in place in late 1989 have been reviewed by Wescott (1990) and, more recently, those that apply to Western Port by the Resource Assessment Commission and the Victorian Department of Premier and Cabinet (1992). Further information on the administrative obligations of government departments is given in the *Victorian Government Directory*, which is updated annually.

Government administrative units are organised by sectors, within which planning, approval, and management functions may be separate entities. This means that more than one administrative unit has responsibilities along the coast, as outlined in Box 18.3.

The separation of legislative and policy onus within the government, while having a number of benefits, also leads to a number of difficulties. The formation of larger government departments through the amalgamation of administrative units over the last decade has improved the co-ordination of strategic planning and management.

One body with specific co-ordination responsibilities is the Coastal Management and Coordination Committee. Established under the *Crown Land (Reserves) Act* 1978, this inter-agency committee comprises representatives from the Departments of Conservation and Natural Resources and Planning and Development and the Port of Melbourne Authority. It is responsible to the Minister for Conservation and Natural Resources and has the role of co-ordinating and approving development and works proposals on coastal public land outside Port Phillip Bay but not within national parks and ports. It also assists in the development of coastal land management plans and by developing technical guidelines and policies.



Popes Eye - covered by the Fisheries Act.

However, the government has no single agency or mechanism available to provide co-ordination of the range of activities and government responsibilities along the entire coast.

To further improve co-ordination, the government has proposed to establish a Coastal and Bay Management Council. It is intended that this Council will:

* establish long-term strategy plans for the entire Victorian coastline with the key aim of ensuring the sustainable use of coastal natural resources

* establish short-term goals (such as the improved management of smaller ports and jetties) and medium-term goals (such as the progressive elimination of the use of ocean outfalls for sewage disposal) for coastal management

* act as a single reference point for coastal protection and utilisation

* be responsible for overall planning from the land to the 3 nautical mile limit

* work closely with the port authorities, and in particular with the Victorian Marine and Harbours Board (a new body established to take over the functions of the Marine Board and to administer the non-core functions of the Port of Melbourne Authority) on boating and related facility issues

* liaise closely with other agencies involved in environmental resource planning and management, such as the Land Conservation Council and the Environment Protection Authority, and with user groups and interested organisations

Commonwealth—State agreements

A number of relevant agreements cover the coast and these have been highlighted in the RAC reports for the Coastal Zone Inquiry. The list of key agreements below, while not comprehensive, demonstrates the scope of arrangements and issues covered.

* The Intergovernment Agreement on the Environment (IGAE)

This agreement provides a basis for a co-operative approach to environmental issues. The IGAE: sets out the roles of the parties and establishes the 'ground rules' under which Commonwealth, State, Territory, and local governments will interact on the environment; includes a broad set of principles to guide the development of environmental policies; and outlines co-operative arrangements on a wide range of specific issues.

* National Strategy for Ecologically Sustainable Development

  Following the development of this Strategy - which aims at promoting the sustainable development of Australian resources - by Commonwealth, State, and local governments and by conservation, union, and business groups, it was endorsed by the Council of Australian Governments in December 1992.

* National Plan to Combat Pollution of the Sea by Oil

  The aim is to maintain a national organisational framework capable of effective response to marine oil pollution incidents and to provide up-to-date environmental information to assist in responding to oil spills.

* Off-shore Constitutional Settlement

  Prior to a High Court legal challenge in the mid 1970s there was a common misconception that the territorial sea adjacent to each State was part of the State territory and that the resources of these seas belonged to the States. The High Court found that this was not the case and at that time the States and Commonwealth considered the decision inconvenient - for example, the Commonwealth did not have the facilities or the wish to exercise responsibility over the territorial sea. At the June 1979 Premiers Conference, the States and Commonwealth agreed to arrangements known as the Off-shore Constitutional Settlement to resolve this problem.

Following the Settlement, it was agreed that the States would ask the Commonwealth to grant to them title over the territorial sea. In 1979 the Victorian Government did so with the *Constitutional Powers (Coastal Waters) Act* 1979. The Commonwealth then responded with *Coastal Waters (State Powers) Act* 1980.

This Act allows State laws to apply to the sea-bed, the subsoil beneath, and the airspace above as if its coastal waters were within the State's limits. In vesting in the States the title to the sea-bed beneath the territorial sea, the Commonwealth reserved its right to use the sea-bed for such national purposes as:

* defence
* cables
* navigation aids
* quarantine

The status of the territorial sea under international law was expressly preserved. States' extra-territorial powers in the off-shore area were also safeguarded and the convention that Commonwealth law prevailed over inconsistent State law was maintained.

Agreements covered a number of other topics, including those listed below.

Off-shore petroleum and mining - agreement provides for the management arrangements within and beyond the territorial sea.

Fisheries agreement permits negotiation to provide for management of a fishery under a single law (Commonwealth or State) from the territorial baseline to 200 nautical miles.

Historic shipwrecks - The Commonwealth *Historic Shipwrecks Act* 1976 was to be amended so that it expressly provided that, with one exception relating to Western Australia, it only be applicable with the consent of the State. Victoria consented to these arrangements in 1981.

Marine parks - Where an area proposed as a marine park or reserve lies across the boundary of the territorial sea, the State concerned will establish its portion under State legislation and the Commonwealth will legislate for that portion seawards of the outer limit of the territorial sea (based on agreement on policy, planning, and management for the whole area). The only departure envisaged from this general division of responsibilities is where the Commonwealth and the State concerned agree that a proposed park within the territorial sea has international significance but where the State does not wish to legislate itself. In that event, the Commonwealth will legislate.

Box 18.4: Baseline

Proclamations describing the baseline are made under the Commonwealth *Seas and Submerged Lands Act* 1973. The greater part of the baseline is the low-water line along the coast, based on the Lowest Astronomical Tide, which is the lowest level that can be predicted to occur under average meteorological conditions.

The remainder of the baseline consists of straight lines as follows:

* lines across the mouths of rivers that flow directly into the sea
* bay-closing lines to enclose certain bays not more than 24 miles wide at their mouths
* straight baselines to enclose waters where the coastline is deeply indented and cut into, or where a fringe of islands borders the coast in its immediate vicinity

Local government

Local government has certain responsibilities through its function as a delegated authority or as a delegated committee of management for Crown land, usually to the high-water mark. Within Port Phillip Bay municipalities have planning-approval responsibility to 600 m off-shore. Municipalities also have a wide range of planning responsibilities for private land.

While local government does not directly administer any specific coastal zone legislation, the following Acts are relevant to its functions.

* The *Local Government Act* 1958, 1989 establish the powers, functions, and responsibilities of local municipalities.

* The *Planning and Environment Act* 1987 establishes local municipalities as responsible authorities and outlines their responsibilities and powers to control use and development on freehold land.

* The *Crown Land (Reserves) Act* 1978, among other matters, enables appointment of local municipalities and other groups as delegated foreshore Committees of Management.

POLICIES, STRATEGIC PLANS, AND MANAGEMENT PLANS

Such policies or plans have been developed for several areas, resources, or particular uses along the coast (see Table 18.2). Their preparation usually involves the release of a draft report for public comment and approval of the final plan by the appropriate Minister(s).

PUBLIC LAND USE

Consideration of the public land associated with coasts for the purposes of this investigation involves many of the Council's existing categories of public land use. This section outlines the most relevant land use categories and policies, as approved or varied by government. These provide a framework of existing recommendations along the coast and for the catchments to coastal streams.

Land Conservation Council recommendations

Locations of individual recommendations, descriptions, and detailed recommendation wording are given in Council's published final recommendations for the nine regionally based Council studies along the coast. These are:

* South-western Area, District 1, Review (1983)
* South-western Area, District 2 (1982)
* Corangamite Area (1978)
* Melbourne Area (1977)
* Melbourne Area, District 1, Review (1987)
* South Gippsland Area, District 2 (1982)
* South Gippsland Area, District 1 (1973)
* Gippsland Lakes Hinterland Area (1983)
* East Gippsland Area, Review (1986)

A review of the Melbourne Area District 2, that is, the eastern part of the original Melbourne Area, is in progress.

These recommendations were derived from separate regional studies where coastal use was just one of the uses to be considered in a region. The context varied between regions and also would have evolved over the 14 years (1973—87) taken to complete them. Consequently it was not possible to achieve the consistency for coastal planning that a study such as the present one can provide. It should also be noted that the Victorian Government did not have title to the sea floor to 3 nautical miles off the open coast until 1980. Consequently, Council's recommendations before then were limited to the land above the

Table 18.2: Victorian Government Policies, and Strategic and Management Plans

Name	Location	Object	Status and reference
POLICIES			
State Environment Protection Policies (SEPP)		Government declaration of the nature and level of protection to be given to specified beneficial uses	
SEPP - Waters of Victoria	All surface waters of Victoria, including coastal waters (except where varied by a separate SEPP)	To attain and maintain levels of water quality that are sufficient to protect the specified beneficial uses. The beneficial uses of the coastal segment are: • maintenance of natural aquatic ecosystems and associated wildlife • water based recreation • production of molluscs for human consumption • commercial and recreational use of edible fish and crustacea • industrial water use	SEPP (1988)
SEPP Waters of Port Phillip Bay	Waters of Port Phillip Bay bounded by the high-water mark, a line drawn between Point Lonsdale and Point Nepean and latitude 37°50' 30"S where the parallel crosses the Yarra River mouth		SEPP (1975) (currently under revision)
SEPP - Waters of Western Port Bay and Catchment	Western Port Bay, its islands and catchment lying north of a line drawn between West Head and Point Grant and north of a line drawn at 45° angle in a north-easterly direction from Cape Woolamai to the coast (Cardinia Reservoir and its catchment is excluded)		SEPP No W-28 (1979)
SEPP - Waters of Far East Gippsland	Coastal catchments (including estuaries) east of and including Bemm River		SEPP No W-21 (1985)
A Coastal Policy for Victoria	Victorian coast	Policy to protect and guide development of coastal areas based on the principles of sustainable development. It is aimed at maintaining a balance between conservation and development of coastal resources and managing the use of coastal areas so that conflict of interests and needs is minimised. It also establishes a framework within which future use, development, and conservation can occur.	September 1988
Flora and Fauna Guarantee Strategy	Victoria	For aquatic and marine habitats: • establish and implement ecological management objectives and criteria for environmental conditions for each river system • maintain or improve the quality of riparian and riverine habitats • protect the values of all high-value wetlands • protect representative and ecologically viable samples of Victorian marine ecosystems in a comprehensive reserve system • develop a strategy for the conservation of estuarine and marine environments	Draft
Wetlands Conservation Program for Victoria	Victoria's wetlands (areas of marsh, fen, peatland or water, whether natural, or artificial, with water that is static or flowing, fresh, brackish, or salt, including mudflat or mangrove areas exposed at low tide)	Ensure that wetlands on public and private land are managed so that they collectively provide the complete range of conservation, social and economic values for the community	September 1988

Table 18.2: Victorian government policies, and strategic and management plans (continued)

Name	Location	Object	Status and reference
Trial Dredge Protocol	Estuarine and marine waters of Victoria (it does not apply to shellfish harvesting)	Provide uniform and workable guidelines for environmental protection during dredging while recognising the practical realities of providing navigation and port facilities for commercial and recreational purposes.	Trial Protocol (1992) (compliance is voluntary)
STRATEGIC PLANS			
Making the Most of the Bay	Port Phillip Bay	Planning and management guidelines aimed at maintaining a balance between development and the protection of the natural environment	November 1990 (Department of Planning and Urban Growth, and Department of Conservation and Environment, 1990)
Western Port Bay Strategy	Western Port	Strategy for the protection and development of Western Port	Approved strategy October 1992 (Western Port Regional Planning and Coordination Committee, 1992)
Victorian Ports Land Use Plan	Commercial ports; Portland, Geelong, Melbourne, and Hastings	Provide for Victoria's port requirements to 2010	Final plan in preparation
Coastal Management and Coordination Committee Policy[1]	Victoria's coast (outside Port Phillip Bay and excluding national parks and ports)		
- Surf Live Saving Association use of Crown land		Provide a framework for the operations of the Surf Life Saving Association	July 1977
- Guidelines on the siting and design of storm-water discharge and sewage-disposal systems on coastal Crown land		Guidance on the siting and design of storm-water discharge and sewage-disposal systems on coastal Crown land	January 1989
- Policy relating to boating club use of coastal Crown land		Promote efficient use of the coastline and to guide boating clubs on the forms of development considered acceptable on the coast	January 1989
MANAGEMENT PLANS FOR MAJOR AREAS OF COASTAL LAND			
Lower Glenelg National Park	Lower Glenelg	Management Plan	
Discovery Bay Coastal Park	Discovery Bay	Management Plan	
Port Campbell National Park	Port Campbell	Management Plan	
Colac Region Coastal Management Plan	Lorne to Apollo Bay	Management Plan for public land	Draft 1991[2]
Geelong Region Coastal Management Plan	Cinema Point to Point Lonsdale	Regional Management Plan for Public Land	Proposed Plan - December 1991; Final plan June 1993[2]
Swan Bay Marine and Wildlife Reserves	Swan Bay	Management Plan	Proposed Plan - January 1991
Point Nepean National Park	Point Nepean (Point Nepean Section only)	Management Plan	
Shallow Inlet Marine and Coastal Park	Shallow Inlet	Management Plan	Proposed Plan - January 1990
Bunurong Marine and Coastal Park	Coal Creek to Wreck Point (17 km of coast)	Management Plan	Proposed Plan - May 1992 Submissions under evaluation
Wilsons Promontory Marine Park	Wilsons Promontory	Management Plan	Proposed Plan - 1991
Wilsons Promontory National Park	Wilsons Promontory	Management Plan	
LOCAL MANAGEMENT PLANS[2]			
Bridgewater Bay Foreshore Reserve Management Plan	Bridgewater Bay (0.5 km of coast)	Management Plan	In preparation; final plan due June 1993
Point Danger Central Management Plan	Point Danger (1 km of coast)	Management Plan	Draft plan 1986; Approval of final under consideration
Moyne River Coastal Reserve Management Plan	Moyne River (0.5 km of coast)	Management Plan	Final plan 1983
Warrnambool Coastal Management Plan	Warrnambool (3 km of coast)	Management Plan	Final plan 1988
Warrnambool City Coastal Management Plan	Warrnambool City	Management Plan	In preparation
Breakwater Rock (Warrnambool) Coastal Management Plan	Breakwater Rock	Management Plan	1990
Werribee Coastal Management Plan	Campbells Cove to Little River	Management Plan	Proposed Plan 1991

Table 18.2: Victorian government policies, and strategic and management plans (continued)

Name	Location	Object	Status and reference
Jawbone Flora and Fauna Reserve	Kororoit Creek to Bayview St (2.5 km of coast)	Management Plan	Final plan 1989
Williamstown Coastal Strategy	Williamstown (6 km of coast)	Management Plan	Final plan currently under consideration
City of South Melbourne	Albert Park and Middle Park (2.4 km of coast)	Management Plan	Draft plan 1992
St Kilda Breakwater - Wildlife Management Cooperative Area Management Plan	St Kilda Breakwater	Management Plan to protect the habitat of little penguins	Draft plan March 1992
Brighton Foreshore Coastal Management Plan	Brighton (5 km of coast)	Management Plan	Draft plan 1992
Elwood Foreshore Strategy	Elwood (0.4 km of coast)	Management Plan	Draft plan 1992
Chelsea Foreshore Management Plan	Chelsea (9 km of coast)	Management Plan	Draft plan 1992
Seaford Foreshore Management Plan	Seaford (9 km of coast)	Management Plan	Final plan 1991
Indented Heads/Point Leonards Foreshore Management Plan	Indented Heads to St Leonards	Management Plan	Proposed Plan 1989; Final plan August 1993
Mordialloc Foreshore Environs Strategy Plan	North of Mordiallock Creek (2 km of coast)	Management Plan	Final plan 1989
Sandringham Coastal Management Plan	Sandringham (9.6 km of coast)	Management Plan	Draft plan June 1992
Point Leo Management Plan	Point Leo (3.5 km of coast)	Management Plan	Draft 1992 (inactive)
Shoreham Foreshore Reserve Management Plan	Shoreham (3.5 km of coast)	Management Plan	Draft 1992 (inactive)
Merricks Beach Coastal Reserve Management Plan	Merricks beach (3 km of coast)	Management Plan	Final plan to be updated in 1993
Somers Management Plan	Somers (8.5 km of coast)	Management Plan	Draft 1992 (inactive)
Balnarring Management Plan	Balnarring Beach (3 km of coast)	Management Plan	Draft plan 1992
Flinders Foreshore Reserve Management Plan	Flinders (5 km of coast)	Management Plan	Draft 1991 (inactive)
Conservation Plan for the Bittern Coastal Wetland Area	Hastings to Stony Point (10 km)	Management Plan	Final plan 1992
Hastings Foreshore Reserve Management Plan	Hastings (17 km of coast)	Management Plan	Draft 1992
Yaringa Foreshore Reserve Management Plan	Yaringa (7 km of coast)	Management Plan	Draft 1992 (inactive)
Phillip Island Foreshore Management Plan	Phillip Island (63 km of coast)	Management Plan	In preparation
Wonthaggi Heathland Coastal Reserve	Wonthaggi (8.5 km of coast)	Management Plan	In preparation
Inverloch and Andersons Inlet Management Plan	Inverloch and Andersons Inlets (34 km of coast)	Management Plan	In preparation
Jack Smith Lake State Game Reserve	90 Mile Beach (13.5 km)	Management Plan	Final plan 1991
Lake Tyers Beach and Surrounding Strategy Plan	Lake Tyers-Lake Bunga to Mill Point (12 km of coast)	Management Plan	Final plan 1991
Mallacoota Foreshore Management Plan	Mallacoota (10 km of coast)	Management Plan	Draft 1989 (inactive)

Notes:

1. Two other CMCC policies also apply. These are: Planning Guidelines for tourist information and interpretation facilities on coastal Crown land; and policy on consent for works on the coast.
2. Management plans for areas managed under the provisions of the *Crown Land (Reserves) Act* 1978. Most of the local management plans are carried out under these provisions.

low-water line, the bays, inlets, and estuaries within the 'baseline' for Victoria, and the offshore islands.

Changes to final recommendations

Council's recommendations, when considered by government, may be approved or varied or subsequently amended by a specific government decision. For example, when Victoria acquired Point Nepean from the Commonwealth this area was amalgamated with the Cape Schanck Coastal Park to become the Point Nepean National Park.

Map 3 shows a simplified representation of Council's recommendations as approved or varied by government, and the distribution of public and private land along the coast.

Land-use categories can be grouped into: those that directly affect coastal uses and are the subject of this investigation; and those that affect catchment land and can thus have an impact on the estuaries and the coast to which they drain. The former are described here. They include categories whose recommendations provide for: the protection of coastal land and seas; uses of coastal land; and conservation

Table 18.3: Public Land Use Categories Along the Coast

Existing LCC category	Proposed LCC category system [1]	Categories on Map 3
Reference area	Reference area	Parks
National park State park Coastal park Gippsland Lakes reserve/ Coastal reserve	National park State park	Parks
Marine reserve Marine and wildlife reserve	Marine park	Marine and coastal parks, and marine reserves
Flora reserve Flora and fauna reserve Wildlife reserve[2]	Nature conservation reserve	Nature conservation reserves
Coastal reserve	Coasts	Coastal reserves
Coastal waters	Coasts	Coastal waters
Wildlife reserve[2] Wildlife management co-operative areas Public land water frontage reserve Bushland reserve	Natural features reserve	Other reserves
Education area Recreation reserve	Community use area	Other reserves
Mineral and stone producton reserve	Earth resources	Other reserves
State forest Uncommitted land	State forest	State forest and other public land
Utilities and survey	Services and utilities	State forest and other public land
Township land Other reserves and public land	Uncategorised public land	State forest and other public land

Notes:
1. This proposed system is explained in the proposed recommendations for the Melbourne Area District 2 Review.
2. Recommended wildlife reserves provisionally classified as faunal reserves, nature reserves or game refuges are shown as Nature conservation reserves. Those wildlife reserves provisionally classified as State game reserves are listed under natural features reserves, and are shown on Map 3 as 'other reserves'.

of and recreation at certain wetlands and estuaries, see Table 18.3.

Coastal Land Uses

The following section summarises coastal land-use categories. For more detail refer to the published final recommendations for the areas listed above. Table 18.4 describes the areas or lengths of coast according to land use.

Reference areas

Along the coast these are restricted to terrestrial habitats. They are small areas established to maintain natural systems as a reference against which to measure the impacts of uses. Eight such areas occur within 1 km of the coast: Stony Creek (north of Blanket Bay within Cape Otway National Park); French Island - north and French Island - east (within French Island State Park); Anser Island and Entrance Point (within Wilsons Promontory National Park); and Baawang (between Point Hicks and Petrel Point), Barga (north-west of Tamboon Inlet), and Seal Creek (between Little Rame Head and Shipwreck Creek), all within Croajingolong National Park.

Reference areas are protected by proclamation by the Governor in Council under the *Reference Areas Act* 1978. Those listed above all lie within areas reserved under the *National Parks Act* 1975. The Minister may issue directives for their protection, control, and management.

Table 18.4: Land Use Recommendations and Reserves within 1 km of the Coast

Category	Area or length of coastline involved
Land Conservation Council category[1]	
Reference area	
Stony Creek	370 ha
French Island - north	570 ha
French Island - east	290 ha
Anser Island	80 ha
Baawang	600 ha
Barga	1030 ha
Seal Creek	905 ha
National park	
Port Campbell	68 km
Cape Otway	11 km
Point Nepean	38 km
Wilsons Promontory	96 km
The Lakes	15 km
Croajingolong	93 km
State park	
Angahook–Lorne	22 km
French Island	
Lake Tyers	9 km
Coastal park	
Discovery Bay	93 km
Bay of Islands	34 km
Venus Bay–Waratah Bay	53 km
Gippsland Lakes	83 km
Sydenham Inlet	39 km
Marine park	
Marine reserve	
Point Cook	
Williamstown	17 ha
Harold Holt	
Swan Bay	2 800 ha
Mud Island	600 ha
Popes Eye	3 ha
Point Lonsdale	37 ha
Point Nepean	90 ha
Wilsons Promontory	
Marine and coastal park	
Bunurong	
Shallow Inlet	2 050 ha
Wilsons Promontory	
Corner Inlet	15 650 ha
Nooramunga	22 390 ha
Nature conservation reserve	
Flora reserves	
Tyrendarra	150 ha
Krambruk	16 ha
Wongarra	64 ha
Angahook	50 ha
Anglesea	1000 ha
Yanakie	7 ha
First and Second Islands	23 ha
Flora and fauna reserves	
Yambuk	103 ha
Limeburners Bay	30 ha
Portarlington	50 ha
Grantville	120 ha
The Gurdies	200 ha
Wildlife reserves (fauna reserves, game refuges, nature reserves)	
Lawrence Rocks	1 ha
Lady Julia Percy Island	150 ha
Lonsdale Lakes	150 ha
Swan Bay to Flinders Point	250 ha
The Spit	300 ha
St Leonards	24 ha
Mud Island	56 ha
Western Port	1650 ha
Reef Island and Bass River	150 ha
Reef Island and Bass River	150 ha
Rhyll Swamp	250 ha
Seal Rocks	2 ha
Phillip Island	450 ha
Newhaven Swamp	45 ha
Seal Islands	60 ha
Coasts	
Coastal reserve	
Narrawong	7 km
Fitzroy River to Eumeralla River	25 km
Port Fairy to Warrnambool	30 km
Storm Point to Cape Patten	25 km
Kennett River, Wye River,	4 km
Lorne to Torquay	38 km
Barwon Heads to Point Lonsdale	9 km
Port Phillip Bay	45 km
Flinders to Hanns Inlet	23 km
Hanns Inlet to Watson Inlet	16 km
Lang Lang River to Corinella	30 km
Phillip Island	1 km
San Remo to Wonthaggi	20 km
Cape Paterson to Point Smythe	8 km
Waratah Bay–Shallow Inlet	21 km
Port Franklin–Port Welshpool	28 km
McLoughlins Beach–Seaspray	38 km
Lakes Entrance to Lake Tyers	7 km
Gippsland Lakes	86 km
Marlo	9 km
Mallacoota	6 km
Coastal waters (applies only to Port Phillip Bay and open coastal waters - Melbourne Area, District 1, Review.)	
Natural features reserve	
Wildlife reserves (State game reserves)	
Lake Gillear	20 ha
Serpentine Creek	62 ha
Lake Connewarre (not public land)	
Freshwater Swamp	34 ha
Jack Smith Lake	2465 ha
Lake Denison	80 ha
Ewing Marsh	6700 ha
Lake Corringle	980 ha
Wildlife management co-operative area	
Western Port	28 400 ha
Rhyll–Newhaven	2 500 ha
Reef Island–Bass River	700 ha
Andersons Inlet	2 430 ha
Mallacoota Inlet	2 600 ha
Public land water frontage reserve (various)	
Bushland reserve (various)	
Community use area	
Education area	
Eumeralla	313 ha
Cape Conran	780 ha
Recreation reserve (various)	
Earth resources	
Mineral and stone production reserve (various)	
Alcoa lease area	
State forest	
State forest	
Marlo, Mallacoota	
Uncommitted land	
Glenaire	
Services and utilities	
Utilities and survey (various)	
Uncategorised public land	
Township land (various)	
Lorne	
Other reserves and public land (various)	
Other categories of land	
Crown land within cities and rural cities (not public land under the *Land Conservation Act* 1970)	
Private land	
Commonwealth land	

Note: 1. As proposed - see Table 18.3, Note 1.

National and State parks

Both types of park contain important landward sections of the coast, particularly in the Port Campbell—Otway coast, Cape Schanck—French Island areas, and East Gippsland. Their seaward boundaries generally lie at low-water mark. Management of these parks provides protection for many important coastal values.

Those that adjoin the coastline are:

> National parks - Port Campbell, Cape Otway, Point Nepean, Wilsons Promontory, The Lakes, and Croajingolong
>
> State parks - Angahook—Lorne, French Island, and Lake Tyers

The Council's aims for the system of national or State parks are to provide for public enjoyment, education, and inspiration in natural environments, to protect outstanding natural features, as far as possible to represent the State's land types, and to conserve native flora and fauna. These parks are reserved under the *National Parks Act* 1975. Both Wilsons Promontory and Croajingolong National Parks contain wilderness zones.

Coastal park

These areas of coastal land, usually linear in shape and comprising the coastal reserve and adjoining public land, have natural features, flora, and/or fauna that are of particular landscape and conservation significance. They usually include small areas that are intensively used for recreation and others that have conservation significance owing to the occurrence of remnant native vegetation or important faunal habitat. It is necessary to zone coastal parks to provide for the continuation of recreational pursuits while ensuring that the natural values are protected.

Coastal parks include Discovery Bay, Bay of Islands, Venus Bay—Waratah Bay, and Sydenham Inlet—Cape Conran. The Gippsland Lakes Coastal Reserve recommended by the Council has also been reserved as a coastal park.

Marine reserve, and marine and coastal park

Council's recommended marine reserve is an area of off-shore underwater terrain and the waters above it, together with the associated flora and fauna, set aside to conserve and protect marine and/or estuarine ecosystems. Marine and coastal parks (recommended by Council as marine and wildlife reserves) have been designated in areas of particular importance for the habitat of international migratory waders.

Victoria has several marine and coastal parks and marine reserves, representing a variety of habitats. These are located at the entrance to and within Port Phillip Bay, and around Wilsons Promontory, Corner Inlet Nooramunga, Shallow Inlet, and Cape Paterson. Port Phillip Bay contains the Point Cook, Williamstown, and the Harold Holt Marine Reserve, covering a total area of about 3400 hectares.

The Harold Holt Reserve consists of Swan Bay, Mud Islands, Point Lonsdale, Point Nepean, and the Popes Eye Annulus areas. The remaining six marine reserves or marine and coastal parks are located east of Port Phillip Bay off the South Gippsland coast. Five of these, covering about 50 000 ha, surround Wilsons Promontory: the Bunurong Marine Park, Shallow Inlet Marine and Coastal Park (2000 ha), Wilsons Promontory Marine Park and Wilsons Promontory Marine Reserve (10 000 ha), and Corner Inlet and Nooramunga Marine and Coastal Parks.

Nature conservation reserves

A number of small flora reserves, and flora and fauna reserves, are located close to the coast. These are listed in Table 18.4. Several recommended wildlife reserves - in most cases wetlands and islands that provide specialised habitat for large flocks of birds, fish, crustaceans, and some mammals - are not available hunting of game. Those that adjoin the coastline include: Lawrence Rocks; Lady Julia Percy Island; Lonsdale Lakes; Swan Bay to Edwards Point; The Spit; St Leonards; Mud Island; Western Port (northern); Reef Island and Bass River; Rhyll Swamp; Seal Rocks; Phillip Island; Newhaven Swamp; and Seal Islands.

Council's policies cover the need for conservation of habitat areas sufficiently large and diverse to support genetically viable populations of species.

Coasts

Coastal reserves are strips of land along the coast that have been identified for public recreation, education, and inspiration in coastal

environments. They are usually less than 200—500 m wide and sometimes much narrower on the landward side, but some have been reserved up to 600 m off-shore. Coastal public lands specifically reserved for some other purposes (parks, wildlife reserves, sites for navigation aids, or major ports) are not included in the coastal reserve category. The major coastal reserves along the coast are listed in Table 18.4.

The coastal waters category was used only in the Melbourne Area, District 1, Review. It applied to the areas of Port Phillip Bay and the territorial waters of the open coast adjoining that study area. The recommendations provided 'that, where the sea-bed is not reserved for a specific purpose, it be used and managed in a way that will protect identified values and does not preclude reservation for as-yet-unknown public purposes'.

Natural features reserves

Wildlife reserves in this category are those that are available seasonally for game-hunting. They include Ewing Marsh, Jack Smith Lake, and several smaller reserves.

Wildlife Management Co-operative Areas have high values for wildlife conservation. However, they also have capabilities for other uses, and land tenure and management are orientated towards these other uses. In order to give special consideration to the protection of wildlife values, some modification of the aims of management can be achieved by co-operation between the responsible authorities. Declaration as wildlife management co-operative areas under the provisions of the *Wildlife Act* 1975 aims at encouraging such co-operation. A management plan for each area is necessary in order to ensure that the wildlife values are adequately protected. The plan maintains the jurisdiction of the respective government departments and agencies over the area and the activities that take place within it.

Government has accepted the Council's recommendation for the following Wildlife Management Co-operative Areas: Western Port (28 400 ha); Rhyll—Newhaven (2500 ha); Andersons Inlet (2430 ha); and Mallacoota Inlet (2600 ha).

Several small areas adjoining the coast have been reserved as public land water frontage reserves along streams, or as bushland reserves, but have not been separately described.

Community use area

Two education areas - Eumeralla and Cape Conran - and numerous recreation reserves are located along the coastline.

Earth resources

The Alcoa lease area near Anglesea lies partly within 1 km of the coast. It is available for coal production, although the Council has also identified important floral values in parts of it. Some small stone reserves are also found near the coast.

State forest

Small areas of State forest, at Marlo and Mallacoota, lie close to the coastline, as does a small area of uncommitted land near Glenaire.

Services and utilities

This grouping includes roads, ports, airfields, power lines, pipelines, outfalls, etc. found in many places along the coast.

Uncategorised public land

Other reserves and public land areas, although not reserved for a specific purpose at present, are recommended to be used in a way that does not preclude their future reservation for as-yet-unknown public purposes. Some land was recommended to be available for township purposes, for example, at Lorne.

Council policies

Council has established a number of policies that relate to public land in general, such as those for mineral and stone production. Only one - scenic coast - relates specifically to the coast.

'Scenic coast' is an overlay recommendation for areas of the coast of outstanding beauty that remain in a relatively unspoilt state. This quality is derived primarily from natural attributes, but may be supplemented or enhanced by cultural features such as lighthouses, or by pleasant rural landscape features.

Sections of the coast recommended as scenic coast include: Warrnambool to Lorne (167 km); Lorne to Point Roadknight (24 km); Point Nepean to West Head, Flinders (46 km); Griffith Point, San Remo, to Black Head, Kilcunda (10 km); Cape Paterson to Entrance

oint (180 km); Lake Corringle to Pearl Point (45 km); Tamboon Inlet to Mallacoota Inlet (78 km); and Lake Barracoota to Cape Howe (12 km).

ISSUES

* fragmentation, overlap, and uncertainty of legislative responsibility
* public confusion about existing legislation and regulations
* co-ordination of local, State, and national coastal and marine legislation
* shortcomings of marine conservation and fisheries legislation

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PART VI

APPROACHES TO COASTAL CONSERVATION AND RESOURCE USE

19. APPROACHES TO MARINE CONSERVATION AND RESOURCE USE

Conservation is concerned with the way in which the human race utilises the resources available to it. The term implies both protection and use of a resource, but in such a way that ensures wise exploitation in order to provide maximum sustainable benefit to society.

It is important to view the conservation of resources from a long-term perspective, rather than to capitalise on the short-term benefits of a rapid rate of resource use at the expense of their benefit to future generations. Conservation must also take into account the nature of the resources - that is, whether they are finite or renewable.

The need to conserve both these types of resources is obvious, as society uses them for many of the material needs of modern life. Conservation of other values such as biological diversity, cultural assets, and native flora and fauna, however, is equally important, although the benefits are less tangible and harder to quantify. In recent times, society has come to place a greater emphasis on the latter, in view of the mounting body of evidence that these other values are being depleted at an alarming rate. Human activities have resulted in the loss of valuable genetic material from the global 'gene pool', reductions in the extent of essentially unmodified ecosystems, and the loss of other natural values and, potentially, of our own ability to survive.

Each species of plant or animal is a unique assortment of biological characteristics that contributes to the richness and diversity of the natural environment in which we live. It is part of our heritage, and society, while providing for this generation, has a moral responsibility to protect it and pass it on to future generations. The environment, with all its interwoven complexities, has the potential to enrich our quality of life and our knowledge. The loss of individual species, habitats, or ecosystems results in the diminution of the value of the natural environment.

The following comments are derived from Kelleher and Kenchington (1991). The sea and sea-bed cover more than two and a half times as great an area as the total land masses of the world, but less than 1% of the marine environment is currently within established protected areas. Clearly, the extent to which the marine environment is conserved through application of the 'protected area' concept lags far behind the terrestrial environment.

The marine environment is an integral part of the natural and cultural heritage of the world with its diversity of marine and estuarine animals, plants, and communities which are essential components of self-sustaining systems of local, regional, and international significance.

While already some areas have become seriously degraded by the direct or indirect effects of human activities, and the rate of degradation is increasing rapidly, it is important in any policy for marine areas protection to consider the continued welfare of people who have customarily used such areas.

By its nature, the marine environment imposes national and international responsibilities for the proper stewardship of the living and non-living resources of coastal and deeper ocean seas and the sea-bed, to ensure their maintenance and appropriate use for the direct benefit and enjoyment of present and future generations. The development of such stewardship requires co-ordination and integrated management of a number of potentially competing uses at international, national, and regional levels for managing the use of marine areas on a sustainable basis. Relevant programs include the:

* Regional Seas Program of the United Nations Environment Program (UNEP) and the regional protocols on protected areas it fosters
* Man and the Biosphere Program of the United Nations Educational, Scientific and Cultural Organisation (UNESCO)
* Marine Science Program of UNESCO
* South Pacific Regional Environment Program
* initiatives of the Food and Agriculture Organisation of the United Nations

(FAO), the International Maritime Organisation (IMO), the International Whaling Commission (IWC), and other international organisations
* establishment of marine protected areas by many nations.

Conservation strategies

International concern led in 1980 to the release of a World Conservation Strategy prepared by the International Union for Conservation of Nature and Natural Resources, with the United Nations Environment Program and the World Wildlife Fund. This Strategy stresses as a matter of urgency that human beings, in their quest for economic development and enjoyment of the riches of Nature, must come to terms with the carrying capacities of ecosystems and must take account of the needs of future generations. It argues that a reconciliation between development and conservation is a major requirement for human survival, pointing out that each is necessary for prosperity and well-being. The need to integrate conservation with development is also the theme of the National Conservation Strategy for Australia, prepared jointly in 1983 by industry, conservation, and government groups.

It can be argued that species should be allowed to exist in their own right and continue to flourish, and that we should not merely conserve those things that are perceived to be of economic worth to the human race. In this connection, the National Conservation Strategy for Australia 1983 states that:

> 'Australians have obligations to other living things and ... activities must at times be modified to respect the natural cycle of other life forms and their ecosystems'.

Drawing from both that Strategy and the World Conservation Strategy (1980), Victoria's Conservation Strategy notes:

> 'Many people believe that Australians have obligations to other living things and that activities must at times be modified to respect the natural cycles of other life forms and their ecosystems. According to the World Conservation Strategy, because humans have become a major evolutionary force with the power to radically change ecosystems and cause the extinction of species, we are morally obliged to act prudently in the interests of other species...'

Human influence over species and ecosystems is increasing as we continually modify the natural environment, and this kind of modification is the single greatest threat to the environment.

In more recent times, many countries including Australia have developed strategies and policies in which conservation and development issues are integrated by the principles of Ecologically Sustainable Development (ESD). In Australia, an ESD strategy has evolved over several years through extensive consultation with all levels of government, business, academia, voluntary organisations, community-based groups, and individuals. In December 1992, the Council of Australian Governments endorsed a national ESD strategy, noting that implementation would be subject to budgetary priorities and constraints in individual jurisdictions, (Anon. 1992). The following is summarised from that strategy.

The goal of ESD is development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. Implicit in this sustainable approach to development 'is the need to consider in an integrated way, the wider economic, social and environmental implications of our decisions and actions for Australia, the international community and the biosphere; and the need to take a long-term rather than short-term view when taking these decisions and actions'.

The core aims are:

* to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations
* to provide for equity within and between generations
* to protect biological diversity and maintain essential ecological processes and life support systems

The guiding principles are:

* decision-making processes should effectively integrate both long- and short-term economic, environmental, social, and equity considerations
* where anything threatens serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to

Box 19.1: Ocean Rescue 2000

In November 1990 at the General Assembly of the IUCN in Perth, the then Prime Minister, Mr Hawke, announced that:

> 'the Australian Government has decided to work towards the expansion of Australia's marine reserve system. In association with the State and Territory Governments, we will investigate the establishment of a national, representative system of marine protected areas for Australia that will protect these areas, while permitting appropriate uses and promoting public education.'

Following the Prime Minister's announcement, the Minister for the Arts, Sport, Environment and Territories, Mrs Kelly, initiated a 10-year marine conservation program - Ocean Rescue 2000.

It seeks to bring together all available marine information and to provide expertise to assist in the development of long-term plans to ensure the wise and sustainable use of all Australia's marine environments. If this aim is to be achieved it will involve all sectors of the community, including: local, State, and territory governments; recreational and commercial fishing organisations; tourist operators; recreational groups; industrial, technological and mining interests; and the coastal Aboriginal and Torres Strait Island communities. Ocean Rescue 2000 is administered by the Department of Environment, Sport, and Territories in partnership with the Great Barrier Reef Marine Park Authority and the Australian National Parks and Wildlife Service. It consists of six inter-related parts.

State of the Marine Environment Report will be a comprehensive description and assessment of Australia's marine environment, resources, and the impact of human activities. The report will provide baseline information for the Australian marine conservation strategy, for the national marine education program, and for future environmental reporting.

National Representative System of Marine Protected Areas aims at developing a national system of marine parks and reserves that contain representative examples of the full range of Australia's marine environments - from coral reefs to estuaries, and from tropical waters to cold southern waters - and at protecting and managing them while allowing a range of appropriate uses. One important goal of the program will be the protection of important areas of fish habitat to help safeguard marine fish stocks.

Australian Marine Conservation Strategy will be a broad plan for the conservation and sustainable use of the Australian marine environment into the next century. It will be developed through consultation with governments, industry, and the community.

National Marine Education Program will inform all Australians on how we can work together to safeguard our marine environments for the future. It seeks to provide accurate and timely information based on the latest marine research and will target the general community, schools, the media, industry, and recreational groups.

National Marine Information System being developed by the Environmental Research Information Network will be a comprehensive computerised scientific information base. It will include significant data on all aspects of our marine environments, including fisheries, mineral resources, ocean currents, climate, and the distribution of marine life around our coastline.

Marine and Coastal Community Network will foster community involvement in marine conservation through facilitating information exchange and consultation. The network is co-ordinated by a non-government organisation, the Australian Littoral Society.

prevent environmental degradation

* the global dimension of environmental impacts of actions and policies should be recognised and considered
* the need to develop a strong, growing and diversified economy that can enhance the capacity for environmental protection should be recognised
* cost-effective and flexible policy instruments should be adopted, such as improved valuation, pricing, and incentive mechanisms
* decisions and actions should provide for broad community involvement in issues that affect them

Despite widespread endorsement of ESD, examples of its practical application are few. Consensus on the application of the 'uncertainty principle' and the way in which costs and benefits are to be distributed, for example, will only arise through practical application.

Therefore, ESD provides a framework within which to use and manage the range of marine and coastal resources. The ways in which this may be achieved will vary and may involve a combination of approaches, which are discussed further below.

However, before these approaches can be implemented it is important to understand the geographic and temporal variations of the

system. An understanding of the biogeography of the region will thus assist planning.

Classification of marine environments

Given that a marine environment is a very complex system with many interactions, both within and external to it, there is a need to develop a process that can group similar areas together and distinguish distinctive regions on the basis of their key characteristics. This enables planners and managers of such areas to describe more easily the attributes of particular marine areas and how they can be distinguished from others.

In the terrestrial environment, the Land Conservation Council has developed such descriptions on the basis of physical and biological attributes to derive what are known as 'land systems'. Such areas have similar geology, topography, climate, and vegetation assemblages. At a broader scale a group of land systems makes up a geomorphic unit - an area of land with similar geology and topography.

In relation to the marine environment in Victoria, the Land Conservation Council in conjunction with the Department of Conservation and Natural Resources has initiated the development of a biophysical classification system. This project has been made possible through funding from the Ocean Rescue 2000 program, an initiative of the Commonwealth Government (see Box 19.1). The classification will be published separately when it is finalised and before the Council begins to formulate its proposed recommendations for the present study. Similar classification systems have been developed in New South Wales (again as a result of funding through the Ocean Rescue 2000 program) and also in New Zealand (see Box 19.2) and Canada (see Box 19.5). Each of these uses physical and biological parameters to derive a classification.

The basis of any use or management of marine resources must be a description of the resources themselves, their distribution, abundance, and factors affecting their ongoing survival, their use, or potential for use. For many resources within the marine environment, such information is unknown, limited in extent, or very difficult and often expensive to obtain.

A broad biophysical classification system such as outlined above provides a framework in which common elements can be grouped into broad bio-regions. This classification should enable a more systematic approach to the use, protection, and monitoring of marine resources.

Box 19.2: Marine Reserves in New Zealand

Marine reserves in New Zealand are established under the *Marine Reserves Act* 1971. Under the Act, specified non-government bodies with an interest in marine life or natural history may apply to the head of the Department of Conservation for an area to be declared a marine reserve. The Director-General of Conservation may also make an application - in this case applying to himself or herself. Marine reserves include only those areas that are covered by water and are to be used for scientific purposes.

Following public notification of the application, objections to the proposal may be lodged within a period of 2 months. The applicant has a right of reply. The relevant Minister then considers the application, objections, and responses. The Minister must uphold objections if satisfied that the reserve would interfere unduly with an estate or interest in the reserve or land adjacent to it, or interfere with existing right of navigation, commercial fishing, or any recreational uses. Then, provided the Minister does not uphold any objections and considers that the declaration of the reserve will be in the interest of scientific study, will benefit the public, and is expedient, the reserve may be declared.

Once declared, the reserve is managed by the Director-General of Conservation in the interests of conservation, propagation, and preservation of species and to ensure that the marine life of the reserve is maintained in its natural state. Structures such as wharves, jetties, and landings are rarely permitted except as may be needed for scientific observation. Usually a 'no take' philosophy applies to marine reserves, but fishing may be allowed under some circumstances. A statutory board provides input into the management planning process for all these marine reserves within an administrative region (along with terrestrial reserves).

Following 10 years of discussion, the first reserve was declared in 1975. Located on the north-east coast of the North Island, it covered 6 km of coast up to 1 km off-shore and was centred on a small island. In 1990 the Department of Conservation, recognising that marine reserves were only one of the means for the protection of the coast, announced its intention, with community consent, to establish a national network of marine reserves based on areas that are unique and cover a geographic spread of representative features.

As at February 1993, New Zealand had seven marine reserves with 20 further proposals either being developed or under ministerial consideration.

In an Australian context, Ray and McCormick-Ray in a 1992 consultancy report for the Australian National Parks and Wildlife Service, have identified six biogeographic regions. Victoria is a part of one such region. Clearly, this is of limited value for the use and management of marine resources in Victoria, but it does provide a framework on which to construct a more detailed biophysical classification, specific to this State.

APPROACHES TO CONSERVATION AND MANAGEMENT

Several approaches can be adopted for the conservation and management of marine and coastal areas. They range from an activity based approach to an area-based one that identifies particular areas and specifies a range of appropriate uses for them.

In most instances planning is based on an amalgam of these approaches. There is also the need to ensure that uses of adjacent areas are co-ordinated. For the sea, this means the use of both the sea and the adjacent land.

Activity based approach

This approach does not necessarily preclude an activity from an area, but regulates activities by the extent to which they comply with specified performance standards. For example, the maintenance of water quality as outlined in the SEPP - Waters of Victoria, (see Chapters 12 and 18) establishes the levels of water quality required to protect specified beneficial uses, such as the maintenance of ecosystems at pristine levels or for recreational activities where water contact only is likely to occur.

For fishing, this approach may entail the maintenance of the fish stock at a particular level set by economic and/or biological constraints, or the use of fishing techniques that ensure a minimal by-catch or the absence of any adverse habitat impacts. The Canadian Department of Fisheries and Oceans, for example, introduced in 1986 a principle of 'no net habitat loss' when considering habitat management.

The activity-based approach provides an incentive whereby, through technical innovation or the adoption of 'best practice', an activity may take place that might otherwise have been excluded. Codes of 'best practice' may be either voluntary or enforced, so that compliance is either through self-enforcement or through legislation. The Code of Forest Practice, for example, provides, among other things, for activities to be carried out in a manner that lessens the impact on catchment water quality - important when considering the management of the estuaries into which they drain. Recreation groups from bushwalkers to fishers have also shown interest in codes. For fishers, an ethos of 'limit your catch rather than catch your limit' reduces fishing pressure and ensures there is enough for next time.

For the oil industry the Australian Petroleum Exploration Association in 1988 produced for its member companies a Code of Environmental Practice - Onshore and Offshore. The code provides, in the absence of specific regulation, advice on best practice for the minimisation and amelioration of adverse environmental impacts, strategies to avoid and protect areas of high environmental sensitivity, monitoring, employee training, and other matters.

Area-based approach

Three area-based approaches have evolved that centre on the use of particular areas to varying degrees and these have been outlined by Kelleher and Kenchington (1992).

The first and, in the past, most common approach to the conservation and management of marine resources has involved the regulation or control of specific activities, such as fisheries. It has usually been carried out by a specialist agency with varying degrees of co-ordination of regulation between different agencies. This has often resulted in conflict between different user groups in the community and between different policy groups within government. Without co-ordination, some waters have been used for both fishing and waste disposal - resulting in contaminated fish flesh unsuitable for human consumption. Clearly, such arrangements are not consistent with the principles of ESD.

In the second approach, the creation of small reserves has provided special protection for particularly valuable areas within broader ones that were subject to regulation of the first type or, in some cases, to no regulation. Such reserves have been established to protect populations of rare, threatened, or depleted species, to preserve the nursery or breeding grounds for significant commercial species, or for ecological reasons. Examples of this in

Victoria include the Harold Holt Marine Reserves in Port Phillip Bay and the South Gippsland marine parks and reserves.

The third and most recent approach involves the establishment of a large, multiple-use area with an integrated management system providing varying levels of protection throughout. Ideally this integration should extend to co-ordinated management of marine and terrestrial areas in the coastal zone and beyond. An example of this approach is provided by the Great Barrier Reef Marine Park (see Box 19.3). Although significantly smaller in size, the South Gippsland Marine and Coastal Park is another example. The integration of the use of marine areas with that of the adjacent land has been highlighted in proposed plans for the Bunurong Marine and Coastal Park and the Wilsons Promontory Marine Park. For Wilsons

Box 19.3: Planning in the Great Barrier Reef Marine Park

The Great Barrier Reef is the world's largest system of corals and associated life forms. It is included in the world's largest marine park, covering 350 000 sq. km on the Australian shelf. The Reef stretches for almost 2000 km and is a complex maze of about 2900 individual reefs ranging in area from less than 1 ha to more than 100 sq. km. Biological features of the region and the Reef include: six species of turtles; more than 1500 species of fish; the endangered dugong, which is relatively common; about 350 species of reef-building coral; and islands that are inhabited or visited by more than 240 species of bird.

It is an important commercial fishing and tourism resource and some areas these activities have already reached levels that may fully exploit its productive capacity. It is also exposed to the effects of run-off from islands and the mainland, which contains elevated suspended-sediment, nutrient, and other pollutant loads. Further, the reef is crossed by major shipping routes.

The park is managed by the Great Barrier Reef Marine Park Authority under the *Great Barrier Reef Marine Park Act* 1975. The Park is not a national park, but a multiple-use protected area (fitting the definition of Category VIII of the classification system used by IUCN). The use of zoning separates conflicting activities and allows certain activities within specified areas. Levels of protection vary - from almost no restrictions in some zones, to zones within which almost no human activity is permitted.

Activities prohibited in the entire Park are oil exploration, mining (other than for approved research purposes), littering, spearfishing with scuba, and the taking of large specimens of certain species of fish. Some activities, although allowed in the Park, require specific permits. These include waste discharges and most commercial activities.

For planning purposes the Park has been divided into three major zones:

* preservation zones or scientific research zones (the only activity permitted is strictly controlled scientific research subject to permit)
* marine national park zones (the major uses permitted are scientific, educational, and recreational)
* general-use zones (all reasonable uses are permitted consistent with the conservation of the ecosystems and their major elements; commercial and recreational fishing are generally permitted, although bottom trawling is prohibited in some areas)

The zones are fixed during the life of a zoning plan (generally 5 to 7 years). During this time additional special-need areas may be declared. These may be:

* replenishment areas, closed to collecting and fishing during specified periods to enable recovery of fish and other resource stocks
* reef-appreciation areas, open to the public for observation of undisturbed marine life
* seasonal closure areas, closed during a breeding season
* reef research areas, only open for specific research purposes.

Complementing these are generally smaller areas that give periodic special protection to animal breeding or nesting sites, sites in general use, other zones that must be protected to allow appreciation of nature free from fishing or collecting, and sites suitable for scientific research.

The original zoning scheme focused on fishing, with approximately 30% of the Park closed to trawling. However, as a result of the increasing competition for tourism use, the scheme was recently expanded to specifically incorporate this use by dividing the zones other than the preservation zone into areas in which:

* no structures are permitted (mooring buoys may be permitted)
* structures are permitted, under permit, provided they meet environmental guidelines

The Park is subject to impact from a number of off-site activities, especially pollution, over which the Authority has no legislative control. In these circumstances planning and management are achieved through the co-ordination of policy between relevant agencies.

Promontory, the plan notes that the reservation of the promontory as a national park provides such long-term protection for the adjacent marine park.

Managing for a range of uses in this way may utilise one or more techniques that can be described as compatible, zonal, and temporal. The compatible type involves determining, within a management area, which uses do not conflict. The zonal type separates incompatible uses in space, and care is taken to avoid ecologically damaging effects that a use in one area may have on another area. This is often achieved by the use of buffers, which physically separate the impact zones of different uses. The temporal type is illustrated in the case of migratory species such as whales, which may be present in an area for only a portion of the time; for protection of these, certain activities may need to be curtailed for only part of the year.

To ensure that uses are compatible with each other and that the area is capable of sustaining them, or where it is not necessary to mitigate their impact, the area is usually zoned with the uses specified within the zones. Thus while a large area as a whole may support a variety of uses, specific sections of it may not. There is a limited number of areas set aside where the uses are generally consistent with high levels of protection, while those set aside for resource use generally provide for a wider range of activities.

A potential disadvantage, however, is that the zones are not usually permanently protected and can be readily changed, as opposed to specific marine reserves, which are usually protected in perpetuity by legislation.

The principles of ESD could be achieved by any one or a combination of the three approaches described above. However, as discussed by Kelleher and Kenchington (1991), the integrated management of a large area for a wide range of uses has the advantage that co-ordination of regulation of different human activities can be more readily achieved when the overriding responsibility for management rests with one agency. They argue that co-ordinated management is even more important in marine environments than in the terrestrial sphere because of the high degree of connectivity in the sea and estuaries, which facilitates the transmission of particles, plants, animals, pollutants, and debris both vertically and horizontally within the water column. Thus, despite the great length of coastlines, and the vast distances across oceans, marine systems are closely linked to each other and to activities on the adjacent land.

CONCEPTS OF MARINE PROTECTED AREAS

The International Union for the Conservation of Nature (IUCN) has defined a marine protected area (MPA) as:

> 'Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment' (Kelleher and Kenchington 1992).

Thus, the definition includes reserves such as the Great Barrier Reef Marine Park, the South Gippsland marine and coastal parks, the Wilsons Promontory Marine Reserve, and the Harold Holt Marine Reserve complex in Port Phillip Bay.

According to the IUCN, the primary goal of marine conservation and management is:

> 'to provide for the protection, restoration, wise use, understanding and enjoyment of the marine heritage of the world in perpetuity through the creation of a global, representative system of marine protected areas and through the management in accordance with the principles of the World Conservation Strategy of human activities that use or affect the marine environment'.

Criteria that may be applied in selection of an MPA are given in Box 19.4.

Many different names are used to describe areas reserved for or protected of the marine environment. In Australia in 1984, Ivanovici identified 23 different categories, ranging from 'Marine National Park', 'Marine Reserve', and 'Fishery Reserve', to 'Historic Shipwreck Protection Zone'. As implied by the names, the areas to which they applied also had different management goals, which can lead to confusion among users about the activities that may or may not be permissible. Two commonly used terms are 'marine park' and 'marine reserve', but it must be emphasised that all the terms listed above are included in the IUCN definition of a marine protected area.

Box 19.4: Criteria for Marine Protected Areas

A number of criteria can be used in deciding whether an area could be a marine protected area or in determining boundaries for one.

Naturalness	- the extent to which the area has been protected from, or has not been subject to, human-induced change
Biogeographical importance	- either contains rare biogeographical qualities or is representative of a biogeographical 'type' or types - contains unique or unusual geological features
Ecological importance	- contributes to maintenance of essential ecological processes or life-support systems - e.g., source for larvae for downstream areas - has integrity - either by itself or in association with other protected area(s), encompasses a complete ecosystem - contains a variety of habitats - contains habitat for rare or endangered species - contains nursery or juvenile areas - contains feeding, breeding or rest areas - contains rare or unique habitat for any species - preserves genetic diversity i.e. is diverse or abundant in species terms
Economic importance	- existing or potential contribution to economic value by virtue of its protection - e.g., protection of an area for recreation, subsistence, use by traditional inhabitants, appreciation by tourists and others, or as a refuge nursery area or source of supply for economically important species
Social importance	- existing or potential value to the local, national, or international communities because of its heritage, historical, cultural, traditional aesthetic, educational, or recreational qualities
Scientific importance	- value for research and monitoring
International or national significance	- is or has the potential to be listed on the World or a National Heritage List, or declared as a biosphere reserve, or included on a list of areas of international or national importance, or is the subject of an international or national conservation agreement
Practicality/feasibility	- degree of insulation from external destructive influences - social and political acceptability, degree of community support - accessibility for education, tourism, recreation - compatibility with existing uses, particularly by locals - ease of management, compatibility with existing management regimes

Source: Kelleher and Kenchington (1992).

In Victorian usage, a marine park is an MPA that is generally zoned for multiple use and is generally large in area, while a marine reserve is an MPA that is generally not zoned and is generally smaller in area. A marine reserve is envisaged as the more protective category of the two and may be included within a marine park.

Although the definition of marine protected area refers only to land below high-water mark, coastal land above high-water mark, including islands, is sometimes included in the 'marine and coastal parks' category used in Victoria. This form of reservation is particularly appropriate for coastal wetlands, and is being considered increasingly, in accordance with the principles of an integrated approach to coastal management. Land-use categories for the Victorian coast are described in more detail in Chapter 18.

As described in Box 19.5, an aim of the Ocean Rescue 2000 program is to develop a national representative system of MPAs. In the absence of a consistent definition and set of management aims, it would be difficult to achieve this goal. The 'Marine Protected Areas National Advisory Committee' has been established to advise ANZECC on this matter.

THE BIOSPHERE RESERVE CONCEPT

Recent publications have discussed the potential application of the biosphere reserve concept to coastal areas (Ray and Gregg 1991;

Box 19.5: Canada - National Marine Parks

In 1987 Canada developed an Oceans Policy in recognition of its extensive oceanic territories, the broad range of existing oceans policies and programs, and the need to ensure that these were co-ordinated in an effective and efficient manner, as well as to provide clear future directions.

The Canadian national marine park system is based on the principle that it should protect a representative, outstanding, and unique sampling of the country's Arctic, Atlantic, and Pacific marine environments, and the Great Lakes. The goal is to establish a system that represents the range of biogeographic regions. Each region either is relatively homogeneous in terms of climate, sea-bed geology, ocean currents, water mass characteristics (temperature and salinity), sea-ice distribution, coastal landforms, marine plants, sea-birds, and marine mammals, or contains recurring patterns of these characteristics.

Five steps were used to develop the system.

1. Identification of representative marine areas: which was done by summarising the region's biological and oceanographic features, as well as cultural themes to identify candidate marine areas, which encompass a high diversity of these key regional characteristics and have a high degree of naturalness.

2. Selection of potential marine park areas: which involves considering the social and political issues and alternate uses of the areas identified from Step 1.

3. Assessment of national park feasibility: by preparing a proposal for detailed assessment and public consultation. The factors mentioned in Step 2 are now considered in greater detail. If a park is not an option for the area, another representative area in the region is considered.

Steps 4 and 5 relate to the specific constitutional arrangements that exist in Canada and are not described here.

The Canadian parks service consider that five elements must be considered in the creation of a park: comprehensive planning; the support of the large majority of local residents and resource-users who may be affected by the proposal; political support; adequate funding to provide for the park's subsequent planning and development; and the support of the other management agencies that would be involved in the co-operative management of the park following its establishment.

Kenchington and Argardy 1990). This section is based on these publications.

With ever-growing numbers of humans living in the coastal fringe and both directly and indirectly impacting on adjacent marine ecosystems, a method relying solely on exclusion is likely to fail.

The biosphere reserve concept was formalised in 1971 by UNESCO as part of its 'Man and the Biosphere Program' and is based on the premise that humans are an integral part of the system. The primary goals are outlined in Box 19.6. The original intent was to set aside representative lands as biosphere reserves to preserve specific genetic stocks of plants and animals and to better human society in regions undergoing environmental degradation. A reserve of this kind is integrative, linking sustainable use with normal functioning of the ecosystem, and is conducive to co-ordinating management.

Initially, designations of biosphere reserves around the world were often superimposed on existing parks, involving few management changes; consequently the designations were mainly symbolic.

This applied in Victoria, where two of the three designated reserves were along the coast: Wilsons Promontory National Park, and Croajingolong National Park - Nadgee Nature Reserve. These reserves are predominantly land-based, extending to low-water mark only and consist of core protected areas only.

In principle, biosphere reserves promote sustainable development by utilising carefully developed zoning plans in which different areas

Box 19.6: Biosphere Reserves - Goals

* Conserve for present and future use the diversity and integrity of communities of plants and animals within natural and semi-natural ecosystems and safeguard the genetic diversity of species on which continuing evolution depends.
* Provide areas for ecological and environmental research and monitoring consistent with the above goal.
* Provide facilities for the education and training of scientists, managers of protected areas, and interested individuals.
* Provide a forum for the exchange of information.

serve differing roles of: conservation (preservation of species and habitats); logistics (providing controlled locations for research into ecological systems and human interactions with them); and development (controlled resource use).

In the case of terrestrial ecosystems a biosphere reserve zoning has to meet a range of goals. This involves the designation of one or more 'core' areas that, singly or together, comprise a self-sufficient conservation unit representing a defined ecotone that can be strictly protected in the long term. Around these core areas, in buffer zones, the controlled use of resources and of the environment acts to prevent impacts from damaging the core ecosystems. Outside the cores and their buffers, large 'areas of co-operation' within the reserve provide a means for joint co-operative management and effective planning involving inputs from local user groups as well as administrative agencies.

Some people consider the biosphere reserve concept to be ideally suited to coastal marine areas, although, as emphasised by Kenchington and Agardy (1990), the roles of core, buffer, and co-operation areas need to be redefined from terrestrial to marine systems.

On land, relatively small reserves may be sufficient for protection of a particular habitat. In marine systems, the water column, with its associated chemical and biological components, may link areas which are great distances apart. For example, plankton and nutrients carried by some currents may travel almost 500 km in a week; many marine animals are migratory and range over considerable distances. Consequently, if a reserve is intended to protect a species and the reserve is small in comparison with the habitat range, the animal may be put at risk by uses outside the reserve. Marine linkages are not only widespread in a geographical sense, but also highly variable in time and space due to water currents and tides. As a result, most core or conservation units in the marine context would have to be enormous. Therefore Kenchington and Agardy suggest that the core of a reserve in a marine system should focus on:

> 'establishing a viable logistic network of research or reference sites. These reference sites would provide data for studies that investigate the impact of human activity on the system and the role of management in the continued functioning of that system. The development role, of managing human impacts to keep them within sustainable levels which do not compromise the ecological functioning of the system, may be addressed largely by buffer zones. There may need to be several types of buffer zone to provide appropriate separation for orderly management of potentially conflicting uses.'

In summary, a general priority in marine biosphere reserves is not a strict 'reserve protected area' designation, but a logistic role of reference sites.

However, in some cases a reserve may be particularly important if it is located in a breeding ground - where congregating animals would be at greater risk of capture or more vulnerable to particular uses than in other areas - or in a habitat of a localised and sedentary species.

LAND CONSERVATION COUNCIL APPROACH

Irrespective of the approach taken to protect the marine environment, the successful development of a representative network of marine protected areas will depend on community support and a comprehensive consideration of all other existing and potential uses.

Such consideration forms an integral part of any Land Conservation Council study and will be part of the development of proposed recommendations for this Marine and Coastal Special Investigation. Issues involved include a range of commercial and recreational uses. The framework of ecologically sustainable development provides a context for their consideration.

MARINE PROTECTED AREAS IN VICTORIA

To date, 12 marine protected areas have been declared in Victoria. The first of them - the 3300 ha Harold Holt Marine Reserves, proclaimed in 1979 - comprised five separate areas at the southern end of Port Phillip Bay and were established under Section 79A, *Fisheries Act* 1968. None of the areas is zoned. These reserves owe their origin, in part, to a 1972 proposal by the Scuba Divers Federation of Victoria for a large reserve at the southern end of the Bay. Their principle aims are preservation and protection of a range of marine ecosystems.



Whisky Bay - Wilsons Promontory Marine Park

The Harold Holt Reserves consist of Swan Bay, Mud Islands, Point Lonsdale, Point Nepean, and the Popes Eye Annulus. Swan Bay Marine Reserve of 2800 ha is an internationally significant coastal wetland listed under the Ramsar Convention because of its importance for migratory wading birds and of value for its marine ecosystems. The sheltered environment of Swan Bay contains seagrass meadows, extensive tidal flats, and saltmarsh communities which were excluded from community fishing, because of their significance as a nursery area, before Swan Bay was established as marine reserve.

Mud Islands Marine Reserve (600 ha) was established to complement the Mud Islands Wildlife Reserve of 56 ha, which protects breeding sea-birds. The Islands are a series of low-lying sandbanks around a central lagoon, surrounded by very shallow water. The intertidal and subtidal areas are important for bird feeding and support extensive seagrass meadows.

Point Lonsdale Marine Reserve of 37 ha on the western side of the entrance to Port Phillip Bay contains subtidal reefs and a large rock platform with rich algal communities. Successive biologists and naturalists have been exploring the rock platform for more than a hundred years.

Point Nepean Marine Reserve of 90 ha on the eastern side of the entrance has marine habitats, similar to those of Point Lonsdale, that remain largely undisturbed because public access is restricted. As a consequence the reserve is very valuable for scientific reference.

The Popes Eye Annulus Marine Reserve is Victoria's smallest, covering only 3 ha. Originally constructed as a fortification, this structure provides a safe anchorage for pleasure craft and the substrate for a rich benthic community and associated fish fauna, which are very popular with recreational divers. All fishing is prohibited.

In 1982 the Point Cook Marine Reserve, of 120 ha, at the northern end of Port Phillip Bay, was declared under the *Fisheries Act* 1968. It contains rich intertidal and subtidal reef communities. The incentive for its protection was the prevention of damage that might have resulted from unrestricted shellfish collection when the shore at Point Cook was opened to public access. The reserve has an inner zone (from high water to 200 m seaward) from which shellfish collection is excluded and an outer zone in which fishing is permitted.

In its South Gippsland Area District 2 study in 1982, the Council recommended to the government that several marine and marine and wildlife reserves be established around Wilsons Promontory and Corner Inlet. Following the government's acceptance of this recommendation, the then Department of Conservation released a draft zoning proposal for public comment and a final zoning plan was released when the marine and coastal parks were declared in 1986.

Five separate areas were protected: Wilsons Promontory Marine Reserve, Wilsons Promontory Marine Park, Shallow Inlet Marine and Coastal Park, Corner Inlet Marine and Coastal Park, and Nooramunga Marine and Coastal Park. These parks, which include the largest and most significant marine areas reserved in Victoria, were reserved under the *Crown Land (Reserves) Act* 1978 and are also protected under the provisions of the *Fisheries Act* 1968 and other relevant Acts.

Amateur and commercial fishing are permitted in the Shallow Inlet, Corner Inlet, and Nooramunga Marine and Coastal Parks and, with some restrictions, off the northern shores of Wilsons Promontory. All fishing and harvesting is proposed for exclusion from the southern end of the Promontory.

In 1987, the government proposed the Bunurong Marine Park covering 17 km of coastline off Cape Paterson and extending 1 km out to sea. This was declared in December 1991 under the *Crown Land (Reserves) Act* 1978 and *National Parks Act* 1975. The park is zoned to exclude exploitative activities from the central sanctuary zone, but to allow some fishing in adjoining zones. The area has extensive intertidal rock platforms which

contain a remarkably wide range of habitats. It provides opportunities for beach walks, snorkelling, and scuba-diving.

Concurrently the Bunurong Sanctuary Zone was proclaimed and rules specified under Section 79A of the *Fisheries Act* 1968.

ISSUES

* identification of information gaps and research requirements especially for marine biological resources

* development of a biophysical classification for Victoria's marine areas and consequent development of a representative system of marine protected areas

* enforcement of regulations

* approaches to marine planning

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APPENDICES

Appendix I

SITES OF GEOLOGICAL AND GEOMORPHOLOGICAL SIGNIFICANCE

KEY

No — Assigned number, sites are numbered west to east. For features that are clusters of sites, the feature is listed first and component sites are then listed.

Feature — Feature name; '*' indicates a clustered site.

Sig — Individual significance rating of each site:
'I' - International significance
'N' - National significance
'S' - State significance
'RL' - Regional/local significance

Map — 1:100,000 mapsheet number

East/North — The Australian Map Grid co-ordinates of the feature. Note, the grid reference describes the approximate centre of the site, the site may be a point, a linear feature or cover a relatively extensive area particularly for the clustered sites.

Description — Brief description of the feature.

Source: Geological Survey of Victoria - GEDIS database (March 1993). See also Buckley, R.W. (1993), Sites of geological and geomorphological significance along the Victorian coast. Geological Survey of Victoria. Unpublished Report 1993/4.

No	Feature	Sig	Map	East	North	Description
001	Glenelg Estuary	RL	7121	500300	5788000	Large open tidal estuary
002	Long Swamp	RL	7121	508000	5784000	Extensive back barrier swamp
003	Nobles Rocks	RL	7121	510000	5781600	Calcarenite cliffs with palaeosoils
004	Discovery Bay	RL	7121	513000	5780000	Foredune and dune complex.
005	Cape Montesquieu	RL	7121	515700	5778000	Calcarenite cliffs & shore platform on a sandy coast
006	Swan Lake	RL	7121	527100	5771000	Coastal lagoon formed by Recent dunes damming Johnstone Creek
007	Bridgewater Lakes & Caves	S	7121	535000	5758900	Freshwater lakes, old sea caves & type section of Bridgewater Fm
008	Cape Bridgewater Promontory*	N	7121	533000	5751000	Excellent examples of volcanism, cliff top dunes & sea caves
008.01	Cape Duquesne	S	7121	531700	5752000	Calcarenite cliff with caves & blowholes overlying basalt
008.02	Cape Bridgewater Karst Area	RL	7121	533700	5752000	Unusual limestone & coastal features
008.03	Bridgewater Sea Caves	S	7121	534500	5750500	Sea caves with extensive carbonate decoration
008.04	Cliff Top Dunes - Cape Bridgewater	S	7121	534500	5753600	One of the best cliff top dune systems on Victoria
008.05	Bridgewater Volcano	S	7121	535500	5751000	Cross section exposure through basalt & basaltic tuff volcanoe
009	Shelly Beach, Bridgewater Bay	RL	7121	539000	5753900	Fine example of modern shell accumulation
010	Cape Nelson, Nelson Bay*	N	7221	547000	5746000	Dune calcarenites & volcanic complex
010.01	Cliff Top Dunes - Cape Nelson	RL	7121	547400	5751200	One of the best examples of cliff top dunes in Victoria
011	Cape Grant, Grant Bay	RL	7221	555000	5750000	Eroded remnant of volcano composed of lava and tuff.
012	Lawrence Rocks	S	7221	558200	5748400	Remnant peaks of submerged volcano
013	Portland Cliffs	RL	7221	553100	5756700	Accessible exposures of late Tertiary marine sediments
014	Prograding Beach Sector - Portland	RL	7221	552900	5755800	Transition between degraded cliff to low sandy beaches
015	Fawthrop Lagoon	RL	7221	552400	5754500	Disturbed lagoon, indicating former estuarine conditions
016	Cliff Coast - Anderson Pt to Dutton Way	RL	7221	552800	5757400	Landslip in weathered basalt and stratigraphic exposures
017	Maretimo Cliffs	RL	7221	552300	5758500	Fossiliferous Maretimo clay and marls
018	Dutton Way Bluff and Beach Ridges	RL	7221	552700	5759100	Parallel dune ridges and swales undergoing coastal erosion
019	Beach Ridge Sequence - Narrawong	RL	7221	559400	5764700	Dune ridge sequence
020	Tyrendarra Lava Flow	N	7221	568000	5766500	Narrow valley basalt flow that extends 16km offshore
021	Lady Julia Percy Island	N	7221	587000	5747000	Island of Newer Volcanic Basalt formed by a sub-marine eruption
022	The Craigs	S	7321	599000	5751200	Calcarenite cliffs exhibiting palaeosoils & dune development
023	Cape Reamur	RL	7321	602000	5750000	Lava outcrops with tumuli and synformal structures.
024	Port Fairy Drain	RL	7321	608000	5751500	Rich molluscan fossil site
025	Belfast Lough	RL	7321	610000	5753200	Large shallow estuarine lagoon
026	Killarney Beach	RL	7321	614500	5753500	Emerged shore platform indicates Holocene high sea level
027	Kelly Swamp	RL	7321	622000	5754000	Remnant of a larger back barrier swamp/lagoon
028	Thunder Point	RL	7321	627900	5748600	Calcarenite cliffs with palaeosoils containing midden material
029	Lake Pertobe	RL	7321	629000	5749600	Sediments reflect changes in sea level
030	Lake Gillear	RL	7421	639000	5745000	Site of former channel of Hopkins River
031	Childers Cove	RL	7421	645700	5738400	Excellent exposure of Port Campbell Limestone
032	Stanhope Bay	RL	7420	647700	5736800	Excellent exposure of Port Campbell & dune limestone
033	Bay of Islands	RL	7420	658500	5728000	Illustrates coastal erosion & karst forming processes
034	Peterborough-Childers Cove karst	RL	7420	661000	5727000	Spectacular example of karst topography
035	Peterborough Point	RL	7420	663200	5724850	Displays geomorphic processes involved with sea level change
036	Curdies Inlet and Newfield Bay	RL	7420	664000	5726000	Coastal evolution as a response to sea level change
037	Crown of Thorns	RL	7420	665100	5724500	Unusual landform
038	Port Campbell National Park*	N	7520	683000	5718000	Coastal erosion processes & karst topography
038.01	The Grotto	RL	7420	666600	5723600	Spectacular landform
038.02	London Bridge	S	7420	667400	5723600	Excellent example of arched rock stack
038.03	The Arch	RL	7420	669100	5723000	Unusual landform
038.04	Two Mile Bay	RL	7420	671500	5722900	Example of stranded coastal landform
038.05	Beacon Steps	RL	7420	673700	5723100	Benches cut into the cliffs display coastal erosion processes
038.06	Sentinel Rock	RL	7520	675800	5722100	Prominent landform
038.07	Goudies Lookout	RL	7520	676600	5722000	Landforms illustrating coastal erosion
038.08	Rutledge Creek Crab locality	RL	7520	678300	5721000	Important fossil crab locality
038.09	Loch Ard Gorge	S	7520	680000	5720000	Major cliffed landform of the Port Campbell National Park
038.10	The Twelve Apostles	N	7520	683000	5718000	Spectacular example of coastal erosion processes
038.11	Gibsons Steps	RL	7520	684000	5717200	Contact between Gellibrand Marl & Port Campbell Limestone
038.12	Clifton Beach	RL	7520	686500	5714400	Type section of Gellibrand Marl Contact with Clifton Formation
038.13	Point Ronald	RL	7520	687400	5713400	Type section of Clifton Formation
039	Point Ronald to Point Margaret	RL	7520	687400	5713400	Shows contact between various rock units
040	Pebble Point	N	7520	689900	5710400	Unconformity b/w Mesozoic & Tertiary rocks Type section of Pebble Point Formation

Appendix I - Sites of Geological and Geomorphological Significance (continued)

No	Feature	Sig	Map	East	North	Description
041	Princetown quarry	RL	7520	689900	5712100	Exposure of Dilwyn Formation
042	Bell Point	RL	7520	690300	5709700	Displays stratigraphic relationship between rock units
043	Australite fields Ferguson Hill	RL	7520	691500	5709500	Presence of possible extra-terrestrial australites or tektites
044	Racecourse Steps	RL	7520	692200	5707900	Important plant fossil locality
045	Cat Reef Point	RL	7520	692500	5707600	Unconformity between Eumeralla & Dilwyn Formations
046	The Gable	RL	7520	693000	5707500	High cliffs show unconformity between Mesozoic & Tertiary rocks
047	Gellibrand River backswamp and spurs	RL	7520	693500	5710500	Interesting fluvial landforms & sediment
048	Moonlight Head	RL	7520	694300	5706400	Good exposure of Eumeralla Formation
049	Cape Volney	S	7520	696800	5706800	One of the few of petrified trees in Victoria
050	Devils Kitchen Cliff fossil locality	S	7520	698500	5709500	Plant fossil site, youngest Otway Group outcrop
051	Lion Headland - Slippery Point	N	7520	703000	5707750	Fossil dinosaur footprint in the rocks
052	Johanna dune	RL	7520	707350	5706500	Influence of faulting sea level change & dune formation
053	Rotten Point to Johanna River	RL	7520	708300	5705500	Illustrates Tertiary stratigraphy & lithologies
054	Dinosaur Cove	I	7520	708800	5704700	World renowned fossil dinosaur locality
055	Castle Cove Fault	RL	7520	711000	5704800	Illustrates changes associated with movement along fault
056	Castle Cove to Sentinel Rock	RL	7520	711500	5703500	Castle Cove Fault & contact with Tertiary & Mesozoic rocks
057	Eaglenest Rock	RL	7520	712000	5703175	Important plant fossil locality
058	Spud Point	RL	7520	712000	5704700	Good exposure of Calder River Limestone
059	Sentinel Rock fossil locality	N	7520	712250	5702700	Unique Miocene fossil plant locality
060	Lake Hordern	RL	7520	714000	5705000	Site of Holocene pollen record
061	Duck Point	RL	7520	714600	5704300	Exposure of Fishing Point Marl
062	Guerards Hill	RL	7520	715700	5701400	Good example of wind blown dunes
063	Point Flinders	RL	7520	716300	5698125	Important plant fossil locality
064	Point Flinders	RL	7620	717400	5697500	Mesozoic - Quaternary contact with cliff top dunes
065	Cape Otway	S	7620	717900	5696000	Displays faults & folds in bedrock & unique shore platform
066	Point Franklin	S	7620	721800	5696200	Important dinosaur bone locality
067	Parker River mouth	RL	7620	722300	5696800	Excellent exposure of sedimentary features in Otway Group
068	Point Lewis Dinosaur locality	N	7620	724200	5699000	Prolific dinosaur skull bone site
069	Stony Creek	RL	7620	725800	5701200	Displays evidence for a fault
070	Shelly Beach	RL	7620	728200	5702800	Major shell beach
071	The Blowhole	RL	7620	729000	5703000	Landform provides information on sea level change
072	Barham River mouth	RL	7620	731800	5705800	Oldest outcrop of the Lower Cretaceous rocks
073	Rusty Road Falls	RL	7620	733800	5710000	Vertical waterfall illustrating valley development
074	Skenes Creek monocline	RL	7620	737400	5711000	Rock structure determines orientation of the coastline
075	Carisbrook Falls	RL	7620	744000	5714000	Longest & highest rapid & cascade section of streams in Otways
076	Ramsdens Cave, Cape Patton	N	7620	746950	5713500	High sea cliffs display geological structure & large sea cave
077	Kennett River emerged shore platform	RL	7620	749000	5716200	Abandoned intertidal features due to uplift of sea level
078	View Point emerged platform	RL	7620	750850	5718300	Abandoned shoreline and intertidal features
079	Point Stuart shore platform	RL	7620	751850	5718900	Well formed shore platform with evidence of a higher sea level
080	Boggaley Creek boulder beach	RL	7620	753600	5721700	Provides evidence of previous sea level changes
081	Artillery rocks	RL	7620	754200	5723000	Sandstone concretions on shore platform
082	Mount Defiance anticline	RL	7620	755300	5724700	Example of folding in Otway Group
083	Cumberland river caves	RL	7620	756800	5725900	Example of coastal caves controlled by jointing
084	Sheoak Falls	RL	7620	757900	5727200	Correlation between rock structure & geomorphic development
085	Lorne shore platform	RL	7620	760200	5729000	Extensive wave cut shore platform
086	Eastern View	RL	7721	241500	5737200	Contact between Cretaceous & Tertiary sediments.
087	Jan Juc Ck to Aireys Inlet*	N	7721	260000	5747000	Facies changes in Tertiary stratigraphy
087.01	Aireys Inlet	S	7721	247000	5738000	Stratigraphic exposure & large solution pipes
087.02	Split Point	S	7721	247400	5738000	Older Volcanic basalt overlain by Point Addis Limestone
087.03	Urquharts Bluff	RL	7721	249300	5741500	Good exposure of the Angahook Member
087.04	Soapy Rock	S	7721	253700	5743600	Type section of Angahook Member. Large landslip present.
087.05	Demons Bluff to Black Rock	S	7721	257500	5746100	Type section of Anglesea Member. Large landslides also present
087.06	Point Addis	S	7721	260000	5746500	Type section for Point Addis Limestone.
087.07	Bells Headland	RL	7721	262400	5749400	Excellent exposure of various Tertiary sediments
087.08	Rocky Point	RL	7721	262800	5749700	Good exposure of Puebla Formation & Point Addis Limestone
087.09	Dead Mans Gully	RL	7721	263200	5750600	Good exposure of Puebla & Jan Juc Formation
087.10	Fishermans Steps	RL	7721	263600	5750900	Good exposure of Puebla & Jan Juc Formations
087.11	Bird Rock to Jan Juc Creek	S	7721	264900	5752100	Type section for Jan Juc & Puebla Formations
087.12	Jan Juc (Rocky) Point	RL	7721	265600	5752300	Rare exposure of Zeally Limestone
088	Point Roadknight	S	7721	254000	5742500	Pleistocene dune calcarenite with contrasting shore-platforms
089	Yellow Bluff	RL	7721	266300	5753800	Good exposure of Puebla Formation
090	Barwon Heads	RL	7721	281200	5758800	Calcarenite coastal bluff
091	Lake Connewarre	S	7721	278000	5767000	Large estuary with variable salinity & sea level history
092	Point Lonsdale Lighthouse - Calcarenite Beds	RL	7821	291200	5759900	Calcarenite cliffs and shore platform features
093	Point Lonsdale - Calcarenite complex	RL	7821	291300	5758900	Pleistocene calcareous dune sequence
094	Queenscliff Isthmus - Parallel dune ridges	RL	7821	293400	5761200	Relatively intact high parallel sand ridges
095	Shortlands Bluff - Calcarenite Beds	RL	7821	295200	5761100	Calcareous formations
096	Port Phillip Bay Entrance & Great Sands*	S	7821	292000	5760000	Incised entrance with sandy flood tidal delta on rocky platform
096.01	Queenscliff - Prograded Beach	RL	7821	295800	5761900	Prograded coast
096.02	Swan Island - Sand accretion	RL	7821	298300	5764200	Major emerged sand accumulation
096.03	Mud Island Ridges & Lagoons	RL	7821	304500	5761500	Uncommon type of island development in Victoria
096.04	Observatory Point Cuspate Foreland	RL	7821	297000	5757500	One of the few sites in the Bay to show sustained sandy accretion
096.05	Point Nepean Platforms	S	7821	294200	5757800	Entrance controlling many of the features of Port Phillip Bay
097	Duck Island/Point Norgate - Tidal flats	RL	7821	297000	5765900	Spit system and broad tidal flat
098	Swan Bay - Tidal flat	RL	7821	294000	5761600	Low energy, fine grained shell rich depositional environment
099	Swan Bay - Embayment infill and delta	RL	7821	292800	5763800	Prograding sheltered coastline as a result of biogenic materials
100	Swan Bay -Alluvial Fans	RL	7821	296700	5769100	Complex coastal landform history
101	Edwards Point - Spit complex	RL	7821	298500	5767300	Compound branching barrier/spit system
102	The Bluff (Miller Point) - Active Cliff	RL	7821	299700	5771000	Small coastal cliff/bluff system
103	St Leonards Jetty - Cuspate Spit	RL	7821	300100	5772500	Artificially induced cuspate spit
104	St Leonards - Lagoon	RL	7821	299500	5774000	Former marine embayment
105	Indented Head South - Deep Weathering	RL	7821	299800	5774700	Coastal cliff cut into deeply weathered sand & sandy clay rock
106	Indented Head - Gravel Bed	RL	7821	300100	5775200	Higher sea level beach
107	Portarlington East - Shore Platform	RL	7821	296200	5778600	Unusual gravel veneer on the coastal platform
108	Steeles Rock, Portarlington	RL	7821	295300	5778600	Complex structural and stratigraphic sequence
109	Portarlington Pier - Geological section	RL	7821	294400	5778900	Older Volcanics sequence and coastal platform
110	Point Richards - Cuspate foreland	RL	7821	292100	5779400	Site of persistent sand accumulation
111	Point Richards South - Lobate foreland	RL	7821	291000	5778700	Late Holocene coastal sedimentary history
112	Spray Farm Lane - Raised beach	RL	7821	291000	5777600	Stranded beach deposit

Appendix I - Sites of Geological and Geomorphological Significance (continued)

No	Feature	Sig	Map	East	North	Description
113	McAdams Lane - Landslip & geological site	RL	7821	287500	5776500	Complex range of geomorphological and geological features
114	Clifton Springs - Slump amphitheatre	RL	7821	287700	5775700	Major backward rotational coastal landslip
115	Beacon Point Road - Geological site	RL	7821	287500	5775400	Tertiary stratigraphic sequence
116	Clifton Springs Jetty - Unconformity	RL	7821	286800	5774800	Conglomerate ferruginised base of the Moorabool Viaduct Sand
117	Clifton Springs - Limestone Reef	RL	7821	286300	5774300	Faulted and folded Tertiary limestone
118	Curlewis Exposure*	S	7821	280600	5773200	Various significant features clustered along the coast
118.01	Curlewis - Shore platforms	RL	7821	282500	5773300	Tertiary stratigraphic sequence and wide shore platform
118.02	Curlewis (Bellarine Beacon) - Volcanic plug	RL	7821	280600	5773200	Visible eruption point of the Older Volcanics
118.03	Curlewis - Coastal terrace	RL	7821	280400	5773000	Unusual example of a stable coastal sector
118.04	Curlewis - Limestone reef	RL	7821	280100	5773000	Intensely folded Tertiary sediments
119	Point Henry - Elongate spit and beach ridges	RL	7721	280400	5773000	Long elongate cuspate spit & parallel ridge and lagoon system
120	Point Henry (west) - Clay Platform	RL	7721	273700	5775000	Intertidal platform developed in unconsolidated silt and clay
121	Limeburners Point - Limestone and kilns	RL	7721	270700	5774500	Freshwater limestone containing diprotodon remains
122	Western Beach (Geelong) - Tertiary sediments	RL	7721	268300	5776300	Tertiary stratigraphic sequence
123	North Shore(Geelong)-Moorabool Viaduct Sand	RL	7721	269600	5779500	Contact between Fyansford Formation & Moorabool Viaduct Sand
124	Hovells Creek - Mid-Holocene sea level site	S	7721	272400	5786700	Marine shell bed suggesting a higher mid-Holocene sea level
125	Limeburners Bay estuary	S	7721	272500	5782500	Funnel shaped compound estuary
126	Point Lillias and Bird Rock - Lava coastline	RL	7721	275700	5780800	Drowned lava flow coast
127	Avalon - Lava Edge Coast	RL	7721	276800	5781800	Submerged stony rises
128	Point Wilson - Shell ridges	RL	7821	281600	5781600	Shell dominated actively prograding coast
129	Sand hummocks - Barrier Spits	S	7821	282000	5785500	Tidal lagoon system dominated by storm wave & tidal processes
130	Werribee River Mouth	RL	7822	296850	5794400	Exposure of important & unusual deltaic sediments
131	Point Cook Parallel Sand Ridges	RL	7822	305500	5799800	Sand ridges that relate to sedimentary history of the area
132	Point Cook Relict Spits	RL	7822	306350	5800400	Sand ridges that relate to sedimentary history of the area
133	Skeleton Creek Relict Spits	RL	7822	306400	5802400	Example of relict coastal landform
134	Altona Sand Ridges	RL	7822	307000	5805400	Remnant of dune system suggesting higher Holocene sea level
135	Altona Shore Platform	RL	7822	309700	5806000	Illustrates shore platform development
136	Kororoit Creek Tidal Channels	RL	7822	311900	5807400	Remnant example of original tidal wetland
137	Altona East Sand Bars	RL	7822	312000	5807300	Major sand bar/spit/ridge system
138	Altona Meadows Active Sand Spits	RL	7822	312000	5807300	Example of spit/bar system on rare prograding coast
139	Merret Rifle Range Shore Platform	RL	7822	313300	5806700	Shore platform & shell deposits with mangrove
140	Williamstown Foreshore	RL	7822	315100	5806100	Emergent basalt shore platform & boulder terrace
141	Williamstown Lava Blister	RL	7822	315850	5806200	Unusual rock formation
142	Picnic Point	RL	7822	323800	5798100	Emerged shore platform with shell beds
143	Red Bluff	RL	7922	325120	5796100	Type locality for Tertiary sediments Active coastal cliff
144	Black Rock Point	RL	7922	325130	5795370	Contact between Black Rock Sandstone & Red Bluff Sands
145	Ricketts Point	RL	7922	326950	5792800	Displays relationship between rock structure & landforms
146	Table Rock Point	RL	7922	327620	5792600	Extensive development of cliffs in Black Rock Sandstone
147	Beaumaris Cliffs - Keefers to Yacht Sqadron	I	7922	328200	5793200	Internationally important Late Miocene fossil site
148	Beaumaris Cliffs - Beaumaris	RL	7922	328500	5793500	Example of a monoclinal fold
149	Seaford - Parallel Dunes	RL	7921	335400	5780000	Remnant of a large barrier wetland complex
150	Olivers Hill - Tertiary Section	RL	7921	334400	5775300	Best exposure of sub-basaltic sediments on the Bay's east coast
151	Davies Bay - Manyung Fault	S	7921	333500	5774500	Major exposure of Selwyns Fault
152	Pelican Point - Cliff and Raised Platform	RL	7921	332400	5774000	Unusually stable cliff form in Port Phillip Bay
153	Half Moon Bay Point Cliff (Mt Eliza)	RL	7921	331600	5772900	Excellent section of the Baxter Formation, complex shore platform
154	Earimil Creek (Dennant Creek) Manyung Fault	RL	7921	331600	5772200	Exposure of the Manyung Fault
155	Gunyong (Grices) Creek - Manyung Fault	RL	7921	330900	5771200	Significant exposure of the Balcombe Clay
156	Gunyong Creek (Grices Creek)-Spinifex Terrace	RL	7921	330900	5771100	Good example of a terraced foredune
157	Manyung Rocks - Balcombe Clay	RL	7921	330700	5770700	Significant exposure of the Balcombe Clay
158	Sunnyside Beach - Mesozoic Sediments	RL	7921	330300	5770100	Extensive and complex exposure Mesozoic rocks
159	Manmangur Creek - Mesozoic and Granite	RL	7921	330100	5769800	Most easterly outcrop of Mesozoic rocks from the Otway basin
160	Red Bluff (Mornington) - Raised Platform	RL	7921	328200	5768500	Excellent exposure of a raised platform & overlying deposits
161	Schnapper Point - Baxter Sandstone	RL	7921	327600	5768500	Exposure of the Baxter Sandstone
162	Linley (Fishermans) Point - Raised Platform	RL	7921	327100	5767000	Exposure of the Baxter Formation
163	Fossil Beach - Stratigraphy & Palaeontology	S	7921	327300	5765200	Type locality for the Balcombian Stage
164	Harmon Rocks - Geological Section	RL	7921	327200	5764200	Clear & extensive exposure of Middle Tertiary stratigraphy
165	Balcombe Creek - Blind Estuary	RL	7921	326400	5762700	Comparatively intact estuary on the eastern side of the Bay
166	Mt Martha Shore Platforms & Sedimentary Raft*	S	7821	324300	5758500	Granitic shore platforms with sediment blocks within the granite
166.01	Balcombe Pt(Martha Cliffs) Granite Platform	RL	7821	325100	5762000	One of the few Victorian platforms developed in granite
166.02	Mount Martha - Sedimentary Raft	RL	7821	324500	5760800	Large sedimentary blocks in the Mount Martha Granodiorite
166.03	Martha Point East - Shore Platforms	RL	7821	324300	5758500	One of the few Victorian shore platforms developed in granite
167	Anthonys Nose - Fault Scarp	RL	7821	319900	5754100	Only coastal exposure of Dromana Granite
168	White Cliffs - Soil Pipes	RL	7821	308700	5751000	Display of soil pipes and complex calcrete development
169	The Sisters - Calcarenite Cliff	RL	7821	304300	5753100	Clear exposure of a calcareous dune sequence
170	Point McArthur - Cemented Band in Calcarenite	S	7821	301900	5756300	Site interpreted as indicating a higher Holocene sea level
171	Point Franklin - Calcarenite Cliffs	RL	7821	300500	5765300	Unusual calcarenite cliff in Port Phillip Bay
172	Point Nepean to Rye Ocean Beach*	S	7821	300000	5754000	Cliffed calcarenite coast with shore platforms, stacks & arches
172.01	London Bridge	RL	7821	298000	5755000	Arched rock stack
172.02	Diamond Bay	RL	7821	302500	5752200	Rugged calcarenite cliffs with extensive shore platforms
173	Rowley Rocks	RL	7821	315500	5739000	Exposure of Selwyns Fault
175	Cape Schanck to Bushranger Bay	S	7821	316000	5737000	High coastal cliffs of basalt and limestone
176	Bushranger Bay to Double Creek	RL	7821	320000	5737000	Basalt shore platforms with stacks & boulder beaches
177	Yallerong Creek Reserve	I	7821	322500	5738000	World famous classical zeolite mineral locality
178	Flinders - Marine Cliffs and Bluffs	RL	7921	327800	5738700	Cliff-bluff sequence typical of hard rock coast lines
179	Flinders - Dodds Creek Mouth	RL	7921	327500	5740000	Beach composition indicating diverse beach sediment sources
180	Flinders - Coastal Bluff and Cliff	RL	7921	328200	5741100	Isolated marine cliff by the accretion of beach ridges
181	Musk Ck - Valley Incision and Raised Beaches	RL	7921	328500	5741800	Features indicating changes in wave environment or sea level
182	Shoreham - Hanging Valley	RL	7921	328700	5742600	Small hanging valley
183	Shoreham - Landslips	RL	7921	328700	5743000	Landslips at the margins of the coastal plateau
184	Shoreham - Basalt Cliff	RL	7921	329200	5743400	Clear & accessible section of the Older Volcanics
185	Shoreham - Cliffs and Beach Ridges	RL	7921	330000	5744300	Variety of cliffs and bluffs
186	Point Leo - East Creek Dry Valley	S	7921	331500	5745200	Features related to different sea level stages
187	Point Leo Beach	RL	7921	332000	5745500	Popular gemstone collecting locality
188	Coles Beach - High Level Beach Terrace	RL	7921	332500	5746700	Dunes illustrating a variety of dune forming processes
189	Merricks Beach & Palmer Bluff-Cliffs & Bluff	RL	7921	334700	5747900	Weathering & erosion sequence of marine cliffs & bluffs
190	Balnarring Beach-Merricks Ck Barrier System	RL	7921	337000	5749000	Clear example of a multiple barrier system at a stream mouth
191	Somers - Sandy Point*	S	7921	341000	5748400	One of the largest spit systems on the Victorian coast
191.01	Somers - Beach Ridges & Bluff	RL	7921	341000	5748400	Part of one of the largest spit systems on the Victorian coast

Appendix I - Sites of Geological and Geomorphological Significance (continued)

No	Feature	Sig	Map	East	North	Description
191.02	Sandy Point - Beach Ridge & Spit System	RL	7921	344300	5747500	Part of one of the largest spit systems on the Victorian coast
191.03	Sandy Point - Salt Marsh and Relict Spit	RL	7921	344800	5748400	Early development of the Sandy Point complex
192	Hanns Inlet - Relict Spits and Tidal Inlets	S	7921	344100	5749000	Rapidly prograding shoreline
193	Stony Point - Baxter Formation	RL	7921	344800	5751000	Outcrop of Baxter Formation
194	Jacks Beach - Silurian and Tertiary	RL	7921	343200	5755300	Extensive Silurian outcrop in Westernport Bay
195	Sandstone Island - Silurian Outcrops	RL	7921	343700	5756000	Major coastal exposure of Silurian strata
196	Tyabb	RL	7921	345000	5762700	Teaching site for role of mangroves in coastal sedimentation
197	Bungower Point - Multiple Spit	RL	7921	347300	5765600	Relict multiple recurved sand spit
198	Watson Inlet and Quail Island	S	7921	349200	5766100	Relatively undisturbed mangrove and salt marsh area
199	Rutherford Inlet - Warneet Beds	RL	7921	352700	5768600	Best exposure of the Warneet Beds
200	Western Port North Shore*	S	7921	364300	5768000	Display of the impact of the drainage of Koo-Wee-Rup Swamp
200.01	Chinaman Island to Blind Point	RL	7921	353400	5767600	Ferruginous sandstones of unknown origin and relict spits
200.02	Main Western Contour Drain - Outcrop	RL	7921	355700	5769000	Good exposure of ferruginous sandstone
200.03	Tooradin - Tidal Meanders of Sawtells Inlet	RL	7921	358600	5769700	Clearly displayed flood tide meanders
200.04	Pelican Point - Coastal Deposits	RL	7921	360200	5768000	Tidal drainage pattern not widely represented in the Bay
200.05	Lyall Inlet to Bunyip River	S	7921	363400	5768600	Display of the impact of the drainage of Koo-Wee-Rup Swamp
200.06	Bunyip River - Delta	RL	7921	364300	5768000	Delta formed due to the artificial drainage of Koo-Wee-Rup Swamp
200.07	Yallock Creek Swamp Sediments	S	7921	367200	5767300	Remnant of the great swamp that existed to the NE of Westernport
200.08	Lang Lang Earth Cliffs	RL	7921	369000	5763000	Example of a rapidly changing low coastal cliff
201	Red Bluff - Baxter Formation Coastal Cliff	RL	8021	370100	5757800	Best coastal exposure of the Baxter Formation in Westernport
202	Stockyard Point - Cuspate Foreland	RL	8021	370300	5755700	Distinctive medium sized cuspate foreland
203	The Gurdies - Mangrove Die Back	RL	8021	373200	5751800	Small embayment formed as a result of mangrove dieback
204	Grantville - Beach Ridges	RL	8021	372600	5750000	Local coastal sandridge accumulation
205	Queensferry - Beach Ridges and Swamp	RL	8021	370000	5746700	Landforms reflecting the extensive and easterly sand drift
206	Tenby Point - Cliffed Coast	RL	7921	367500	5747600	An unusual and temporary sand accumulation
207	Corinella - Former Outlet of Bass River	RL	7921	364400	5747300	One of the largest abandoned river outlets on the Victorian coast
208	Corinella - Cobb Bluff - Reef Island*	RL	7921	361700	5747600	Various landforms and lithologies in Older Volcanic rock
208.01	Corinella - Corinella Structure	RL	7921	363000	5747300	Structure of unknown origin influencing shoreline development
208.02	Corinella - Older Volcanics	RL	7921	361700	5747600	Major exposure of deeply weathered Older Volcanics
208.03	Cobb Bluff - Coastal Cliffs	RL	7921	362700	5743500	Uncommon cliff form with X-section of weathered Older Volcanics
208.04	Reef Island - Kennedy Point	RL	7921	361400	5740600	Unusual coastal configuration
209	Corinella - Raised Beach	S	7921	361800	5747700	Site used to interpret Holocene sea level history
210	Pelican Island	RL	7921	360800	5747700	The island indicates the extent of basalt west of Corinella
211	Bass River Delta & Floodplain	S	7921	364000	5738000	Complex delta subject to intensive scientific investigation
212	San Remo Peninsula - North Shore	RL	7920	361800	5735600	Contact between the Older Volcanics and Mesozoic sediments
213	San Remo Back Beach-Older Volcanics	RL	7920	357800	5733800	Example of the physiographic effect of the Older Volcanics
214	The Nobbies to Pyramid Rock*	S	7920	336800	5735000	Examples of the processes that have shaped the ocean coast
214.01	Point Grant & The Nobbies to Phelan Bluff	RL	7920	336800	5735000	Examples of the processes that have shaped the ocean coast
214.02	Kitty Miller Bay	RL	7920	340400	5735800	Readily accessible diverse coastal & geological features
214.03	Watt Point	RL	7920	340700	5735400	Rare coastal exposure of Cambrian greenstone
214.04	Native Dog Creek to Thorny Beach	S	7920	342200	5735200	One of the best exposures of Early Tertiary volcanic sequences
214.05	Pyramid Rock Unconformity	RL	7920	344900	5739400	Contact between the Older Volcanics & the prevolcanic surface
215	Redcliff Head - Tuff Beds	RL	7920	343800	5734300	Major exposure of the Older Volcanics tuffs
216	Cunningham Bay, Jessie Island	RL	7920	346000	5735600	Unusual coastal forms
217	Smith Point - Hanging Valley	RL	7920	347300	5736600	Classic small scale example of a hanging valley
218	Smith Beach - Quartzite	RL	7920	347800	5736700	Unusual quartzite ridge, with no equivalent on the Victorian coast
219	Sunderland Bay - Cliff Stack and Slump Bluff	RL	7920	348800	5736400	Cliff, bluff, platform, and beach features of the ocean coast
220	Surfies Point - Cliff Top Dunes	RL	7920	350500	5736100	Transition between cliff and dune dominated coastlines
221	Forrest Bluff and Forrest Caves	RL	7920	352800	5734600	Accessible sea cave and rapidly eroding cliffs
222	Cape Woolamai & Tombolo	S	7920	355500	5732300	Dune system forming a tie-bar & high granite cliffs
223	Cape Woolamai - Granite Tombolo	N	7920	356500	5730100	Former island forming part of a tombolo, high granite cliffs
224	Homestead Point - Prograding Beach Ridges	RL	7920	356000	5735100	Major example of a prograding sandy beach ridge shoreline
225	Churchill Island	RL	7920	355000	5737300	Features indicative of higher sea levels
226	Swan Corner - Cliffs and Bluffs	RL	7920	351500	5736400	Active and relict marine cliffs
227	Chambers Point to Long Point - Raised Beach	S	7921	351700	5738100	Important assemblage of emerged coastal forms
228	Koolyns - Silurian Outcrop	RL	7921	351400	5739800	Eastern most exposure of Silurian sediments on the coast
229	Rhyll Quarry - Rhyll Arkose	RL	7921	351200	5741700	Only Mesozoic outcrop known on Phillip Island
230	Rhyll Inlet (The Nits)	RL	7921	350700	5741800	Major tidal inlet & complex array of active & relict features
231	Rhyll Swamp	RL	7921	349500	5740600	Swamp margins represent former coastlines at higher sea levels
232	Erehhwon Point, Mussell Rocks - Older Volcanic	RL	7921	346300	5742800	Tuffs of the Older Volcanics
233	Penguin Pt & Red Rocks Pt - Dipping Tuff Bed	RL	7921	342500	5742300	Good & accessible outcrop of tuffs in the Older Volcanics
234	Saltwater Creek - Incised Floodplain	RL	7921	342500	5741600	Only valley open to the sea on the north coast of Phillip Island
235	McHaffie Lagoon	RL	7921	339300	5739000	Relatively undisturbed lagoon
236	Cat Bay to Ventnor	RL	7921	339000	5739000	Exposure of tuffs in Older Volcanics
237	Flynn Lagoon	RL	7921	338900	5738200	Example of coastal lagoon formation
238	Green Lake - Swamp & Cliff Top Dunes	RL	7920	338700	5737000	Interesting dune system dynamics
239	Swan Lake - Tombolo and Dunes	RL	7920	339000	5736000	Example of a double tombolo formation on the Victorian coast
240	Cowrie Beach-Higher Level Gravel Beach Terrac	RL	7920	336300	5735700	Gravel beach terrace suggestive of higher sea levels
241	The Anchorage	RL	7921	350500	5748700	Contact between Tertiary and Mesozoic formations
242	Chesapeake - Sand Ridges	RL	7921	352500	5748000	Paired spit development at an embayment entrance
243	Rams Island - Tombolo	RL	7921	355700	5745900	Good example of a small tombolo
244	Elizabeth Island	RL	7921	357500	5746500	Rock outcrops that may represent a late Tertiary volcanic stage
245	Red Bluff - Mesozoic Sandstone	RL	7921	358500	5748300	Lithological, structural & weathering features in sandstone
246	Mosquito Creek - Salt Marsh	RL	7921	359900	5750400	Features illustrating salt marsh and chenier formation
247	Freeman Point - Cliffs in Baxter Formation	RL	7921	365000	5752200	Exposures of vertical sections of the Baxter Formation
248	Blue Gum Point to Spit Point - Spit Complex	RL	7921	367500	5753100	Sandy shoreline progradation and landform development study site
249	Albions - Mangrove Die Back	RL	7921	367000	5755600	Changing mangrove distribution & deeply weathered basalt
250	Palmer Point - Sand Ridges	RL	7921	364500	5758300	Features displaying a relict geomorphic process
251	North Coast of French Island	S	7921	356000	5758700	One of the main mangrove and salt marsh areas of Victoria
252	Barrallier Island	RL	7921	352400	5762000	Small gravelly island
253	Crawfish Rock	RL	7921	350800	5762600	High relief feature in a now submerged drainage system
254	Scrub Point - Ferruginous Sandstone	RL	7921	350700	5761000	Easily studied ferruginous sandstone above high tide level
255	Tankerton to River Point - Sand Spit	S	7921	349700	5756200	Research site for coastal dynamics and sediment movement
256	Chilcott Rocks - Ferruginous Sandstone	RL	7921	349000	5752900	Ferruginous sandstone above hightide level
257	Tankerton Creek - Channel Changes	RL	7921	349300	5750700	Physiographic changes that can occur following mangrove die-back
258	Tea Tree Point	RL	7921	349000	5748000	Diverse coastal landforms suitable for further study

Appendix I - Sites of Geological and Geomorphological Significance (continued)

No	Feature	Sig	Map	East	North	Description
259	Griffith Point to Kilcunda	S	7920	363000	5733000	Cliffed Cretaceous sandstone coast with shore platforms & arches
260	Punchbowl fossil locality	N	7920	360700	5733200	Dinosaur fossil locality
261	Punch Bowl	RL	7920	360700	5733200	Cave collapse giving closed depression
262	Powlett River	RL	8020	370500	5728000	Shore platforms with basalt dykes intruding Cretaceous sandstone
263	Eagles Nest	N	8020	384200	5718700	Rich fossil dinosaur locality. Prominent stack.
264	Point Smythe	RL	8020	389500	5721600	Mobile recurved sandy spit
265	Screw Creek (Townsend Bluff)	RL	8020	391500	5722700	Circular pyroclastic & basaltic volcanic neck intruding sandstone
266	Andersons Inlet	RL	8020	394000	5721000	Large estuary with mobile sandy tidal delta.
267	Arch Rock	RL	8020	403800	5700200	Rock stacks formed in calcarenite. Several small caves
268	Waratah Bay - Cape Liptrap	N	8020	410000	5694000	One of the best exposures of Lower Paleozoic rocks in Victoria
269	Shallow Inlet*	S	8120	427000	5699000	Large estuary with dynamic entrance and wide sandy barrier spit
269.01	Shallow Inlet Spit	RL	8120	427000	5699000	Accessible and outstanding example of barrier spit dynamics
269.02	Shallow Inlet - Foredune Terrace	RL	8120	429500	5697500	Unusually high and wide foredune terrace
269.03	Blue Lagoon - High Dune Ridge	RL	8120	429500	5699500	Active dune system advancing over former parabolic dunes
269.04	Red Swamp - Siliceous Dunes	RL	8120	428500	5699500	Possible relict siliceous dune system
269.05	Winchesters Bluff (Tallandbar)	RL	8120	427500	5703500	Unusual faces of the Haunted Hills Formation
269.06	Marsh Islands	RL	8120	426500	5704000	Marsh islands not associated with delta growth
269.07	Adams Road - Shallow Inlet	RL	8120	427000	5705000	Only recorded site of gold mineralisation in the Shallow Inlet
269.08	Adams Road - Shallow Inlet	RL	8120	425500	5705700	Ecological change (marsh growth) leading to a change (reduction)
269.09	Shallow Inlet - Palaeozoic Outcrop	RL	8120	425000	5706000	One of the few Palaeozoic outcrops in the area
269.10	Quine's Creek	RL	8120	424300	5706100	Cliff exposure of Pleistocene lagoonal deposits
269.11	Ennis' Bend & the Dead End	RL	8120	426500	5701000	Swamp indicating the a former position of the Shallow Inlet
269.12	Shallow Inlet - Tidal Channel	RL	8120	425000	5704700	Sinuous tidal channel
269.13	Shallow Inlet - Channel Bars	RL	8120	427800	5702500	Elongated channel bars developed in response to ebb & flood tides
270	Wilsons Promontory National Park*	N	8119	445000	5680000	Granitic massif with numerous geomorphological & geological sites
270.01	Darby Beach	RL	8120	436400	5686000	Calcarenite cliffs with palaeosoils. Peat outcrops on beach.
270.02	Squeaky Beach	RL	8119	439700	5680000	White well rounded quartz sand, squeaky noise when walked on
270.03	Norman Point	S	8119	441000	5677300	Example of multiple granite injection within a batholith
270.04	Great Glennie Island	RL	8119	434000	5673000	A 25m deep cave occurs behind the beach in a sheltered cove
270.05	Cleft Island	S	8119	439000	5665300	Spectacular sea cave 20m above sea level with 60m high roof
270.06	Five Mile Beach	RL	8120	452000	5688000	Well developed beach cusps. Narrow barrier with large back swamp
270.07	Chinaman Creek Delta	RL	8120	448500	5698500	Major deltaic feature indicating environmental change
270.08	Barrys Hill - Bennison Point	RL	8120	447000	5699000	A recent and rapidly changing coastline
270.09	Millers Landing	RL	8120	439500	5693200	Coastal granite weathering features and vegetation patterns
271	Corner Inlet*	S	8120	439000	5709000	Major tidal inlet with tidal channels & long term subsidence
271.01	Yanakie Dunes	S	8120	438500	5697000	Beach nourished by adjacent dunes
271.02	Townsends Point	RL	8120	436500	5703000	One of the few hard rock coasts in the area
271.03	Duck Point	RL	8120	436500	5704500	One of the few sustained sandy prograding areas of the coast
271.04	Duck Point West	RL	8120	435000	5704000	Wide shore platform & unusually high beach/chenier storm ridges
271.05	Red Bluff	RL	8120	433500	5704000	Intrusive margin of the Wilsons Promontory granites
271.06	The Chalk Cliffs	RL	8120	432500	5707000	Wide smooth shore platform & stratigraphic contact
271.07	Cotters Swamp Foreland	RL	8120	432000	5708000	Remnant of a former swamp and tidal inlet
271.08	Black Swamp Barrier	RL	8120	430000	5711000	Site illustrates a change in the style of coastal sedimentation
271.09	Tea Tree Point & Tea Tree Island	RL	8120	431000	5713000	Marsh island formation as a result of subsidence
271.10	Foster Beach	RL	8120	435000	5716500	Rapid and sustained erosion of an exposed coast
271.11	Van Dykes Property - Port Franklin	RL	8120	436800	5717000	One of the most vigorous growth sites for Spartina
271.12	Franklin Island	RL	8120	437000	5716000	One of the largest & least modified mangrove & salt marsh systems
271.13	Long Point	RL	8120	439000	5716500	Continuing ecological and physiographic change
271.14	Agnes River	RL	8120	445500	5718000	Natural tortuous tidal meanders
271.15	Agnes River Estuary	RL	8120	445500	5718100	Bench mark area for the study of the impact of Spartina
271.16	Toora Island	RL	8120	443300	5717700	One of the most rapidly changing islands in Corner Inlet
271.17	Toora Channel - Intertidal Flats	RL	8120	444000	5716000	Tidal drainage system of small circular & elongate depressions
271.18	Mangrove Island	RL	8120	441600	5715000	Mangrove fringed marsh island in the early stages of formation
271.19	Corner Island	RL	8120	441000	5696000	Example of the rapid change that can occur on an exposed marsh
271.20	Bennison Island & Tidal Flats	RL	8120	445000	5700000	Weathering features unusual on granitic coasts
271.21	Doughboy Island	RL	8120	437100	5708200	Northern near margin outcrop of the Wilsons Promontory Batholith
271.22	Long Island	RL	8120	438500	5699000	Shoreline showing recent and rapid retreat
271.23	Yanakie -submerged dunes	RL	8120	439000	5696000	Possible eastern extent of the Yanakie Isthmus calcareous dunes
271.24	Corner Inlet	RL	8120	439000	5709000	Tidal drainage topography on the floor of Corner Inlet
271.25	Barrier Ridges - Barry Beach - Welshpool	RL	8120	449000	5717000	Clear example of inner barrier formation
272	Corner Inlet Islands & Barrier*	N	8220	485000	5719000	Tidal channels, inlets, deltas, mangroves, barriers & islands
272.01	Dune Ridges - Gellions Run	RL	8220	468500	5721000	Wind reworked barrier dunes
272.02	Dunes, Marsh, Beaches - Gellions Run	RL	8220	469000	5720000	Clear & little modified example of barrier terrain
272.03	Albert River Estuary	RL	8220	470800	5722700	Large estuary with a diverse salt marsh community
272.04	Tarra River Estuary	RL	8220	475300	5722700	Vegetation distribution with regard to tidal and salinity level
272.05	Snake Island	S	8220	460800	5711500	Extensive sequence of parallel & converging beach ridges
272.06	Tidal Entrance & Tidal Delta	S	8220	471000	5712000	Classic example of tidal channels, inlets & deltas
272.07	Clonmel Island	S	8220	474700	5714600	Classic example of barrier island formation
272.08	Tidal Entrance & Tidal Delta	S	8220	478500	5717000	Classic example of tidal channels, inlets & deltas
272.09	Tidal Entrance & Tidal Delta	S	8220	485000	5719000	Classic example of tidal channels, inlets & deltas
272.10	Tidal Entrance & Tidal Delta	S	8220	489500	5723300	Classic example of tidal channels, inlets & deltas
273	Gippsland Lakes Outer Barrier*	N	8321	530000	5765000	Latest stage of evolution of the complex Gippsland Lakes barrier
273.01	Outer Barrier-Shallow Inlet to Reeves Beach	S	8220	490000	5724500	Major example of the formation & modification of barrier systems
273.02	Woodside Beach - Barrier & Lagoons	RL	8220	500000	5734500	Important sectors in understanding barrier evolution
273.03	Jack Smith Lake	RL	8220	503500	5739000	Large coastal lagoon
273.04	McGaurans Beach - Lagoon Sediments	RL	8321	508700	5744400	Lagoon sediments indicating barrier formation & retreat
273.05	Lake Denison - Barrier and lagoon evolution	RL	8321	513500	5749000	Lake, barrier, bluff and lagoon channel evolution
273.06	Outer Barrier near Seaspray	RL	8321	519000	5754700	Single high & grassy outer barrier ridge
273.07	Barrier Dunes - Ninety Mile Beach	S	8321	528000	5764300	Displays the evolution of the Gippsland Lakes barrier
273.08	Lake Reeve & Outer Barrier - Paradise Beach	RL	8321	537300	5773600	Widest section of the outer barrier of the Gippsland Lakes
273.09	Hopetoun Channel, Hidden Lake	RL	8422	583500	5805500	Late Holocene barrier development
273.10	Cuspate Forelands at Lakes Entrance	RL	8422	585500	5805800	Prograding sandy foreland
273.11	Cunninghame Arm	RL	8522	590000	5807600	Physiographic consequences of an artificial entrance to the Lakes
274	Merriman Creek - Delta	RL	8321	515900	5751700	Ocean coast river delta

Appendix I - Sites of Geological and Geomorphological Significance (continued)

No	Feature	Sig	Map	East	North	Description
275	Sperm Whale Head to Boole Poole Peninsula	N	8422	565000	5797000	Illustrates the evolution of the barrier system
276	Abandoned Cliff - Lake Bunga - Red Bluff	RL	8522	592500	5808400	Illustrates the processes affecting an abandoned sea cliff
277	Red Bluff	RL	8522	593400	5808400	Active marine cliff in Tertiary sediments
278	Lake Tyers	RL	8522	596000	5810000	Large submerged branching river valley
279	Lake Tyers entrance and tidal delta	RL	8522	596000	5810000	Two stages of tidal islands possibly related to changing sealevel
280	Ewing Marsh	RL	8522	610000	5814500	Swamp filled stream outlets into Ewing Marsh
281	Ewing Marsh (Simpson Creek)	RL	8522	622000	5815000	Late Quaternary evolution of a lagoon and barrier system
282	Lake Corringle	RL	8622	633000	5819000	Feature demonstrating the evolution & dynamics of the lower Snowy
283	Corringle Swamp	RL	8622	634000	5815000	Features indicating the evolution of the Snowy River estuary
284	Snowy River Islands	RL	8622	634000	5816000	'Tidal delta' islands of unknown origins
285	Snowy River entrance	S	8622	636000	5815000	Dynamic river entrance
286	Lake Curlip	RL	8622	638000	5820500	Tidal lagoon & swamp related to the Snowy & Brodribb Rivers
287	Frenches Narrows - Cliff	RL	8622	638500	5815300	Coastal cliff exposure of Tertiary and Pleistocene sediments
288	Point Ricardo - Cape Conran dune ridges	RL	8622	647000	5815000	Sandy ridges representing an unusual prograded sandy shoreline
289	Cape Conran	S	8622	652000	5813400	Clear contact between granitic intrusion and Ordovician sediments
290	Marlo Plains	S	8622	652000	5815000	Relatively undisturbed Pleistocene coastal sequence
291	Yeerung River	RL	8622	656500	5816000	Tidal lagoon has a pronounced meander, part of a larger feature
292	Dock Inlet	RL	8622	662000	5816600	Fresh water lagoon separated from the sea by only a low barrier
293	Pearl Point - Mineral sands	RL	8622	665500	5815800	Largest recorded heavy mineral deposit in Gippsland
294	Sydenham Inlet	S	8722	674500	5818000	Active & abandoned delta & extensive wetlands & tidal channels
295	Tamboon Inlet	S	8722	687500	5819000	Large relatively unmodified estuary in east Gippsland
296	Tamboon Inlet to Sydenham Inlet	S	8722	680000	5820000	Coastal sand barrier remnant
297	Clinton Rocks	RL	8722	692500	5816500	Quartzose sandstone overlying granite
298	Point Hicks and Thurra River	S	8722	700000	5815000	Important dune stratigraphic sequence
299	Mueller River estuary	RL	8722	704500	5816000	Little modified & important example of a small drowned valley
300	Rame Head	RL	8722	718800	5816100	Cliff top, long vegetated parabolic dune ridges
301	Wingan Inlet	S	8722	720200	5820000	Compound estuary
302	Easby Creek	RL	8822	722000	5820000	Little disturbed river and lagoon system
303	Red River lagoon	RL	8822	726200	5822300	Little modified river catchment and lagoon
304	Sandpatch Point	RL	8822	728500	5821500	Intrusive contact between granite and sedimentary rocks
305	Bennedore River catchment	RL	8822	731000	5824400	Little modified river catchment and lagoon
306	Bastion Point to Little Rame Head	S	8822	739500	5831500	Extensive outcrop of Palaeozoic rock & range of coastal landforms
307	Mallacoota Inlet*	S	8822	744000	5842000	Large dynamic estuary on the Victorian coast
307.01	Tidal Delta (Mallacoota Inlet)	RL	8822	744500	5840000	Large estuarine tidal delta
307.02	Goodwin Sands	RL	8822	745000	5843000	Major exposure of an eroded older barrier remnant
307.03	Allan Head (Mallacoota Inlet)	RL	8822	746300	5843900	Major exposure of the Mallacoota Beds
308	Howe Flat - Lake Barracoota	S	8822	750000	5841500	Large continuous coastal wetland
309	Tullaberga Island	RL	8822	751300	5839300	Intrusive contact between granite and Ordovician sediments
310	Telegraph Point	N	8822	756500	5841000	Large cuspate foreland with active transverse dune ridges
311	Gabo Island	RL	8822	757000	5839000	Devonian granite topped by inactive cliff top dunes
312	Lake Wau Wauka	RL	8822	758700	5844500	Stream blocked by coastal dunes
313	Iron Prince Reef (Cape Howe)	S	8822	761500	5844500	Active transverse dune ridge & Merimbula Group outcrop

Appendix II

CHARACTERISTIC NATIVE VASCULAR PLANT SPECIES OF BROAD HABITAT TYPES

KEY

Broad terrestrial habitat types

1 cliffs/slopes (calcarenite)
2 cliffs/slopes (non-calcarenite)
3 dunes (active, sparsely vegetated)
4 dunes (stable, well vegetated)
5 mangroves
6 marshes (saline)
7 marshes (brackish/freshwater)

Common name	Scientific name	Broad habitat type						
		1	2	3	4	5	6	7
Native species								
Coast wattle	*Acacia sophorae*	1	2	3	4			
White correa	*Correa alba*	1	2	3	4			
Common boobialla	*Myoporum insulare*	1	2	3	4			
Coast beard-heath	*Leucopogon parviflorus*	1	2	3	4			
Coast daisy-bush	*Olearia axillaris*	1	2	3	4			
Coast everlasting	*Ozothamnus turbinatus*	1	2	3	4			
Seaberry saltbush	*Rhagodia candolleana*	1	2	3	4			
Sticky daisy-bush	*Olearia glutinosa*	1						
Thyme rice-flower	*Pimelea serpyllifolia*	1						
Pale turpentine bush	*Beyeria lechenaultii*	1						
Moonah	*Melaleuca lanceolata*	1			4			
Wirilda	*Acacia retinodes* var. *uncifolia*	1			4			
Coast tea-tree	*Leptospermum laevigatum*	1	2		4			
Prickly spear-grass	*Stipa stipoides*	1	2				6	
Cushion bush	*Leucophyta brownii*	1	2					
Sea box	*Alyxia buxifolia*	1	2					
Drooping sheoke	*Allocasuarina verticillata*		2					
Bower spinach	*Tetragonia implexicoma*		2		4			
Coast groundsel	*Senecio spathulatus*		2		4			
Blue tussock-grass	*Poa poiformis*		2		4			
Coast banksia	*Banksia integrifolia*		2		4			
Beaded glasswort	*Sarcocornia quinqueflora*		2			5	6	
Rounded noon-flower	*Disphyma crassifolium*		2				6	
Hairy spinifex	*Spinifex sericeus*			3				
Coast saltbush	*Atriplex cinerea*			3				
Coast fescue	*Austrofestuca littoralis*			3				
Coast stackhousia	*Stackhousia spathulata*			3	4			
Knobby club-sedge	*Isolepis nodosa*			3	4			
Scented groundsel	*Senecio odoratus*				4			
Scurfy pomaderris	*Pomaderris paniculosa*				4			
Coast spear-grass	*Stipa flavescens*				4			
Coast twin-leaf	*Zygophyllum billardieri*				4			
Coast bonefruit	*Threlkeldia diffusa*				4			
Coast ballart	*Exocarpos syrticola*				4			
Coast bitter-bush	*Adriana klotzchii*				4			
Coast sword-sedge	*Lepidosperma gladiatum*				4			
Climbing lignum	*Muehlenbeckia adpressa*				4			

Appendix II - Characteristic native vascular plant species of broad habitat types (continued

Common name	Scientific name	Broad habitat type						
		1	2	3	4	5	6	7
White mangrove	*Avicennia marina*					5		
Streaked arrow-grass	*Triglochin striata*					5		
Sea rush	*Juncus kraussii*					5		7
Salt angianthus	*Angianthus preissianus*						6	
Marsh saltbush	*Atriplex paludosa*						6	
Wiry centrolepis	*Centrolepis polygyna*						6	
Grey glasswort	*Halosarcia halocnemoides*						6	
Black-seeded glasswort	*Halosarcia pergranulata*						6	
Trailing hemichroa	*Hemichroa pentandra*						6	
Salt lawrencia	*Lawrencia spicata*						6	
Creeping brookweed	*Samolus repens*						6	
White sebaea	*Sebaea albidiflora*						6	
Austral seablite	*Suaeda australis*						6	
Thick-head glasswort	*Sarcocornia blackiana*						6	
Shrubby glasswort	*Sclerostegia arbuscula*						6	
Prickly arrow-grass	*Triglochin mucronata*						6	
Shiny swamp-mat	*Selliera radicans*						6	7
Red azolla	*Azolla filiculoides*							7
Bare twig-sedge	*Baumea juncea*							7
Leafy twig-rush	*Cladium procerum*							7
Australian salt-grass	*Distichlis distichophylla*							7
Common spike-sedge	*Eleocharis acuta*							7
Tall spike-sedge	*Eleocharis sphacelata*							7
Chaffy saw-sedge	*Gahnia filum*							7
Woolly tea-tree	*Leptospermum lanigerum*							7
Common reed	*Phragmites australis*							7
Soft twig-sedge	*Baumea rubiginosa*							7
Sea club-sedge	*Bolboschoenus caldwellii*							7
Cumbungi	*Typha orientalis*							7
Eel weed	*Vallisneria spiralis*							7
Silky wilsonia	*Wilsonia humilis*							7

Appendix III

WEEDS OF COASTAL VEGETATION

The following weeds are rated as 'serious' or 'very serious' by the Department of Conservation and Natural Resources - Carr, G.W., Yugovic, J.V., and Robinson K.R. (1992). 'Environmental Weed Invasion of Victoria: Conservation and Management Implications. (Department of Conservation and Environmental and Ecological Horticulture Pty Ltd: Victoria.)

KEY

* These species relate to wetlands in Victoria generally; most (not necessarily all) occur within the coastal zone. Cord-grass (*Spartina maritima*) is doubtfully present in Victoria.

Life form

A	annual	P	perennial herb
B	biennial	Rc	root climber
Ea	emergent aquatic	S	small to medium shrub
Fa	floating aquatic	Sa	submergent aquatic
Gb	bulbous geophyte	Ss	subshrub
Gc	cormous geophyte	T	tree
Gr	rhizomatous geophyte	V	vine
Gt	tuberous geophyte	X	succulent herb, subshrub or shrub
Ls	large shrub		

Origin

Af	Africa	Mex	Mexico
Am	America	N	north
Arg	Argentina	NSW	New South Wales
As	Asia	NZ	New Zealand
C	central	Qld	Queensland
Cal	California	S	south
Ch	China	SA	South Australia
E	east	Tas	Tasmania
Eur	Europe	temp	temperate
Euras	Eurasia	trop	tropical
Hem	hemisphere	USA	United States of America
Is	Islands	Vic	Victoria
Jap	Japan	WA	Western Australia
M	middle	W	west
Med	Mediterranean		

Dispersal

E	animal, external	H	water
I	animal (not bird), internal	W	wind
B	bird, internal	V	vegetative
A	ant		

Distribution

1	widespread, medium to large populations
2	widespread, small populations
3	limited distribution, medium to large populations
4	limited distribution, small populations
5	rare or localised, medium to large populations
6	rare or localised, small populations

Appendix III - Weeds of coastal vegetation (continued)

Common name	Scientific name	Origin	Life form	Dispersal	Distribution
Dry coastal vegetation (broad habitat types 1-4)					
Sallow wattle	*Acacia longifolia*	Vic,NSW,Qld	Ls/T	B and/or A	1
Golden wreath wattle	*Acacia saligna*	WA	Ls/T	?B,A	1
Coast wattle	*Acacia sophorae*	Vic,NSW,Qld,Tas	Ls	B,A	1
Agapanthus	*Agapanthus praecox*	S Af	Gb	H,W	2
Brown-top bent	*Agrostis capillaris*	N Hem	P	E,V,W	1
Silvery hair-grass	*Aira caryophyllea*	Eur,As,Af	A	E,W	1
Angled onion	*Allium triquetrum*	W Med	Gb	V,H	1
Aloe	*Aloe saponaria*	S Af	X	V	2
Marram grass	*Ammophila arenaria*	Eur	P	E,H,W	1
Pimpernel	*Anagallis arvensis*	Eur	A	?	1
Madeira vine	*Anredera cordifolia*	S Am	V	V	6
Sweet vernal-grass	*Anthoxanthum odoratum*	Eur	P	E,H,W	1
Cape water-hawthorn	*Aponogeton distachyon*	S Af	Ea(P)	H,V	3
Cape weed	*Arctotheca calendula*	S Af	A	W	1
Asparagus	*Asparagus officinalis*	Eur,W As	Gt	B,?I	2
Onion-weed	*Asphodelus fistulosus*	Med - N India	X	E,H,W	1
Hastate orache	*Atriplex prostrata*	Eur	A	W	1
Bearded oat	*Avena barbata*	Med	A	E,?I,W	1
Wild oat	*Avena fatua*	Med	A	E,?I,W	1
Large quaking-grass	*Briza maxima*	Med	A	H,I,W	1
Prairie grass	*Bromus catharticus*	S Am	A	E,?I,W	1
Great brome	*Bromus diandrus*	Med	A	E,?I,W	1
Soft brome	*Bromus hordeaceus*	Eur,As,N Am	A	E,?I,W	1
Compact brome	*Bromus madritensis*	S Eur	A	E,?I,W	1
Red brome	*Bromus rubens*	S Eur	A	E,?I,W	1
Slender thistle	*Carduus pycnocephalus*	S Eur	A	E,H,W	1
Angled pigface	*Carpobrotus aequilaterus*	Chile	X	B,?I,V	3
Hottentot fig	*Carpobrotus edulis*	S Af	X	B,?I,V	2
Common centaury	*Centaurium erythraea*	Eur	A/B	?E,?H	1
Centaury	*Centaurium tenuiflorum*	S&W Eur	A	?E,?H	1
Mouse-ear chickweed	*Cerastium glomeratum*	Eur	A	?E,?H,I,?W	1
Boneseed	*Chrysanthemoides monilifera*	S Af	Ls	B,H,I	1
Spear thistle	*Cirsium vulgare*	Eur,As,N Af	B	E,H,W	1
Fleabane	*Conyza albida*	N & S Am	B	?E,H,W	1
New Zealand mirror-bush	*Coprosma repens*	NZ	Ls	B,I	1
Pink pampas grass	*Cortaderia jubata*	S Am	P	H,W	4
Pampas grass	*Cortaderia selloana*	S Am	P	H,W	1
Ferny cotula	*Cotula bipinnata*	S Af	A	H,?I	1
Sea barley-grass	*Critesion marinum*	Med	A	E,H,I	1
Montbretia	*Crocosmia x crocosmiiflora*	S Af	Gc	H,V	1
Monterey cypress	*Cupressus macrocarpa*	Cal	T	H,W	4
Couch	*Cynodon dactylon*	cosmopolitan	P	E,H,V	1
Rough dogs-tail	*Cynosurus echinatus*	Eur	A	E,H,?I	1
Cocksfoot	*Dactylis glomerata*	Eur,N Af,temp As	P	E,H,?W	1
Cape ivy	*Delairea odorata*	S Af	V	V,?W	1
Dipogon	*Dipogon lignosus*	S Af	V	?A	1
Dense waterweed	*Egeria densa*	S Am	Sa(P)	V	3
Perennial veldt grass	*Ehrharta calycina*	S Af	P	E,?I,W	1
Panic veldt grass	*Ehrharta erecta*	S Af	P	E,?I,W	1
Annual veldt grass	*Ehrharta longiflora*	S Af	A	E,?I,W	1
Canadian pondweed	*Elodea canadensis*	N Am	Sa(P)	V	?5
Sea spurge	*Euphorbia paralias*	Med,Euras	P	H,W	1
Fennel	*Foeniculum vulgare*	Eur,W As	P	E,H	1
Freesia	*Freesia leichtlinii*	S Af	Gc	V,W	1
Galenia	*Galenia pubescens*	S Af	P	?	1
Cleavers	*Galium aparine*	Eur	A	E,H	1
Flax-leaf broom	*Genista linifolia*	Med	S	?E,H	1
Montpellier broom	*Genista monspessulana*	Med	S	?E,H	1
Purple cudweed	*Gnaphalium purpureum*	N Am	A/B	?E,W	1
Pin-cushion hakea	*Hakea laurina*	WA	Ls	W	5
Sweet hakea	*Hakea suaveolens*	WA	Ls	W	5
Yorkshire fog	*Holcus lanatus*	Eur,As	P	E,H,I,W	1
One-leaf cape tulip	*Homeria flaccida*	S Af	Gc	E,H,I,V,W	3
Annual flatweed	*Hypochoeris glabra*	Eur,As,Af	A	E,W	1
Flatweed	*Hypochoeris radicata*	Eur,As,Af	P	E,W	1
Purple morning-glory	*Ipomoea indica*	pantropical	V	V	5
Hares-tail	*Lagurus ovatus*	Med	A	E,?I,W	1
Lampranthus	*Lampranthus tegens*	S Af	X	?	5
Hairy hawkbit	*Leontodon taraxacoides*	Eur	P	E,H,W	1
Coast tea-tree	*Leptospermum laevigatum*	Vic,NSW,Tas	Ls/T	H,W	1
Shasta daisy	*Leucanthemum maximum*	Pyrenees	P	?	4
Perennial rye-grass	*Lolium perenne*	Eur,temp As,N Af	P	E,H,I,W	1
Bearded rye-grass	*Lolium temulentum*	W As	A	E,H,I,W	1
Tall wheat-grass	*Lophopyrum elongatum*	S&SE Eur	P	H,?W	5

Appendix III - Weeds of coastal vegetation (continued)

Common name	Scientific name	Origin	Life form	Dispersal	Distribution
Birds-foot trefoil	*Lotus corniculatus*	Eur	A	H,I	1
Cretan trefoil	*Lotus creticus*	Med,Portugal	P	?	6
African box-thorn	*Lycium ferocissimum*	S Af	Ls	B,I	1
Horehound	*Marrubium vulgare*	Eur	P	E,H	1
Little medic	*Medicago minima*	Eur,Med,N Af,W As	A	E,?I	1
Burr medic	*Medicago polymorpha*	Eur,Med	A	E,I	1
Giant honey-myrtle	*Melaleuca armillaris*	Vic,NSW,Qld,Tas	Ls/T	H,W	1
Sweet melilotus	*Melilotus indica*	Med - India	A	?E,?H,?I,?W	1
Bridal creeper	*Myrsiphyllum asparagoides*	S Af	Gt	B,V	1
Serrated tussock	*Nassella trichotoma*	S Am	P	E,H,I,W	1
Tree tobacco	*Nicotiana glauca*	Arg	Ls	E,H,W	1
Water lily	*Nymphaea* alba *hybrids*	Eur (garden origin)	Ea(P)	V	5
Common evening primrose	*Oenothera stricta*	Am	P	?E,H,W	1
Pale wood-sorrel	*Oxalis incarnata*	S Af	Gb	V	2
Soursob	*Oxalis pes-caprae*	S Af	Gb	V	1
Large-flower wood-sorrel	*Oxalis purpurea*	S Af	Gb	V	1
Coast barb-grass	*Parapholis incurva*	Eur,N Af,As	A	E,H,?I,W	1
Slender barb-grass	*Parapholis strigosa*	W Eur	A	E,H,?I,W	1
Cape wattle	*Paraserianthes lophantha*	WA	Ls/T	?B,H,W	1
Paspalum	*Paspalum dilatatum*	S Am	P	E,H,I,W	1
Kikuyu	*Pennisetum clandestinum*	E Af	P	?H,V,?W	1
Toowoomba canary-grass	*Phalaris aquatica*	Med	P	E,H,?I,W	1
Lesser canary-grass	*Phalaris minor*	Med	A	E,H,?I,W	1
Timothy grass	*Phleum pratense*	Eur	P	E,H,W	4
Red ink-weed	*Phytolacca octandra*	trop Am	Ss	B	1
Ox-tongue	*Picris echioides*	Eur	A/B	E,H,W	1
Sweet pittosporum	*Pittosporum undulatum*	E Vic,NSW,Qld	T	B	1
Bucks-horn plantain	*Plantago coronopus*	Eur,W As	P	E,H,I	1
Ribwort	*Plantago lanceolata*	Eur,N Af,As	P	E,H,I	1
Myrtle-leaf milkwort	*Polygala myrtifolia*	S Af	S	H,A	1
Blue psoralea	*Psoralea pinnata*	S Af	Ls	H	1
Borrers salt marsh-grass	*Puccinellia fasciculata*	Eur,temp Af,As,N Am	P	?E,H,?I,W	5
Italian buckthorn	*Rhamnus alaternus*	Eur	Ls	B,?I	3
Common onion-grass	*Romulea rosea* var. *australis*	S Af	Gc	E,I	1
Sheep sorrel	*Rumex acetosella* spp. agg.	Eur,Med	P	E,H,I,W	1
Climbing dock	*Rumex sagittatus*	S Af	V	W	3
Arrow-head	*Sagittaria graminea*	N Am	Ea(P)	B,H	3
Pampas lily-of-the-valley	*Salpichroa origanifolia*	S Am	Gr	B,?I,V	3
Wild sage	*Salvia verbenaca*	Eur,Med	P	E	1
Climbing groundsel	*Senecio angulatus*	S Af	V	V	6
Purple groundsel	*Senecio elegans*	S Af	A	W	3
Variegated thistle	*Silybum marianum*	Eur,Med,N Af	A	E,H,W	1
Apple of sodom	*Solanum linnaeanum*	S Af,Med	S	W	3
Black nightshade	*Solanum nigrum*	cosmopolitan	P	B,H,I	1
Rough sow-thistle	*Sonchus asper*	temp N Hem	A	E,H,W	1
Milk thistle	*Sonchus oleraceus*	Eur,SW As	A	E,H,W	1
Cord-grass	*Spartina maritima*	W Eur	Ea(P)	H/V	3
Townsends cord-grass	*Spartina townsendii*	Eur (hybrid)	Ea(P)	H/V	3
Rat-tail grass	*Sporobolus indicus*	S Af	P	E,H,?I,W	1
Chickweed	*Stellaria media*	Eur,As	A	E	1
Buffalo grass	*Stenotaphrum secundatum*	Af,N Am	P	V	1
Sea wheat-grass	*Thinopyrum junceum*	W&N Eur	P	E,W	?4
Narrow-leaf clover	*Trifolium angustifolium*	Eur	A	E,I,W	1
Hares-foot clover	*Trifolium arvense*	Eur,W As	A	E,I,W	1
Hop clover	*Trifolium campestre*	Eur,N Af,W As	A	?I,W	1
Suckling clover	*Trifolium dubium*	Eur	A	E,I,W	1
Cluster clover	*Trifolium glomeratum*	SW Eur	A	?E,W	1
White clover	*Trifolium repens*	Eur,As	P	E,H,I	1
Subterranean clover	*Trifolium subterraneum*	Eur	A	I	1
Gorse	*Ulex europaeus*	W Eur	Ls	B,H	1
White cudweed	*Vellereophyton dealbatum*	S Af	A	E,H,W	1
Common vetch	*Vicia sativa* ssp. *sativa*	Eur	A	H,?I	1
Blue periwinkle	*Vinca major*	Med	P	V/W	1
Squirrel-tail fescue	*Vulpia bromoides*	Eur,W As,Af	A	E,I,W	1
Rats-tail fescue	*Vulpia myuros forma myuros*	Eur,Med,SW As	A	E,I,W	1
Bulbil watsonia	*Watsonia meriana*	S Af	Gc	H,V	1
White arum lily	*Zantedeschia aethiopica*	S Af	Gt	B,H,V	3
Wet coastal vegetation (broad habitat types 5-7)*					
Brown-top bent	*Agrostis capillaris*	N Hem	P	E,V,W	1
Creeping bent	*Agrostis stolonifera*	N Hem	P	E,V,W	1
Silvery hair-grass	*Aira caryophyllea*	Eur,As,Af	A	E,W	1
Hair-grass	*Aira elegantissima*	Eur	A	E,W	1
Angled onion	*Allium triquetrum*	W Med	Gb	V,H	1
Marsh fox-tail	*Alopecurus geniculatus*	N Hem	P	E	2

Appendix III - Weeds of coastal vegetation (continued)

Common name	Scientific name	Origin	Life form	Dispersal	Distribution
Pimpernel	*Anagallis arvensis*	Eur	A	?	1
Sweet vernal-grass	*Anthoxanthum odoratum*	Eur	P	E,H,W	1
Cape water-hawthorn	*Aponogeton distachyon*	S Af	Ea(P)	H,V	3
Aster-weed	*Aster subulatus*	N Am	B	?E,H,W	1
Hastate orache	*Atriplex prostrata*	Eur	A	W	1
Bearded oat	*Avena barbata*	Med	A	E,?I,W	1
Great brome	*Bromus diandrus*	Med	A	E,?I,W	1
Soft brome	*Bromus hordeaceus*	Eur,As,N Am	A	E,?I,W	1
Bottlebrush	*Callistemon rigidus*	NSW,Qld	Ls	H,W	5
Greater bindweed	*Calystegia silvatica*	S Eur	V	H,V	4
Common centaury	*Centaurium erythraea*	Eur	A/B	?E,?H	1
Centaury	*Centaurium tenuiflorum*	S&W Eur	A	?E,?H	1
Mouse-ear chickweed	*Cerastium glomeratum*	Eur	A	?E,?H,I,?W	1
Spear thistle	*Cirsium vulgare*	Eur,As,N Af	B	E,H,W	1
Fleabane	*Conyza albida*	N & S Am	B	?E,H,W	1
New Zealand mirror-bush	*Coprosma repens*	NZ	Ls	B,I	1
Pink pampas grass	*Cortaderia jubata*	S Am	P	H,W	4
Pampas grass	*Cortaderia selloana*	S Am	P	H,W	1
Cotoneaster	*Cotoneaster glaucophyllus*	Ch	Ls	B,?I	1
Ferny cotula	*Cotula bipinnata*	S Af	A	H,?I	1
Water buttons	*Cotula coronopifolia*	S Af	A/P	E,H,I	1
Sea barley-grass	*Critesion marinum*	Med	A	E,H,I	1
Couch	*Cynodon dactylon*	cosmopolitan	P	E,H,V	1
Drain flat-sedge	*Cyperus eragrostis*	N&S Am	P	E,H,?W	1
Cocksfoot	*Dactylis glomerata*	Eur,N Af,temp As	P	E,H,?W	1
Dense waterweed	*Egeria densa*	S Am	Sa(P)	V	3
Canadian pondweed	*Elodea canadensis*	N Am	Sa(P)	V	?5
African love-grass	*Eragrostis curvula*	S Af	P	E,W	1
Tall fescue	*Festuca arundinacea*	Eur,As	P	E,H,?I,?W	1
Evening-flower gladiolus	*Gladiolus tristis*	S Af	Gc	V	4
Gladiolus	*Gladiolus undulatus*	S Af	Gc	H,V	1
Reed sweet-grass	*Glyceria maxima*	Eur,As	Ea(P)	E,H,?V	4
Purple cudweed	*Gnaphalium purpureum*	N Am	A/B	?E,W	1
Thread iris	*Gynandriris setifolia*	S Af	Gc	?H,?I	1
Yorkshire fog	*Holcus lanatus*	Eur,As	P	E,H,I,W	1
One-leaf cape tulip	*Homeria flaccida*	S Af	Gc	E,H,I,V,W	3
Flatweed	*Hypochoeris radicata*	Eur,As,Af	P	E,W	1
Purple morning-glory	*Ipomoea indica*	pantropical	V	V	5
Yellow water iris	*Iris pseudacorus*	Eur,W As,N Af	Ea(P)	H	5
Sharp rush	*Juncus acutus*	Med,Eur,Am,S Af	P	E,H	1
Jointed rush	*Juncus articulatus*	N Hem	Ea(P)	E,H,V	1
Bulbous rush	*Juncus bulbosus*	Eur,N Af	Ea(P)	E,H,V	1
Soft rush	*Juncus effusus*	temp N Hem	P	E,H,?W	3
Rush	*Juncus microcephalus*	S Am	P	E,H	1
Hares-tail	*Lagurus ovatus*	Med	A	E,?I,W	1
Cut-grass	*Leersia oryzoides*	Eur,temp As,N Am	Ea(P)	H	5
Hairy hawkbit	*Leontodon taraxacoides*	Eur	P	E,H,W	1
Perennial rye-grass	*Lolium perenne*	Eur,temp As,N Af	P	E,H,I,W	1
Wimmera rye-grass	*Lolium rigidum*	Med	A	E,H,I,W	1
Tall wheat-grass	*Lophopyrum elongatum*	S&SE Eur	P	H,?W	5
Birds-foot trefoil	*Lotus corniculatus*	Eur	A	H,I	1
Hairy birds-foot trefoil	*Lotus subbiflorus*	Eur,N Af	P	H,I	1
Greater birds-foot tref.	*Lotus uliginosus*	Eur	P	H,I	1
Mediterranean loosestrife	*Lythrum junceum*	Med	P	?E,H	3
Burr medic	*Medicago polymorpha*	Eur,Med	A	E,I	1
Sweet melilotus	*Melilotus indica*	Med - India	A	?E,?H,?I,?W	1
Pennyroyal	*Mentha pulegium*	Eur - W As	P	E,H,V	1
Ice plant	*Mesembryanthemum cystall.*	S Af	A	H,W	3
Water forget-me-not	*Myosotis laxa* ssp. *caespitosa*	Euras,N Af	P	?E,H	3
Water lily	*Nymphaea* alba hybrids	Eur (garden origin)	Ea(P)	V	5
Coast barb-grass	*Parapholis incurva*	Eur,N Af,As	A	E,H,?I,W	1
Slender barb-grass	*Parapholis strigosa*	W Eur	A	E,H,?I,W	1
Paspalum	*Paspalum dilatatum*	S Am	P	E,H,I,W	1
Water couch	*Paspalum distichum*	cosmopolitan	Ea(P)	E,H,V	1
African feather-grass	*Pennisetum macrourum*	S Af	P	E,H,W	5
Toowoomba canary-grass	*Phalaris aquatica*	Med	P	E,H,?I,W	1
Reed canary-grass	*Phalaris arundinacea*	N Hem,S Af	Ea(P)	?E,H,?I,?W	5
Lesser canary-grass	*Phalaris minor*	Med	A	E,H,?I,W	1
Ox-tongue	*Picris echioides*	Eur	A/B	E,H,W	1
Bucks-horn plantain	*Plantago coronopus*	Eur,W As	P	E,H,I	1
Ribwort	*Plantago lanceolata*	Eur,N Af,As	P	E,H,I	1
English meadow-grass	*Poa pratensis*	Eur,temp As	P	E,H,?I,V,W	1
Annual beard-grass	*Polypogon monspeliensis*	Euras,N Af	A	E,H,?I,W	1
Borrers saltmarsh-grass	*Puccinellia fasciculata*	Eur,temp Af,As,N Am	P	?E,H,?I,W	5
Lesser spearwort	*Ranunculus flammula*	Eur	Ea(P)	H	5
Creeping buttercup	*Ranunculus repens*	Euras	P	?E,H	1

Appendix III - Weeds of coastal vegetation (continued)

Common name	Scientific name	Origin	Life form	Dispersal	Distribution
Common onion-grass	*Romulea rosea*	S Af	Gc	E,I	1
Two-row watercress	*Rorippa nasturtiumaquaticum*	Eur,N Af,W As	Ea(P)	?E,H	1
Marsh cress	*Rorippa palustris*	Eur,N Am	P	?E,H	1
Blackberry	*Rubus discolor*	Eur	Ls	B,I,V	1
Blackberry	*Rubus ulmifolius*	Eur	Ls	B,I,V	1
Sheep sorrel	*Rumex acetosella* spp. agg.	Eur,Med	P	E,H,I,W	1
Clustered dock	*Rumex conglomeratus*	cosmopolitan	P	E,H,I,W	1
Curled dock	*Rumex crispus*	Eur	P	E,H,I,W	1
Arrow-head	*Sagittaria graminea*	N Am	Ea(P)	B,H	3
White willow	*Salix alba*	Eur,N Af,W As	T	H/V	?
Weeping willow	*Salix babylonica*	Ch	T	H/V	2
Grey sallow	*Salix cinerea*	Eur,W As,N Af	Ls/T	H,V,W	1
Crack willow	*Salix* x *rubens*	Eur	T	H/V	1
Climbing groundsel	*Senecio angulatus*	S Af	V	V	6
Black nightshade	*Solanum nigrum*	cosmopolitan	P	B,H,I	1
Rough sow-thistle	*Sonchus asper*	temp N Hem	A	E,H,W	1
Milk thistle	*Sonchus oleraceus*	Eur,SW As	A	E,H,W	1
Townsends cord-grass	*Spartina x townsendii*	Eur (hybrid)	Ea(P)	H/V	3
Rat-tail grass	*Sporobolus indicus*	S Af	P	E,H,?I,W	1
Sea wheat-grass	*Thinopyrum junceum*	W&N Eur	P	E,W	?4
Narrow-leaf clover	*Trifolium angustifolium*	Eur	A	E,I,W	1
Hop clover	*Trifolium campestre*	Eur,N Af,W As	A	?I,W	1
Suckling clover	*Trifolium dubium*	Eur	A	E,I,W	1
Cluster clover	*Trifolium glomeratum*	SW Eur	A	?E,W	1
White clover	*Trifolium repens*	Eur,As	P	E,H,I	1
Rough clover	*Trifolium scabrum*	Eur,W As	A	E,?I,W	?
Knotted clover	*Trifolium striatum*	Eur,W As,N Af	A	E,?I,W	3
Subterranean clover	*Trifolium subterraneum*	Eur	A	I	1
Great reedmace	*Typha latifolia*	N Hem,N&C Af,S Am	Ea(P)	E,H,W	3
White cudweed	*Vellereophyton dealbatum*	S Af	A	E,H,W	1
Squirrel-tail fescue	*Vulpia bromoides*	Eur,W As,Af	A	E,I,W	1
Rats-tail fescue	*Vulpia myuros*	Eur,Med,SW As	A	E,I,W	1
Bulbil watsonia	*Watsonia meriana*	S Af	Gc	H,V	1
Bathurst burr	*Xanthium spinosum*	trop Am	A	E,H	1
White arum lily	*Zantedeschia aethiopica*	S Af	Gt	B,H,V	3

Appendix IV

CHARACTERISTIC FAUNA OF BROAD HABITAT TYPES

KEY

• Denotes introduced species

Broad terrestrial habitat types

1 cliffs/slopes (calcarenite)
2 cliffs/slopes (non-calcarenite)
3 dunes (active, sparsely vegetated)
4 dunes (stable, well vegetated)
5 mangroves
6 marshes (saline)
7 marshes (brackish/freshwater)

Status

S state significance
S(RC) restricted colonial breeding/roosting sites
T JAMBA/CAMBA
I Introduced

Common name	Scientific name	Status	Broad habitat type						
			1	2	3	4	5	6	7
MAMMALS									
Brown antechinus	*Antechinus stuartii*		1			4			
Bush rat	*Rattus fuscipes*		1	2		4			
White-footed dunnart	*Sminthopsis leucopus*		1	2		4			
Common ringtail possum	*Pseudocheirus peregrinus*		1	2		4			
Short-beaked echidna	*Tachyglossus aculeatus*		1	2		4			
Swamp wallaby	*Wallabia bicolor*		1	2		4			
Eastern pygmy possum	*Cercartetus nanus*		1	2		4			
House mouse*	*Mus musculus*	I	1	2	3	4			
Swamp antechinus	*Antechinus minimus*	S	1	2		4			7
Swamp rat	*Rattus lutreolus*		1	2		4			7
Black rat*	*Rattus rattus*	I	1	2	3	4			7
Australian fur-seal	*Arctocephalus pusillis*	S (RC)		2					
Common bent-wing bat	*Miniopterus schreibersii*	S (RC)		2					
European rabbit*	*Oryctolagus cuniculus*	I		2	3				
Water rat	*Hydromys chrysogaster*							6	7
Platypus	*Ornithorhynchus anatinus*								7
BIRDS									
Silvereye	*Zosterops lateralis*		1	2		4			
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*		1	2		4			
New holland honeyeater	*Phylidonyris novaehollandiae*		1	2		4			
European greenfinch*	*Carduelis chloris*	I	1	2		4			
Rufous bristlebird	*Dasyornis broadbenti*	S	1	2		4			
Red-browed firetail	*Emblema temporalis*		1	2		4			
White-eared honeyeater	*Lichenostomus leucotis*		1	2		4			
Yellow-faced honeyeater	*Lichenostomus chrysops*		1	2		4			
Beautiful firetail	*Emblema bella*		1	2		4			
Grey fantail	*Rhipidura fuliginosa*		1	2		4			7
Brown thornbill	*Acanthiza pusilla*		1	2		4			7
White-browed scrubwren	*Sericornis frontalis*		1	2		4			7

Appendix IV - Characteristic fauna of broad habitat types (continued)

Common name	Scientific name	Status	Broad habitat type						
			1	2	3	4	5	6	7
Superb fairy-wren	*Malurus cyaneus*		1	2		4			7
Peregrine falcon	*Falco peregrinus*		1	2				6	7
Welcome swallow	*Hirundo neoxena*		1	2				6	7
Australian pelican	*Pelecanus conspicillatus*	S (RC)		2	3	4		6	7
Buff-banded rail	*Rallus philippensis*			2				6	7
White-fronted chat	*Ephthianura albifrons*			2				6	
Little penguin	*Eudyptula minor*			2		4			
White-faced storm-petrel	*Pelagodroma marina*	S (RC)		2		4			
Common diving-petrel	*Pelecanoides urinatrix*	S (RC)		2					
Singing honeyeater	*Lichenostomus virescens*			2					
Feral pigeon*	*Columba livia*	I		2					
Short-tailed shearwater	*Puffinus tenuirostris*	T		2					
Common starling*	*Sturnus vulgaris*	I		2					
Fairy prion	*Pachyptila turtur*	S (RC)		2					
Black-faced shag	*Leucocarbo fuscescens*	S (RC)		2					
Australasian gannet	*Morus serrator*	S (RC)		2					
Cape barren goose	*Cereopsis novaehollandiae*	S		2					
Pied oystercatcher	*Haematopus longirostris*			2	3				
Ruddy turnstone	*Arenaria interpres*	T		2	3				
Sooty oystercatcher	*Haematopus fuliginosus*			2	3				
Kelp gull	*Larus dominicanus*	S (RC)		2	3				
Crested tern	*Sterna bergii*	S (RC),T		2	3				
White-fronted tern	*Sterna striata*			2	3				
Pacific gull	*Larus pacificus*	S (RC)		2	3	4			
Silver gull	*Larus novaehollandiae*			2	3	4			
Little wattlebird	*Anthochaera chrysoptera*			2		4			
Pied cormorant	*Phalacrocorax varius*			2			5		7
Little pied cormorant	*Phalacrocorax melanoleucos*			2			5		7
Great cormorant	*Phalacrocorax carbo*			2			5		7
Little black cormorant	*Phalacrocorax sulcirostris*			2			5		7
Golden-headed cisticola	*Cisticola exilis*			2					7
White-bellied sea-eagle	*Accipiter cirrhocephalus*	S, T		2	3			6	7
Little tern	*Sterna albifrons*	S,T			3				
Gull-billed tern	*Gelochelidon nilotica*	S (RC)			3				
Bar-tailed godwit	*Limosa lapponica*	T			3				
Caspian tern	*Hydroprogne caspia*	S (RC),T			3				
Wood sandpiper	*Tringa glareola*	T			3				
Terek sandpiper	*Tringa terek*	T			3		5		
Eastern curlew	*Numenius madagascariensis*	S, T			3			6	
Red-capped plover	*Charadrius ruficapillus*				3			6	
Double-banded plover	*Charadrius bicinctus*				3			6	
Red-necked stint	*Calidris ruficollis*	T			3			6	7
Masked lapwing	*Vanellus miles*				3			6	7
Curlew sandpiper	*Calidris ferruginea*	T			3			6	7
Calamanthus	*Sericornis fuliginosus*				3	4		6	7
Fairy tern	*Sterna nereis*	S			3				
Red knot	*Calidris canutus*	T			3				
Sanderling	*Calidris alba*	T			3				
Forest raven	*Corvus tasmanicus*				3				
Hooded plover	*Charadrius rubricollis*	S			3				
Great knot	*Calidris tenuirostris*	T			3				
Grey-tailed tattler	*Tringa breviceps*	T			3		5		
Pink robin	*Petroica rodinogaster*					4			
Rainbow lorikeet	*Trichoglossus haematodus*					4			

Appendix IV - Characteristic fauna of broad habitat types (continued)

Common name	Scientific name	Status	Broad habitat type						
			1	2	3	4	5	6	7
White-throated treecreeper	*Climacteris leucophaea*					4			
House sparrow*	*Passer domesticus*	I				4		6	
Lesser golden plover	*Pluvialis dominica*	T						6	
Spotless crake	*Porzana tabuensis*						5		7
Azure kingfisher	*Ceyx azurea*						5		7
Australian crake	*Porzana fluminea*						5	6	7
Common sandpiper	*Tringa hypoleucos*	T					5	6	7
Great egret	*Egretta alba*	T					5	6	7
Greenshank	*Tringa nebularia*	T					5	6	7
Little egret	*Egretta garzetta*						5	6	7
Little grassbird	*Megalurus gramineus*						5	6	7
Royal spoonbill	*Platalea regia*	S (RC)					5	6	7
Sacred ibis	*Threskiornis aethiopicus*						5	6	7
White-faced heron	*Ardea novaehollandiae*						5	6	7
Banded lapwing	*Vanellus tricolor*							6	
Blue-winged parrot	*Neophema chrysostoma*							6	
Chestnut teal	*Anas castanea*							6	7
European goldfinch*	*Carduelis carduelis*	I						6	
Grey plover	*Pluvialis squatarola*	T						6	
Lewin's rail	*Rallus pectoralis*	S						6	
Orange-bellied parrot	*Neophema chrysogaster*	S						6	
Australasian shoveler	*Anas rhynchotis*							6	7
Australian shelduck	*Tadorna tadornoides*							6	7
Black swan	*Cygnus atratus*							6	7
Black-fronted plover	*Charadrius melanops*							6	7
Black-winged stilt	*Himantopus himantopus*							6	7
Grey teal	*Anas gibberifrons*							6	7
Latham's snipe	*Gallinago hardwickii*	T						6	7
Marsh harrier	*Circus aeruginosus*							6	7
Marsh sandpiper	*Tringa nebularia*	T						6	7
Pacific heron	*Ardea pacifica*							6	7
Red-kneed dotterel	*Erithrogonys cinctus*							6	7
Sharp-tailed sandpiper	*Calidris acuminata*	T						6	7
Australasian bittern	*Botaurus poiciloptilus*	S							7
Australasian grebe	*Tachybaptus novaehollandiae*								7
Baillon's crake	*Porzana pusilla*	S							7
Blue-billed duck	*Oxyura australis*	S							7
Cape barren goose	*Cereopsis novaehollandiae*	S							7
Clamorous reed-warbler	*Acrocephalus stentoreus*								7
Darter	*Anhinga melanogaster*	S (RC)							7
Dusky moorhen	*Gallinula tenebrosa*								7
Eastern bristlebird	*Dasyornis brachypterus*	S							7
Eurasian coot	*Fulica atra*								7
Fairy martin	*Cecropis ariel*								7
Glossy ibis	*Plegadis falcinellus*								7
Great crested grebe	*Podiceps cristatus*								7
Ground parrot	*Pezoporus wallicus*	S							7
Hardhead	*Aythya australis*								7
Hoary-headed grebe	*Poliocephalus poliocephalus*								7
Intermediate egret	*Egretta intermedia*								7
Lewin's rail	*Rallus pectoralis*	S							7
Maned duck	*Chenonetta jubata*								7
Musk duck	*Biziura lobata*								7
Noisy miner	*Manorina melanocephala*								7

Appendix IV - Characteristic fauna of broad habitat types (continued)

Common name	Scientific name	Status	Broad habitat type						
			1	2	3	4	5	6	7
Pacific black duck	*Anas superciliosa*								7
Pink-eared duck	*Malacorhynchus membranaceus*								7
Purple swamphen	*Porphyrio porphyrio*								7
Rufous night heron	*Nycticorax caledonicus*								7
Straw-necked ibis	*Threskiornis spinicollis*								7
Tree martin	*Cecropis nigricans*								7
Whiskered tern	*Chlidonias hybrida*	S (RC)							7
Whistling kite	*Milvus migrans*								7
White-winged tern	*Chlidonias leucoptera*								7
Yellow-billed spoonbill	*Platalea flavipes*								7
REPTILES									
Blotched blue-tongued lizard	*Tiliqua nigrolutea*		1	2	3	4			
Common blue-tongued lizard	*Tiliqua scincoides*		1	2	3	4			
Eastern three-lined skink	*Leiolopisma deperreyi*		1	2	3	4			
Four-toed skink	*Hemiergis peronii*	S	1		3	4			
Southern water skink	*Sphenomorphus tympanum*			2					
Metallic skink	*Leiolopisma metallicum*			2	3	4	5	6	
Grass skink	*Leiolopisma entrecasteauxii*				3	4		6	
Lowland copperhead	*Austrelaps superbus*				3	4			7
White's skink	*Egernia whitii*					4			
Eastern water skink	*Sphenomorphus tympanum*					4			
Striped worm-lizard	*Aprasia striolata*					4			
Tree dragon	*Amphibolurus muricatus*					4			
Garden skink	*Lampropholis guichenoti*					4			
Glossy grass skink	*Leiolopisma rawlinsoni*							6	7
Swamp skink	*Egernia coventryi*	S						6	7
Tiger snake	*Notechis scutatus*								7
Common long-necked tortoise	*Chelodina longicollis*								7
AMPHIBIANS									
Common froglet	*Crinia signifera*								7
Green and golden grass frog	*Litoria aurea*								7
Growling grass frog	*Litoria raniformis*								7
Haswell's froglet	*Paracrinia haswelli*								7
Peron's tree frog	*Litoria peronii*								7
Southern bullfrog	*Limnodynastes dumerilii*								7
Southern toadlet	*Pseudophryne semimarmorata*								7
Spotted marsh frog	*Limnodynastes tasmaniensis*								7
Striped marsh frog	*Limnodynastes peronii*								7
Tyler's toadlet	*Uperoleia tyleri*								7
Verreaux's tree frog	*Litoria verreauxii*								7
Victorian smooth froglet	*Geocrinia victoriana*								7

Appendix V

SITES OF TERRESTRIAL BIOLOGICAL SIGNIFICANCE

KEY

Significant species

Species listed here refer only to species of State significance. Significance status for flora is based on 'Rare or Threatened Plants in Victoria' (Gullan *et al.* 1990) and for fauna from 'Interim List of Threatened Fauna in Victoria in 1993' (Baker-Gabb 1993).

The significance status follows the species name and the following abbreviation is used.

e	- endangered in Victoria	i	- insuffiently known
v	- vulnerable in Victoria	rc	- species having only a few restricted colonial breeding or roosting sites in Victoria
r	- rare in Victoria		

It should be noted that many species of regional and local significance occur along the coast, however these have not been documented due to time and information constraints (lack of survey data). Consideration of these species and their habitats is nonetheless important.

Significance

L	Local	N	National
R	Regional	I	International
S	State	prob.	Probable

Map (location)

This refers to the 1:100 000 mapsheet series name and the nominal grid reference for the site.

Land status

CP	Coastal Park	NP	National Park
CR	Coastal Reserve	RA	Reference Area
EA	Education Area	SP	State Park
FR	Flora Reserve	WR	Wildlife Reserve
LR	Lake Reserve		

Sites of significance

Sites are shown on Map 2. Some sites form part of larger sites of significance that extend further inland than the 1 km considered for this investigation.

No	Name	Significance	Map (location)	Land status	Area (ha)
1	Mouth of Glenelg River	**Flora** S **Fauna** R	Nelson 000875	Discovery Bay CP	230

Habitats

Dunes (active, stable), marshes (saline)

Description

Flora Relatively undisturbed coastal lagoon and salt marsh (restricted vegetation type in western Victoria), intact coastal dune vegetation. Significant species: *Pterostylis cucullata* (v), *Taraxacum cygnorum* (e).

Fauna Rich habitat for waterfowl (swans, ducks, bitterns, rails, etc) and waders; orange-bellied parrot (e), little tern (e), hooded plover (v). four-toed skink (i). Altona skipper butterfly present.

Source: Barson and Calder (1976), Dorward (1976), J. Fisher (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
2	Long Swamp	**Flora** S **Fauna** S	Nelson 100830	Discovery Bay CP, private land	2140

Habitats

Dunes (active, stable), marches (brackish/ freshwater)

Description

Flora Series of diverse swamps behind coastal dunes. Significant species: Haloragis myriocarpa (v), *Logania ovata* (r), *Prasophyllum frenchii* (r), *Pterostylis tenuissima* (r).

Fauna Most westerly population of the eastern subspecies of Ground Parrot (r) and last remaining Victorian population west of Cape Otway. Other significant fauna: swamp antechinus (r), rufous bristlebird (r), Australasian bittern (i), breeding Chestnut Teal. Good wetland habitat.

Site No 2 (continued)

Source: Barson and Calder (1976), Dorward (1976), Meredith and Isles (1980), Meredith and Jaremovic (1990), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
3	Discovery Bay	**Flora** S **Fauna** R	Nelson 260690	Discovery Bay CP	4750

Habitats: Dunes (active), marshes (brackish/ freshwater)

Description
Flora Extensive dune system (although largely unvegetated), dune lakes supporting wetland vegetation.
Fauna Swamp antechinus (r), rufous bristlebird (r).

Source: Dorward (1976), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
4	Bridgewater Lakes	**Flora** S **Fauna** R	Nelson 350590	Discovery Bay CP private land	470

Habitats: Dunes (active, stable), marshes (brackish/ freshwater)

Description
Flora Dune lakes supporting freshwater swamp communities, fringed by Moonah scrub. Significant species: *Corybas despectans* (r), *Schoenus carsei* (r), *Pterostylis cucullata* (v).
Fauna Swamp antechinus (r), Australasian bittern (i)

Source: Barson and Calder (1976), Dorward (1976), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
5	Cape Bridgewater	**Flora** - **Fauna** prob. S	Nelson 360500 (precise boundary not determined)	Discovery Bay CP	<1

Habitats: Dunes (stable), cliffs/slopes (non-calcarenite)

Description
Flora None documented.
Fauna Four-toed skink (i), possible common bent-wing bat (rc) roost; last mainland hauling ground for Australian fur seals (rc).

Source: Dorward (1976), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
6	Cape Nelson	**Flora** S **Fauna** R	Portland 470470	Cape Nelson SP (private land excluded), Commonwealth lighthouse reserve.	540

Habitats: Cliffs/slopes (calcarenite)

Description
Flora Scrub dominated by *Eucalyptus diversifolia* at its eastern range limit. Intact cliff vegetation. Significant species: *Acrotriche cordata* (r), *Caladenia hastata* (e), *Schoenus deformis* (v), *Lasiopetalum schulzenii* (r), *Eucalyptus diversifolia* (r), *Orthrosanthus multiflorus* (r).
Fauna Rufous bristlebird (r), heath mouse (r)

Source: Barson and Calder (1976), Dorward (1976), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
7	Point Danger	**Flora** S **Fauna** R	Portland 565500	Private land (Alcoa), Coastal Reserve	80

Habitats: Cliffs/slopes (non-calcarenite)

Description
Flora Species-rich heathland, cliff vegetation. Significant species: *Caladenia hastata* (e).
Fauna Swamp antechinus (r), heath mouse (r), rufous bristlebird (r).

Source: Barson and Calder (1976), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
8	Lawrence Rocks	**Flora** - **Fauna** N	Portland 585485	WR	c. 20

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora None documented.
Fauna Largest gannet colony in Australia. Seabird breeding colonies: little penguin, fairy prion (rc), common diving petrel (rc), australasian gannet (rc).

Source: Menkhorst (see Chapter 4), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
8A	Lady Julia Percy Island	**Flora** R **Fauna** S	Portland 873474	WR	140

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Good stands of *Asplenium obtusatum* (v). Grassland, closed fernland, *Senecio* herbland and succulent herbland communities present but all affected to some extent by rabbits and weeds.
Fauna Seabird breeding colonies: Little penguin, fairy prion (rc), common diving petrel (rc), short-tailed shearwater. breeding site for Australian fur-seal (rc).

Source: Norman *et al.* (1980), Menkhorst (see Chapter 4), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
9	Cape Reamur	**Flora** R **Fauna** -	Warrnambool 996500 (precise boundary not determined)	Private land Crown land	Not calculated

Habitats
Dunes (active, stable)

Description
Flora Remnant of dune scrub once common along coast between Portland and Warrnambool.
Fauna None documented

Source: Barson and Calder (1976), J. Fisher (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
10	Port Fairy Shore and Griffith Island	**Flora** R **Fauna** S	Warrnambool 084595	CR	100

Habitats
Cliffs/slopes (calcarenite), dunes (stable), marshes (saline)

Description
Flora Supports salt marsh (restricted in western Victoria).
Fauna Breeding colonies of Little Penguin (small nos.) and short-tailed shearwaters (52 000); beaches and rocky coast used by waders but value as wader habitat appears to have declined due to recreational use.

Source: Barson and Calder (1976), Dorward (1976), Menkhorst (see Chapter 4), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
11	Killarney Reef	**Flora** - **Fauna** S	Warrnambool 170540	Not determined	Not calculated

Habitats
Reef offshore of dunes (active)

Description
Flora Nil
fauna Breeding site for crested tern (rc) (200) and silver gull (500)

Source: Menkhorst (see Chapter 4)

No	Name	Significance	Map (location)	Land status	Area (ha)
11A	Rutledges Cutting	**Flora** L **Fauna** S	Warrnambool 170540	Private land	90

Site No 11A (continued)

Habitats	Description
Dunes (stable), salt marsh	**Flora** Salt marsh of local significance. **Fauna** Orange-bellied parrots consistently recorded at the site. breeding site for crested tern (rc) (200) and silver gull (500)

Source: Carr G. (*pers. comm.*), Carr *et al.* (in prep.)

No	Name	Significance	Map (location)	Land status	Area (ha)
12	Armstrong Bay	**Flora** R **Fauna** R	Warrnambool 260500	CR	90

Habitats	Description
Dunes (active), cliffs/slopes (calcarenite), marsh (fresh/ brackish)	**Flora** Supports wetland sedge/herbland complex, dune scrub and coastal tussock grassland, vegetation types which are depleted in western Victoria. Significant species: *Exocarpus syrticola* (r). **Fauna** Coast scrub habitat of regional significane, wetland habitat of local significance.

Source: Larwill *et al.* (1992), J. Fisher (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
13	Warrnambool Shore, Thunder Point	**Flora** - **Fauna** R	Warrnambool 275490	CR	Not calculated

Habitats	Description
Dunes (active)	**Flora** None documented **Fauna** Common bent-wing bat (rc) roosting cave

Source: L. Lumsden (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
14	Middle and Merri Islands, Warrnambool	**Flora** - **Fauna** R	Warrnambool 285480	CR	1-2

Habitats	Description
Not determined	**Flora** None documented **Fauna** Regional significance. little penguin breeding colonies (200 on each island).

Source: Menkhorst (see Chapter 4), J. Fisher (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
15	Lake Gillear Cave	**Flora** - **Fauna** S	Mortlake 390450 (approximate)	Private land	<1

Habitats	Description
Cliffs/slopes (calcarenite)	**Flora** None documented **Fauna** One of only two common bent-wing bat (rc) maternity caves in Victoria.

Source: L. Lumsden (*pers. comm.*), J. Fisher (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
16	Point Mepunga	**Flora** R **Fauna** -	Mortlake 410420	CR	c. 10

Habitats	Description
Cliffs/slopes (calcarenite)	**Flora** Low open shrubland developed on karstic topography (very restricted vegetation type). **Fauna** None documented

Source: Barson and Calder (1976), J. Fisher (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
17	Armstrongs Creek to Flaxmans Hill	**Flora** R **Fauna** -	Port Campbell 525325 (boundary not determined)	CP	Not calculated

Site No 17 (continued)

Habitats	Description
Cliffs/slopes (non-calcarenite), dunes (active)	**Flora** Coastal cliff vegetation, remnant heathland on cliff-top. **Fauna** Little penguin colony near Flaxmans Hill.

Source: Barson and Calder (1976)

No	Name	Significance	Map (location)	Land status	Area (ha)
18	Port Campbell Cliffs and Hinterland	**Flora** S **Fauna** S	Princetown 770220	Port Campbell NP	1780

Habitats	Description
Dunes (active, stable), Cliffs/ slopes (non-calcarenite), marshes (brackish/ freshwater)	**Flora** Cliff vegetation backed by species-rich heathland and forest, marsh vegetation (mostly associated with creeks), dune vegetation. Significant species: *Baumea laxa* (r), *Diuris palustris* (v), *Exocarpus syrticola* (r), *Glycine latrobeana* (v), *Haloragis exalata* (v), *Logania ovata* (r), *Orthrosanthus multiflorus* (r), *Pneumatopteris pennigera* (v), *Thelymitra epipactoides* (e), *Triglochin minutissima* (r). **Fauna** Breeding sites for little penguin, black-faced shag (rc), short-tailed shearwater; peregrine falcon breeding; rufous bristlebird (r); waders on beaches; swamp antechinus (r).

Source: Barson and Calder (1976), Dorward (1976), Colac Region DCNR, Menkhorst (see Chapter 4)

No	Name	Significance	Map (location)	Land status	Area (ha)
19	Moonlight Head (The Gable)	**Flora** S **Fauna** R	Princetown 940070	Otway NP	760

Habitats	Description
Cliffs/slopes (calcarenite), cliffs/slopes (non-calcarenite)	**Flora** Excellent examples of western coastal scrub and heathland communities. **Fauna** Broad-toothed Rat (r), Swamp Antechinus (r)

Source: Barson and Calder (1976), Dorward (1976), J. Yugovic (*pers. obs.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
20	Cape Volney	**Flora** - **Fauna** prob. R	Princetown 970060	Otway NP	<1

Habitats	Description
Cliffs/slopes (non-calcarenite)	**Flora** None documented **Fauna** Probable common bent-wing bat (rc) roosting site.

Source: L. Lumsden (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
21	Cape Volney to Johanna Beach	**Flora** R **Fauna** R	Princetown 030080	Otway NP	420

Habitats	Description
Cliffs/slopes (non-calcarenite), dunes (stable)	**Flora** Largely intact coastal cliff vegetation. **Fauna** Swamp antechinus (r), hooded plover (v), rufous bristlebird (r).

Source: C. Meredith (*pers. obs.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
22	Rotten Point to Point Franklin	**Flora** S **Fauna** S	Princetown 150020	Otway NP	890

Site No 22 (continued)

Habitats
Cliffs/slopes (calcarenite), cliffs/slopes (non-calcarenite), dunes (stable), dunes (unstable)

Description
Flora Calcarenitic vegetation, including the Olearia lanuginosa - Olearia lepidophylla complex (occurs between the Aire River and Cape Otway). Calcarenite cliffs support a distinctive vegetation community which appears to have floristic links with the Mallee. Dune vegetation at Aire River mouth. Non-calcarenitic heathland, woodland, forest and coastal scrub above Rotten Point. Significant species: *Correa backhousiana* (r), *Exocarpos syrticola* (r).
Fauna Swamp antechinus (r), broad-toothed rat (r), hooded plover (v), rufous bristlebird (r).

Source: Barson and Calder (1976); Dorward (1976), Colac Region DCNR.

No	Name	Significance	Map (location)	Land status	Area (ha)
23	Point Franklin to Shelly Beach	**Flora** S **Fauna** N	Otway 250000 (inland boundary not determined; part of larger site of biological significance including all of Otway NP)	Cape Otway NP	880

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Intact woodland, forest and coastal scrub. Significant species: *Eucalyptus brookeriana* (r), *Eucalyptus kitsoniana* (r), *Correa backhousiana* (r).
Fauna High species richness of vertebrates; smoky mouse (r), broad-toothed rat (r), swamp antechinus (r), ground parrot (r), rufous bristlebird (r) (strong population); large area of high quality habitat with little disturbance.

Source: Barson and Calder (1976); Dorward (1976), Colac Region DCNR, C. Meredith (*pers. obs.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
24	Cape Patton to Lorne	**Flora** S **Fauna** S	Otway 540220 (inland boundary not determined; part of larger site of biological significance including all of Angahook - Lorne SP)	Angahook–Lorne SP, private land	1930

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Intact forest and coastal scrub communities.
Fauna Only record for smoky mouse (r) in western victoria (unconfirmed), swamp antechinus (r), rufous bristlebird (r), common bent-wing bat (rc) roosting cave near Cape Patton

Source: Conole and Baverstock (1983), L. Lumsden (*pers. comm.*), C. Meredith (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
25	Lorne to Aireys Inlet	**Flora** R **Fauna** R	Geelong 410370	Angahook–Lorne SP, private land	290

Habitats
Cliffs/slopes (non-calcarenite), dunes (stable)

Description
Flora Coastal scrub communities.
Fauna Significant species: swamp antechinus (r), rufous bristlebird (r).

Source: Conole and Baverstock (1983), L. Lumsden (*pers. comm.*), C. Meredith (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
26	Mouth of Painkalac Creek	**Flora** R/S **Fauna** R	Geelong 465385	CR	60

Site No 26 (continued)

Habitats
Marsh (saline), dunes (stable)

Description
Flora Small estuary supporting salt marsh (rare vegetation type in the Otway region), dune vegetation. Significant species: *Pomaderis oraria* ssp. *oraria* (r).
Fauna Broad-toothed rat (r), good wetland habitat.

Source: Ecological Horticulture (1990), C. Meredith (*pers. obs.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
27	Urquhart Bluff Coastline	**Flora** N **Fauna** N	Geelong 500420	Coastal reserve, private land	590

Habitats
Dunes (stable), cliffs/slopes (non-calcarenite)

Description
Flora Coastal scrub on dunes, species-rich heathland on slopes. Significant species: *Eucalyptus* aff. *alaticaulis*, *Thelymitra benthamiana* (r).
Fauna Swamp antechinus (r), rufous bristlebird (r); part of a site of national significance for its small mammal species richness; on its own, the coastal section of this site is of State significance.

Source: Wilson *et al.* (1986), Meredith *et al.* (1991)

No	Name	Significance	Map (location)	Land status	Area (ha)
28	Anglesea River	**Flora** R **Fauna** L	Geelong 535445	Coastal reserve	40

Habitats
Marsh (saline)

Description
Flora Only extensive area of salt marsh in the Otway region.
Fauna Some waterbird habitat.

Source: Barson and Calder (1976)

No	Name	Significance	Map (location)	Land status	Area (ha)
29	Anglesea to Bells Beach	**Flora** S **Fauna** R	Geelong 600470	Coastal reserve	440

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Coastal scrub on exposed cliff faces and on terraced slumps, species-rich heathland on cliff-tops, forest dominated by *Eucalyptus tricarpa* (part of isolated occurrence in western Otways) and *Eucalyptus obliqua*.
Fauna Rufous bristlebird (r)

Source: Barson and Calder (1976), Wark *et al.* (1987), J. Yugovic (*pers. obs*).

No	Name	Significance	Map (location)	Land status	Area (ha)
30	Breamlea	**Flora** R **Fauna** R	Geelong 710580	Private land	430

Habitats
Marshes (saline)

Description
Flora Small 'dry' salt marsh associated with Thompson Creek.
Fauna Potential habitat for orange-bellied parrot (e). other significant species: hooded plover (v).

Source: J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
31	Lake Connewarre and Barwon River	**Flora** N **Fauna** I	Geelong 770650	Lake Connewarre Game Reserve	3300

Habitats
Marshes (saline), marshes (brackish/ freshwater), dunes (stable)

Description
Flora Extensive, largely undisturbed estuary and coastal lagoon. One of the most diverse salt marsh areas in Australia. Several vegetation communities, such as *Wilsonia humilis* herbland and *Distichlis distichophylla* grassland, are rare elsewhere in Victoria. Southern range limit for *Halosarcia halocnemoides* and *Muehlenbeckia florulenta*. Extensive brackish/freshwater swamp at Reedy Lake, Moonah scrub along Barwon River. Significant species: Adriana quadridentata (e), *Triglochin minutissima* (r).

Site No 31 (continued)

Fauna Listed as part of a larger Ramsar site (Port Phillip Bay (Western Shoreline) and Bellarine Peninsula. Important habitat for large numbers of waders, waterbirds and other fauna. Very significant site for orange-bellied parrot (e) (important winter habitat).

Source: Barson and Calder (1976), Yugovic (1985), Stephenson (1991); Ramsar listing.

No	Name	Significance	Map (location)	Land status	Area (ha)
32	Lonsdale lakes	**Flora** R **Fauna** S	Sorrento 880610	Lonsdale Lakes WR	260

Habitats: Marshes (saline)

Description

Flora 'Dry' salt marsh (although highly disturbed in places), Moonah dune scrub.

Fauna Site for orange-bellied parrot (e) (some winter use). Important habitat for water birds and other fauna.

Source: Stephenson (1991), J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
33	Swan Bay	**Flora** S **Fauna** I	Sorrento 950650	Swan Bay–Edwards Point WR, Swan Bay MR, Commonwealth land, private land	3520

Habitats: Marshes (saline), dunes (stable)

Description

Flora Substantial areas of 'wet' and 'dry' salt marsh, dune scrub on Edwards Point in mosaic with salt marsh. Significant species: *Adriana quadripartita* (e), *Halophila decipiens* (r), *Lepilaena marina* (r), *Triglochin minutissima* (r).

Fauna Listed as part of a larger Ramsar site (Port Phillip Bay (Western Shoreline) and Bellarine Peninsula. Important habitat for large numbers of waders, waterbirds and other fauna. Supports >1% of the Australian populations of lesser golden plover, grey plover, Mongolian plover, double-banded plover and eastern curlew (r), and >5% of the Victorian populations of the marsh sandpiper, grey-tailed tattler and red knot. Significant site for orange-bellied parrot (e) (winter habitat).

Source: Lane *et al.* (1984), Walker (1990), Barson and Calder (1976), Stephenson (1991)

No	Name	Significance	Map (location)	Land status	Area (ha)
33A	Pope's Eye	**Flora** - **Fauna** S	Sorrento 950650	Harold Holt Marine Reserve	<0.5

Habitats: Artificial structure

Description

Flora None

Fauna Breeding site for up to 32 pairs of Australasian gannets.

Source: Marchant & Higgins (1990)

No	Name	Significance	Map (location)	Land status	Area (ha)
33B	Wedge Light	**Flora** - **Fauna** S	Sorrento 950650	Port of Melbourne Authority	<0.5

Habitats: Artificial structure

Description

Flora None

Fauna Breeding site for up to 40 pairs of Australasian Gannets.

Source: Marchant & Higgins (1990)

No	Name	Significance	Map (location)	Land status	Area (ha)
34	Mud Islands	**Flora** S **Fauna** N	Sorento 050620	Mud Islands WR, Harold Holt MR	86

Habitats: Marshes (saline), dunes (stable)

Description

Flora Complex mosaic of salt marsh (in excellent condition) and dune shrubland surrounding sheltered lagoon with *Zostera muelleri*. Significant species: *Lavatera plebeia* var. *tomentosa* (r).

Site No 34 (continued)

Fauna Listed as part of a larger Ramsar site (Port Phillip Bay (Western Shoreline) and Bellarine Peninsula. Important feeding and roosting habitat for large numbers of waders; important seabird and waterbird nesting site for little penguin (2), white-faced storm-petrel (rc) (5 600), silver gull (50 000), crested tern (rc) (2 000), Caspian tern (rc) (25), fairy tern (v) (25), Australian pelican (rc) (30-40) and pied cormorant (100). Supports >1% of the Australian populations of lesser golden plover, ruddy turnstone, Mongolian plover and grey plover, and >5% of the Victorian populations of red knot and great knot.

Source: Lane *et al.* (1984), J. Yugovic (unpublished), Menkhorst (see Chapter 4), Menkhorst *et al.* (1988), Ramsar listing.

No	Name	Significance	Map (location)	Land status	Area (ha)
35	South Channel Island	**Flora** - **Fauna** S	Sorrento 075575	Not determined	<1

Habitats: Dunes (stable)

Description
Flora Artificial island with colonising plant species (mainly weeds). The presence of *Lavatera plebia*, a species of Regional significance.
Fauna Important seabird nesting site: little penguin (2), white-faced storm-petrel (rc) (6800), silver gull (200) and Australasian gannets.

Source: J. Yugovic (*pers. obs.*), Menkhorst (see Chapter 4)

No	Name	Significance	Map (location)	Land status	Area (ha)
36	St Leonards - Salt Lake	**Flora** R **Fauna** -	Geelong 995740	St Leonards WR	90

Habitats: Marsh (saline)

Description
Flora Coastal salt lake supporting 'dry' salt marsh.
Fauna Not described.

Source: J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
37	Geelong Saltworks	**Flora** L **Fauna** N	Geelong 740750	Private land	950

Habitats: Marsh (saline)

Description
Flora Disturbed salt marsh.
Fauna Supports >1% of the Australian populations of eastern golden plover, red-necked avocet, greenshank, curlew sandpiper, sharp-tailed sandpiper, banded stilt and red-necked stint, and >5% of the Victorian population of marsh sandpiper. Other significant species: Latham's snipe.

Source: Lane *et al.* (1984).

No	Name	Significance	Map (location)	Land status	Area (ha)
38	Limeburners Bay	**Flora** R **Fauna** N	Geelong 850730	Limeburners Bay FR	160

Habitats: Marsh (saline)

Description
Flora Isolated occurrence of *Avicennia marina*, examples of 'wet' and 'dry' salt marsh.
Fauna Listed as part of a larger Ramsar site (Port Phillip Bay (Western Shoreline) and Bellarine Peninsula. Important habitat for large numbers of waders. Altona skipper butterfly present.

Source: Lane *et al.* (1984), Schulz *et al.* (1991), Ramsar listing, Barson and Calder (1976).

No	Name	Significance	Map (location)	Land status	Area (ha)
39	Metropolitan Farm Werribee to Avalon Salt Works	**Flora** N **Fauna** I	Sorrento 820850 (inland boundary not shown; part of larger RAMSAR site of biological significance)	Metropolitan Farm, Werribee, The Spit WR, Commonwealth land, private land.	3300

Site No 39 (continued)

Habitats
Marshes (saline), adjacent (altered) native grassland

Description
Flora One of the richest salt marsh areas in Australia. Best development of 'dry' salt marsh in coastal Victoria. Largest area of *Halosarcia halocnemoides* marsh in coastal Victoria. Significant species: *Pterostylis truncata* (e), *Triglochin minutissima* (r).
Fauna Listed as part of a larger Ramsar site (Port Phillip Bay, Western Shoreline) and Bellarine Peninsula. Important feeding and roosting habitat for large numbers of waders and waterbirds. Supports >1% of the Australian populations of double-banded plover, sharp-tailed sandpiper, curlew sandpiper, red-necked stint, red-necked avocet, lesser golden plover, pied oystercatcher and greenshank, and >5% of the Victorian populations of marsh sandpiper and grey-tailed tattler. Extremely significant wintering site for the orange-bellied parrot (e) (The Spit WR is the most important of all mainland habitat areas). Contains breeding colonies of fairy terns (v) (50) and pied cormorants (320).

Source: Lane *et al.* (1984), Schulz *et al.* (1991), Brown & Wilson (1984), Carr (1980), Yugovic (1984), Cropper and Calder (1987)

No	Name	Significance	Map (location)	Land status	Area (ha)
40	Point Cook and Laverton Saltworks	**Flora** S **Fauna** I	Melbourne 060010	Point Cook Metropolitan Park, private land	970

Habitats
Marshes (saline), dunes (stable)

Description
Flora Examples of 'dry' salt marsh, dune vegetation.
Fauna Listed as part of a larger Ramsar site (Port Phillip Bay, Western Shoreline) and Bellarine Peninsula. Important habitat for large numbers of waders and waterbirds. RAAF Lake is important roost for double-banded and lesser golden plovers. orange-bellied parrot (e) occurs here. Striped legless lizard (v) has been recorded. Altona skipper butterfly present.

Source: Meredith *et al.* (1989), Goodwin & Meredith (1992), Lane *et al.* (1984), Schulz et al. (1991), Cantrill and Lunt (1984), McDougall (1987), Cheal *et al.* (in prep.).

No	Name	Significance	Map (location)	Land status	Area (ha)
41	Altona to Williamstown	**Flora** S **Fauna** N	Melbourne 130070	Council Reserve, Jawbone FFR (part)	60

Habitats
Marshes (saline)

Description
Flora Largest occurrence of *Avicennia marina* in Port Phillip Bay. Unique occurrence of mangroves on basalt boulder substrate. Examples of 'wet' and 'dry' salt marsh. Modified native grassland adjacent to salt marsh. Significant species: *Triglochin minutissima* (r).
Fauna Listed as part of a larger Ramsar site (Port Phillip Bay, Western Shoreline) and Bellarine Peninsula. Important feeding and roosting habitat on mudflats for large numbers of waders (especially double-banded plover, red-necked avocet, greenshank, curlew sandpiper, red-necked stint, sharp-tailed sandpiper, banded stilt and marsh sandpiper). Orange-bellied parrot (e) occurs occasionally.

Source: Barson and Calder (1976), McDougall (1987), Yugovic (1987), Ecological Horticulture (1987), Cheal *et al.* (in prep.), Lane *et al.* (1984), Schulz *et al.* (1991), Ramsar listing.

No	Name	Significance	Map (location)	Land status	Area (ha)
42	Sandringham Foreshore (Hampton to Beaumaris)	**Flora** R **Fauna** L	Melbourne 240990	Foreshore Reserve	c. 100

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Remnant areas of Banksia woodland and dune scrub.
Fauna Presence of native birds in an urban location.

Source: Kirkpatrick (1974), Cheal *et al.* (in prep.), Lane *et al.* (1984).

No	Name	Significance	Map (location)	Land status	Area (ha)
43	Seaford Foreshore and Kananook Creek	**Flora** R **Fauna** L	Western Port 340800	Foreshore Reserve	c. 50

Site No 43 (continued)

Habitats
Dunes stable well vegetated, marsh (saline)

Description
Flora Remnant Banksia woodland, dune scrub, swamp scrub.
Fauna Presence of native birds in an urban location.

Source: Cullen (1973), Lane *et al.* (1984), DCE (1991a), Cheal *et al.* (*in prep.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
44	Mornington Foreshore (Mount Eliza to Mount Martha)	**Flora** R **Fauna** L	Western Port 280680	Foreshore Reserve	c. 150

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Supports tea-tree scrub, Banksia woodland, salt marsh. Significant species: *Sarcocornia quinqueflora* ssp. *tasmanica* (e).
Fauna Presence of native birds in an urban location.

Source: Moorrees and Molnar (1992), J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
45	Balcombe Creek Estuary	**Flora** R **Fauna** R	Western Port 270620	Municipal Reserve	c. 100

Habitats
Marshes (brackish/freshwater and saline)

Description
Flora Supports valuable remnants of swamp scrub and salt marsh.
Fauna Provides habitat for waders and other waterbirds.

Source: Moorrees and Molnar (1992), J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
46	Point Nepean and Sorrento coastline	**Flora** S **Fauna** S	Sorrento 150400	Public - NP and CR	2040

Habitats
Cliffs/slopes (calcarenite and non-calcarenite), dunes (stable and unstable)

Description
Flora Contains a range of vegetation communities characteristic of coastal areas, including coastal dune scrub, coastal banksia woodland, coastal grassy forest, riparian forest, coastal tussock grassland, coastal heathland, swamp heathland and sand heathland. Significant species: *Adiantum capillus-veneris* (e), *Adriana quadripartita* (e), *Caladenia patersonii* (r), *Corybas despectans* (r), *Nicotiana maritima* (e), *Olearia* sp. aff. *lanuginosa*, *Pteris comans* (r), *Pterostylis cucullata* (v).
Fauna Important roosting site for cormorants, gulls and terns, supports 5% of Victorian population of sooty oystercatcher, site of only breeding attempt of kelp gull (rc) in Port Phillip Bay, good coastal bushland habitat. Other significant species include hooded plover (v).

Source: Barson and Calder (1976), Moorrees and Molnar (1992), Lane *et al.* (1984).

No	Name	Significance	Map (location)	Land status	Area (ha)
47	Western Port	**Flora** - **Fauna** I	Western Port 570675	Various	52 300

Habitats
Intertidal mudflats

Description
Flora No terrestrial vegetation.
Fauna Western Port Bay is recognized as being of international significance under the Ramsar Convention. At least 295 bird species have been recorded in the bay (Shapiro 1975). The bay represents the third most important overwintering site for waders in Victoria, supporting 12.3% of its wader population (Lane 1987). Thirty-seven species of waders (including five vagrants) have been recorded in the bay (Andrew et al. 1984); many of these are listed under JAMBA and CAMBA Agreements. The bay provides a stronghold for whimbrel and eastern curlew (r) and forms the fourth largest overwintering site for eastern curlew (Lane 1987), a species which is thought to depend on extensive eelgrass beds. Pied oystercatchers and royal spoonbills (rc) also have strongholds in the bay. In addition, 10 species of waders occur here at their highest densities within the State, including terek sandpiper, eastern curlew, bar-tailed godwit, grey-tailed tattler and greenshank.

Site No 47 (continued)

For migratory waders, the main habitat requirements comprise mudflats for foraging (especially those exposed at high tide) and high tide roosts where birds await the next feeding period. Mudflats which remain exposed at high tide are a limited resource in Western Port Bay; the bay therefore favours larger species or those which forage over longer periods (Dann 1987). Andrew et al. (1984) have identified primary and secondary feeding sites for waders in the bay; the authors designated these to be of national and state significance, respectively. High tide roosts consist of islands, promontories and sandy banks.

Although mudflats are available throughout the bay, only 16 major roost sites and nine minor roosts have been identified (Loyn 1978). Three major high tide roosts have been identified by Andrew et al. (1984). Reef Island is utilized by red-necked stint, curlew sandpiper, red-capped plover, ruddy turnstone and double-banded plover. The Settlement Road roost is important for double-banded plover, curlew sandpiper, eastern curlew, red-necked stint and red knot. Yallock Creek mouth is utilized by roosting greenshank, curlew sandpiper, red-necked stint, sharp-tailed sandpiper, eastern curlew and masked lapwing.

NOTE: The Western Port site defined above (site 47) refers only to areas below high tide mark. A number of other coastal sites of significance occur around the Bay; these are listed below (sites 48-57).

Source: Ramsar listing, Andrew *et al.* (1984)

No	Name	Significance	Map (location)	Land status	Area (ha)
48	Coolart	**Flora** L **Fauna** S	Western Port 370490	Public land (includes area of coastal reserve)	130

Habitats: Marshes (saline, brackish/freshwater) dunes (stable)

Description:
Flora Dune scrub woodland, salt marsh, artificial freshwater wetlands.
Fauna Records of over 119 native bird species. Breeding colonies of royal spoonbill (rc), sacred ibis, straw-necked ibis and little pied cormorant. Other significant species: Australasian bittern (i), Cape Barren goose (r) and spotless crake.

Source: Andrew *et al.* (1984)

No	Name	Significance	Map (location)	Land status	Area (ha)
49	Sandy Point	**Flora** S **Fauna** ?R	Western Port 440480	Commonwealth (Navy), CR, some private land	1040

Habitats: Marshes (saline), mangroves, dunes (stable)

Description:
Flora Includes relatively undisturbed examples of dune scrub, Banksia woodland, grassy forest.
Fauna Good population of white-footed dunnart.

Source: Andrew *et al.* (1984) Moorrees and Molnar (1992)

No	Name	Significance	Map (location)	Land status	Area (ha)
50	Crib Point to Hastings	**Flora** R/S **Fauna** R	Western Port 440510	Commonwealth, CR, some private land	670

Habitats: Marshes (saline), mangroves

Description:
Flora Includes relatively undisturbed examples of dune scrub, Banksia woodland, grassy forest, heathland, swamp scrub, salt marsh, mangrove. Significant species: *Triglochin minutissima* (r).
Fauna Includes large remnants of native vegetation, providing a range of habitat types. Record of white-footed dunnart, a regionally significant species. Significant species: swamp skink (r).

Source: Andrew *et al.* (1984), Schulz M. (1985), Moorrees and Molnar (1992), Jaremovic *et al.* (1991).

No	Name	Significance	Map (location)	Land status	Area (ha)
51	Western and Northern Shores of Western Port	**Flora** S **Fauna** S	Western Port 460640	WR, CR, private land	1890

Site No 43 (continued)

Habitats
Dunes stable well vegetated, marsh (saline)

Description
Flora Remnant Banksia woodland, dune scrub, swamp scrub.
Fauna Presence of native birds in an urban location.

Source: Cullen (1973), Lane *et al.* (1984), DCE (1991a), Cheal *et al.* (in prep.).

No	Name	Significance	Map (location)	Land status	Area (ha)
44	Mornington Foreshore (Mount Eliza to Mount Martha)	**Flora** R **Fauna** L	Western Port 280680	Foreshore Reserve	c. 150

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Supports tea-tree scrub, Banksia woodland, salt marsh. Significant species: *Sarcocornia quinqueflora* ssp. *tasmanica* (e).
Fauna Presence of native birds in an urban location.

Source: Moorrees and Molnar (1992), J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
45	Balcombe Creek Estuary	**Flora** R **Fauna** R	Western Port 270620	Municipal Reserve	c. 100

Habitats
Marshes (brackish/freshwater and saline)

Description
Flora Supports valuable remnants of swamp scrub and salt marsh.
Fauna Provides habitat for waders and other waterbirds.

Source: Moorrees and Molnar (1992), J. Yugovic (*pers. obs.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
46	Point Nepean and Sorrento coastline	**Flora** S **Fauna** S	Sorrento 150400	Public - NP and CR	2040

Habitats
Cliffs/slopes (calcarenite and non-calcarenite), dunes (stable and unstable)

Description
Flora Contains a range of vegetation communities characteristic of coastal areas, including coastal dune scrub, coastal banksia woodland, coastal grassy forest, riparian forest, coastal tussock grassland, coastal heathland, swamp heathland and sand heathland. Significant species: *Adiantum capillus-veneris* (e), *Adriana quadripartita* (e), *Caladenia patersonii* (r), *Corybas despectans* (r), *Nicotiana maritima* (e), *Olearia* sp. aff. *lanuginosa*, *Pteris comans* (r), *Pterostylis cucullata* (v).
Fauna Important roosting site for cormorants, gulls and terns, supports 5% of Victorian population of sooty oystercatcher, site of only breeding attempt of kelp gull (rc) in Port Phillip Bay, good coastal bushland habitat. Other significant species include hooded plover (v).

Source: Barson and Calder (1976), Moorrees and Molnar (1992), Lane *et al.* (1984).

No	Name	Significance	Map (location)	Land status	Area (ha)
47	Western Port	**Flora** - **Fauna** I	Western Port 570675	Various	52 300

Habitats
Intertidal mudflats

Description
Flora No terrestrial vegetation.
Fauna Western Port Bay is recognized as being of international significance under the Ramsar Convention. At least 295 bird species have been recorded in the bay (Shapiro 1975). The bay represents the third most important overwintering site for waders in Victoria, supporting 12.3% of its wader population (Lane 1987). Thirty-seven species of waders (including five vagrants) have been recorded in the bay (Andrew et al. 1984); many of these are listed under JAMBA and CAMBA Agreements. The bay provides a stronghold for whimbrel and eastern curlew (r) and forms the fourth largest overwintering site for eastern curlew (Lane 1987), a species which is thought to depend on extensive eelgrass beds. Pied oystercatchers and royal spoonbills (rc) also have strongholds in the bay. In addition, 10 species of waders occur here at their highest densities within the State, including terek sandpiper, eastern curlew, bar-tailed godwit, grey-tailed tattler and greenshank.

Site No 47 (continued)

For migratory waders, the main habitat requirements comprise mudflats for foraging (especially those exposed at high tide) and high tide roosts where birds await the next feeding period. Mudflats which remain exposed at high tide are a limited resource in Western Port Bay; the bay therefore favours larger species or those which forage over longer periods (Dann 1987). Andrew et al. (1984) have identified primary and secondary feeding sites for waders in the bay; the authors designated these to be of national and state significance, respectively. High tide roosts consist of islands, promontories and sandy banks.

Although mudflats are available throughout the bay, only 16 major roost sites and nine minor roosts have been identified (Loyn 1978). Three major high tide roosts have been identified by Andrew et al. (1984). Reef Island is utilized by red-necked stint, curlew sandpiper, red-capped plover, ruddy turnstone and double-banded plover. The Settlement Road roost is important for double-banded plover, curlew sandpiper, eastern curlew, red-necked stint and red knot. Yallock Creek mouth is utilized by roosting greenshank, curlew sandpiper, red-necked stint, sharp-tailed sandpiper, eastern curlew and masked lapwing.

NOTE: The Western Port site defined above (site 47) refers only to areas below high tide mark. A number of other coastal sites of significance occur around the Bay; these are listed below (sites 48-57).

Source: Ramsar listing, Andrew *et al.* (1984)

No	Name	Significance	Map (location)	Land status	Area (ha)
48	Coolart	**Flora** L **Fauna** S	Western Port 370490	Public land (includes area of coastal reserve)	130

Habitats: Marshes (saline, brackish/freshwater) dunes (stable)

Description
Flora Dune scrub woodland, salt marsh, artificial freshwater wetlands.
Fauna Records of over 119 native bird species. Breeding colonies of royal spoonbill (rc), sacred ibis, straw-necked ibis and little pied cormorant. Other significant species: Australasian bittern (i), Cape Barren goose (r) and spotless crake.

Source: Andrew *et al.* (1984)

No	Name	Significance	Map (location)	Land status	Area (ha)
49	Sandy Point	**Flora** S **Fauna** ?R	Western Port 440480	Commonwealth (Navy), CR, some private land	1040

Habitats: Marshes (saline), mangroves, dunes (stable)

Description
Flora Includes relatively undisturbed examples of dune scrub, Banksia woodland, grassy forest.
Fauna Good population of white-footed dunnart.

Source: Andrew *et al.* (1984) Moorrees and Molnar (1992)

No	Name	Significance	Map (location)	Land status	Area (ha)
50	Crib Point to Hastings	**Flora** R/S **Fauna** R	Western Port 440510	Commonwealth, CR, some private land	670

Habitats: Marshes (saline), mangroves

Description
Flora Includes relatively undisturbed examples of dune scrub, Banksia woodland, grassy forest, heathland, swamp scrub, salt marsh, mangrove. Significant species: *Triglochin minutissima* (r).
Fauna Includes large remnants of native vegetation, providing a range of habitat types. Record of white-footed dunnart, a regionally significant species. Significant species: swamp skink (r).

Source: Andrew *et al.* (1984), Schulz M. (1985), Moorrees and Molnar (1992), Jaremovic *et al.* (1991).

No	Name	Significance	Map (location)	Land status	Area (ha)
51	Western and Northern Shores of Western Port	**Flora** S **Fauna** S	Western Port 460640	WR, CR, private land	1890

Site No 51 (continued)

Habitats
Marshes (saline), mangroves, dunes (stable)

Description
Flora More or less continuous strip of foreshore vegetation, including heathland, woodland, swamp scrub, salt marsh, mangroves.
Fauna Primary foraging site for migratory waders (see Western Port Bay). Salt marshes and mangroves are important roosting areas for waders, cormorants, herons and egrets. Other significant species: Australasian bittern (i), orange-bellied parrot (e), swamp skink (r).

Source: Andrew *et al.* (1984), Schulz M. (1985), Moorrees and Molnar (1992)

No	Name	Significance	Map (location)	Land status	Area (ha)
52	Quail and Chinaman Islands	**Flora** S **Fauna** R	Western Port 500670	Wildlife Reserves	540

Habitats
Marshes (saline), mangroves, dunes (stable)

Description
Flora Extensive intact vegetation including heathland, woodland, swamp scrub, salt marsh, mangroves.
Fauna Salt marshes and mangroves are important roosting areas for waders, cormorants, herons and egrets.

Source: Andrew *et al.* (1984), Moorrees and Molnar (1992)

No	Name	Significance	Map (location)	Land status	Area (ha)
53	French Island (including off-shore islands)	**Flora** N/S **Fauna** S	Western Port 570575	Public–State Park, private land	5390

Habitats
Cliffs/slopes (non-calcarenite) marshes (saline), mangroves, dunes (stable)

Description
Flora Supports high quality, representative examples of damp sclerophyll forest, heathland, swamp scrub and sedgeland, salt marsh, mangroves and coastal tussock grassland. Significant species: *Burnettia cuneata* (r), *Caladenia insularis* (v), *Exocarpus syrticola* (r), *Lycopodium serpentinum* (r), *Olearia viscosa* (r), *Prasophyllum truncatum* (r), *Microtis orbicularis* (r), *Tetratheca stenocarpa* (r), *Thelymitra mucida* (v), *Thelymitra* sp. aff. *ixiodes* (r).
Fauna Relatively undisturbed, contains extensive and diverse habitats in a range of native vegetation types which are severely depleted on the mainland. It is the stronghold for the long-nosed potoroo in the Western Port area. Six of the 16 major wader roost sites in Western Port Bay. Tortoise Head is utilized by breeding Caspian (rc) and fairy terns (v) and is an important roost site for Mongolian plovers and eastern curlews (r). Wetland habitats are used by breeding Australian pelicans, pied cormorants, royal spoonbills (rc), blue-billed ducks (r) and white-bellied sea-eagles (r). Rams Island is utilized by breeding fairy tern (v), Caspian tern (rc) and pied oystercatcher; it is also a major roost site for bar-tailed godwit and whimbrel. Barrallier Island is also a major high tide roost, supporting large numbers of waders. Other significant species: orange-bellied parrot (e), king quail (r), swamp skink (r) and glossy grass skink (i).

Source: Dorward 1976, Schulz M. (1985), Andrew *et al.* (1984), Moorrees and Molnar (1992), C. Gordes (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
54	Bass River Mouth	**Flora** R **Fauna** R	Western Port 640390	Public–wildlife reserve, and private land	410

Habitats
Marshes (saline), mangroves

Description
Flora Extensive salt marsh and estuary vegetation.
Fauna Important habitat for a range of birds, secondary feeding areas for migratory waders.
Significant species: Orange-bellied parrot (e).

Source: Barson and Calder (1976), Andrew *et al.* (1984), Moorrees and Molnar (1992)

No	Name	Significance	Map (location)	Land status	Area (ha)
55	Conservation Hill	**Flora** R **Fauna** S	Western Port 500410	WR (proposed)	640

Site No 55 (continued)

Habitats
Mangroves, marsh (brackish/freshwater and saline), cliffs/slopes (non-calcarenite)

Description
Flora Supports mangroves, salt marsh, Banksia woodland, forest, swamp scrub and dune scrub.
Fauna Major breeding colony of Royal Spoonbill (rc), one of few on Victorian coast. Supports over 50 bird species, with many breeding colonies.

Source: Barson and Calder (1976), Andrew *et al.* (1984), Moorrees and Molnar (1992)

No	Name	Significance	Map (location)	Land status	Area (ha)
56	Seal Rocks	**Flora** - **Fauna** N	Woolamai 342343	FR	c.2

Habitats
Cliffs/slopes (non-calcarenite)

Description
Flora Nil
Fauna The largest breeding colony of Australian fur-seal (rc) in the world (22% of population). Only Victorian breeding site of kelp gull (rc), breeding sooty oystercatcher.

Source: Andrew *et al.* (1984)

No	Name	Significance	Map (location)	Land status	Area (ha)
57	Phillip Island (South and West Coasts)	**Flora** S **Fauna** S	Woolamai 470365, Western Port 390390	Public–Coastal Reserve and State Faunal Reserve and private land	1540

Habitats
Dunes (active), marsh (brackish/freshwater), cliffs/slopes (non-calcarenite).

Description
Flora Disturbed remnants of coastal tussock grassland and dune scrub. Coastal tussock grassland is a rare vegetation community in Victoria, being far more common on the islands of Bass Strait. Stands of *Melaleuca lanceolata*, the most easterly occurrence in Victoria. Significant species: *Asplenium obtusatum* (v), *Cyathodes juniperina* (v), *Exocarpus syrticola* (r).
Fauna Major breeding colonies of short-tailed shearwater and little penguin. Breeding colony for royal spoonbill (rc) at Rhyll Swamp. Nesting sites for hooded plover (v) and peregrine falcon.

Source: Barson and Calder (1976), Opie *et al.* (1984), Andrew *et al.* (1984), Moorrees and Molnar (1992).

No	Name	Significance	Map (location)	Land status	Area (ha)
58	Bunurong Coastline	**Flora** S **Fauna** R	Wonthaggi 760200	Bunurong Marine and Coastal Park, Coastal Reserve	1710

Habitats
Cliffs/slopes calcarenite and non-calcarenite, dunes (active, sparsely vegetated), dunes (stable)

Description
Flora Supports species rich heathland, good quality examples of dune scrub and Banksia woodland, salt marsh, coastal tussock grassland. Significant species: *Caladenia fragrantissima* ssp. *orientalis* (v), *Microtis orbicularis* (r), *Prasophyllum lindleyanum* (v), *Prasophyllum truncatum* (r), *Pterostylis cucullata* (v).
Fauna Hooded plover (v) and peregrine falcon nest here. Other ignificant species: Swamp antechinus (r).

Source: Moorrees and Molnar (1992), DCE (1992), S. Taylor, F. MacLennan (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
59	Andersons Inlet	**Flora** R **Fauna** S	Wonthaggi 940210	private land, Marine and Coastal Park	2740

Habitats
Marshes (saline), mangrove, cliffs/slopes non-calcarenite, dunes (stable, well-vegetated)

Description
Flora Dune scrub, large areas of salt marsh and mangroves.
Fauna Important site for migratory and non-migratory waders and waterbirds. Of particular importance for lesser golden plover, double-banded plover, eastern curlew (r), greenshank and red-necked stint. Peregrine nesting area. Other significant species: swamp antechinus (r).

Site No 59 (continued)

Source: Barson and Calder (1976), Lane (1987), S. Taylor, F. MacLennan (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
60	Cape Liptrap to Walkerville	**Flora** S **Fauna** S	Wonthaggi 060930	Venus Bay–Waratah Bay Coastal Park	1380

Habitats
Cliffs/slopes (calcarenite, non-calcarenite)

Description
Flora Diverse heathland, mosaic of age classes. Near coastal remnant of warm temperate rainforest at Bear Gully. Significant species: *Eucalyptus kitsoniana* (r), *Exocarpos syrticola* (r), *Schoenus turbinatus* (r).
Fauna Common bent-wing bat (rc) overwintering cave is located at Arch Rock. Peregrine falcon nesting site located at Cape Liptrap. Other significant species: Swamp antechinus (r) and swamp skink (r).

Source: Barson and Calder (1976), LCC (1980), S. Taylor (*pers. comm.*), F. MacLennan (*pers. comm.*), L. Lumsden (*pers. comm.*), V. Hurley (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
61	Shallow Inlet	**Flora** R **Fauna** N	Foster 260030	Shallow Inlet Marine and Wildlife Reserve	2500

Habitats
Marshes (saline), Dunes (stable, well vegetated)

Description
Flora Small areas of salt marsh, sequence of vegetation from ocean dune to sheltered embayment. Significant species: *Allocasuarina media* (r).
Fauna Important to migratory waders. Holds more than one per cent of the population of an avifaunal region (Australasia) in 1983 for six species: lesser golden plover, double-banded plover, eastern curlew, red-necked stint, curlew sandpiper and sanderling. Other significant species: Swamp antechinus (r), Cape Barren goose (r), and swamp skink (r).

Source: LCC (1980), Lane (1987), DCFL (1990), S. Taylor (*pers. comm.*), F. MacLennan (pers. comm).

No	Name	Significance	Map (location)	Land status	Area (ha)
62	Wilsons Promontory Coast	**Flora** N **Fauna** S	Foster 450900	Wilsons Promontory NP	16980

Habitats
Dunes (stable, active), cliffs/slopes (calcarenite, non-calcarenite), marshes (saline, brackish/freshwater), mangroves (all habitat types)

Description
Flora Highly diverse coastal vegetation in a large range of habitats. Of biogeographic significance, demonstrating links with Tasmanian vegetation, range limit of many species. Significant species: *Asplenium obtusatum* (v), *Baumea laxa* (r), *Cyathodes juniperina* (v), *Eucalyptus kitsoniana* (r), *Gahnia grandis* (v), *Lepidium desvauxii* (r), *Leucopogon esquamatus* (r), *Exocarpus syrticola* (r), *Pimelea drupacea*(v), *Pseudoraphis paradoxa* (e), *Pterostylis cucullata* (v), *Pterostylis tenuissima* (r), *Schoenus carsei* (r).
Fauna Nest sites of white-bellied sea-eagle (r) and peregrine falcon and is one of top 20 sites for hooded plover (v) in Victoria. Other significant species: Swamp antechinus (r), New Holland mouse (e), broad-toothed rat (r) and swamp skink (r).

Source: Barson and Calder (1976), LCC (1980), DCFL (1987)

No	Name	Significance	Map (location)	Land status	Area (ha)
63	Wilsons Promontory Islands	**Flora** S **Fauna** S	Foster, Wilsons Promontory (Shellback Is, Rabbit, Norman Is, Anser Group)	Wilsons Promontory NP, Anser Is RA	Shellback 37 Norman 48 Rabbit 30 Anser Is 74 Kanowna 31 Wattle Is, Anderson Inlets, Cleft Islet - areas not determined

Site No 63 (continued)

Habitats	Description
Cliffs/slopes (non-calcarenite)	**Flora** Tussock grassland, saline herbland and scrub communities. Significant species: *Apium insulare* (r), *Asplenium obtusatum* (v). **Fauna** Breeding colonies of Australian fur-seal (rc) (Kanowna Is., Anderson Islets, Cleft Is.), fairy prion (rc) (Kanowna Is., Anser Is.), common diving-petrel (rc) (Kanowna Is.), Cape Barren goose (r) and Pacific gull (rc) (Shellback Is, Norman Is., Kanowna Is., Anser Is., Wattle Is., Rabbit Rocks). Peregrine falcons breed on Rabbit Island.

Source: Barson and Calder (1976), Norman *et al.* (1980), Menkhorst (see Chapter 4), V. Hurley (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
64	Corner Inlet	**Flora** S **Fauna** I	Yarram 800180	Nooramunga and Corner Inlet MWR, Wilsons Promontory NP (islands), Coastal Reserve, private land	110 000

Habitats	Description
Mangroves, marshes (saline), dunes (active, stable)	**Flora** Salt marsh (one of two large areas in Victoria), mangroves and relatively undisturbed coastal vegetation. Includes the most southern mangroves *Avicennia marina* in the world. Parts of the mangrove/salt marsh vegetation is bounded by undisturbed hinterland vegetation (Gellions Run, Wilsons Promontory). Interesting vegetation succession on coastal sands. Significant species: *Asplenium obtusifolium* (v), *Cyathodes juniperina* (v), *Lepidium desvauxii* (r), *Pterostylis aciculiformis* (r), *Senecio diaschides* (r), *Triglochin minutissima* (r). **Fauna** Important for resident and migratory waders; it supports up to 21.5% of Victoria's wader population. In addition, it supports up to 50% of Victoria's migratory waders, in particular grey plover, bar-tailed godwit, red knot and great knot. Of particular significance for eastern curlew (r), sooty oystercatcher, Mongolian plover, double-banded plover, grey-tailed tattler, greenshank, red-necked stint, curlew sandpiper, sanderling and chestnut teal. Breeding colonies for fairy tern (v) (Manns Beach, Snake Island), little tern (e) (small numbers), crested tern (rc) and Caspian tern (rc) and rufous night-heron (rc) are located there. Black-faced shag (rc) nest on Granite Island. Other significant species: Orange-bellied parrot (e), swamp antechinus (r), hooded plover (v), ground parrot (r), white-bellied sea-eagle (r). Records of New Holland mouse (e) from Reeves Beach.

Source: Barson and Calder (1976), LCC (1981), Mansergh and Norris (1982), Gullan *et al.* (1984), Frood (1986), Lane (1987), Menkhorst (see Chapter 4), S. Taylor (*pers. comm.*), F. MacLennan (*pers. comm.*), J. Reside (*pers comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
65	Jack Smith Lake	**Flora** R **Fauna** S	Sale 010400	Jack Smith Lake WR, Ninety Mile Beach CR, private land	c. 3700

Habitats	Description
Marshes (saline, brackish/freshwater) dunes (stable)	**Flora** Supports salt marsh and remnants of Banksia woodland and dune scrub. Vegetation has been grazed and partly cleared. **Fauna** Important habitat corridor between Corner Inlet and Gippsland lakes, large coastal wetland, habitat for waterbirds and birds of prey. Supports 19 bird species listed on JAMBA and CAMBA; it is one of the top 20 sites for double-banded plover in Victoria. An Australian pelican (rc) breeding colony is located here. Significant species: Orange-bellied parrot (e), white-bellied sea-eagle (r) and hooded plover (v) and glossy grass skink (i).

Source: Mansergh and Norris (1982), DCE (1991b) S. Taylor (*pers. comm.*), F. MacLennan (pers comm.)

No	Name	Significance	Map (location)	Land status	Area (ha)
66	Lake Dennison	**Flora** R **Fauna** R	Sale 120490	Lake Dennison WR, Ninety Mile Beach CR, private land	640

Site No 66 (continued)

Habitats
Marshes (saline, brackish/freshwater) dunes (stable)

Description
Flora Supports salt marsh and remnants of Banksia woodland and dune scrub. Vegetation has been grazed and partly cleared.
Fauna Habitat for waterbirds and birds of prey. Supports species listed on JAMBA and CAMBA. Other significant species: Glossy grass skink (i).

Source: S. Taylor (*pers. comm.*), F. MacLennan (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
67	Gippsland Lakes	**Flora** S **Fauna** N	Bairnsdale 640980	Lakes Entrance to Lake Tyers CR, Gippsland LR, private land	18400

Habitats
Dunes stable, well vegetated, marshes (saline and brackish/ freshwater)

Description
Flora Supports extensive Salt marsh, relatively undisturbed primary dune scrub and coastal banksia woodland. Significant species: *Agrostis billardieri* var. *filifolia* (v), *Lepidium desvauxii* (r), *Thryptomene micrantha* (r).
Fauna Forms part of the Gippsland Lakes chain which is of international significance for fauna. These wetlands support up to 40-50 thousand ducks, swans, coots and other waterfowl and up to 4% of Victoria's wader population. The lakes form an important drought refuge for waterbirds. Emergent trees provide breeding sites for white-bellied sea-eagle (r). Breeding colonies of little tern (e) located on beaches near the Entrance, at Ocean Grange and on Rigby Island, Crescent Island and Albifrons Island. Little tern (e) may nest along Lake Reeve (near Seaspray), but this has not yet been confirmed. Lake Reeve is one of the 5 most important areas for migratory waders in Victoria. Significant species: New Holland mouse (e), hooded plover (v). Martin's toadlet (i) and Tyler's toadlet (i).

Source: Ramsar listing, LCC (1972), Barson and Calder (1976), (Dorward 1976), Norris and Mansergh (1981), Ladd *et al.* (1977), Bilney and Emison (1983), J. Reside (*pers. comm.*), G. Gillespie (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
68	Lake Tyers	**Flora** R **Fauna** S	Orbost 970100	Lakes Entrance to Lake Tyers CR, private land	170

Habitats
Marshes (saline)

Description
Flora Warm temperate rainforest, salt marsh
Fauna Two breeding colonies of little tern (e) and fairy tern (v) are located at Lake Tyers: one on Ocean Beach and another more recently established colony on the largest of three artificial islands (Conservation Islands) created in order to encourage little tern (e) nesting. Other significant species: New Holland mouse (e) (near red bluff) and eastern bristlebird (v).

Source: Barson and Calder (1976), Norris and Mansergh (1981).

No	Name	Significance	Map (location)	Land status	Area (ha)
69	Ewing Marsh to Point Ricardo	**Flora** S **Fauna** R/S	Orbost 200150	Ewing Marsh WR, Lake Corringle—Lake Wat Wat WR, Corringle Creek—Sydenham Inlet CR, private land	4820

Habitats
Dunes (unstable, stable), marshes (saline, brackish/ freshwater).

Description
Flora Salt marsh (restricted distribution in East Gippsland) at Lakes Corringle/Wat Wat and French's Narrows, relatively undisturbed primary dune scrub and sedgeland/herbland complex at Ewing Marsh (rich in aquatic species), heathland and woodland near Marlo. Significant species: *Agrostis billardieri* var. *filifolia* (v), *Cryptostylis erecta* (v), *Cryptostylis hunteriana* (v), *Leucopogon esquamatus* (r), *Marsdenia flavescens* (r), *Pseudoraphis paradoxa* (e), *Pterostylis grandiflora* (r), *Sparganium erectum* (r).

Site No 69 (continued)

Fauna Diverse range of wetland habitats, of particular importance for waterbirds and amphibians. Significant species: Lewin's rail (r), square-tailed kite (v), hooded plover (v), spotless crake.

Source: Barson and Calder (1976), Norris and Mansergh (1981), DCE (1992), Twyford (unpublished), A. Pollock (*pers. comm.*), T. Mazzer (*pers. comm.*)

No	Name	Significance	Map (location)	Land status	Area (ha)
70	First and Second Islands	**Flora** R **Fauna** -	Murrungowar 335164	Flora and Fauna Reserve, private land	1.5

Habitats: Rainforest (on alluvial island), marsh (saline)

Description

Flora Small remnant of warm temperate rainforest (now extremely rare on the floodplain of the Snowy River), partly fringed by salt marsh. Significant species: *Sambucus australasica*.

Fauna Not documented.

Source: Forbes *et al.* (1981), DCE (1990), Peel and Coram (1993)

No	Name	Significance	Map (location)	Land status	Area (ha)
71	Point Ricardo to Wingan Inlet	**Flora** N **Fauna** N	Murrungowar 750200	Croajingolong NP, Commonwealth land, Coastal Reserves, Bemm River EA, Baawang RA	9650

Habitats: Dunes (active, stable), slopes/cliffs (non-calcarenite)

Description

Flora Coastal vegetation in excellent condition, including highly diverse coastal heathland. Significant species: *Helichrysum argophyllum* (r), *Stackhousia nuda* (r), *Stylidium laricifolium* (v).

Fauna Diverse range of wetland habitats, of particular importance for waterbirds and amphibians. Little tern (e) nest at Tamboon Inlet while both little and fairy terns (v) nest at Sydenham Inlet. Smoky mouse (r) records for Cape Conran. Significant species: ground parrot (r), Lewin's rail (r), square-tailed kite (v), hooded plover (v), spotless crake, Australasian bittern (i), glossy grass skink (i), swamp skink (r), Martin's toadlet (i) and Tyler's toadlet (i).

Source: Forbes *et al.* (1981), Norris and Mansergh (1981), Twyford (1992), DCNR (in press), K. Twyford (*pers. comm.*).

No	Name	Significance	Map (location)	Land status	Area (ha)
72	The Skerries	**Flora** - **Fauna** S	Mallacoota 220180	Croajingolong NP	1-2

Habitats: Cliffs/slopes (non-calcarenite) - rocky island

Description

Flora None

Fauna Breeding colonies of Australian fur seal (rc) and crested tern (rc). Roosting site for black-faced shag (rc).

Source: Norris and Mansergh (1981), Menkhorst (see Chapter 4), DCNR (in press)

No	Name	Significance	Map (location)	Land status	Area (ha)
73	Wingan Inlet to Mallacoota	**Flora** N **Fauna** N	Mallacoota 350250	Croajingolong NP, Seal Creek RA, Commonwealth land, Township land	3170

Habitats: Dunes (active, stable) cliffs/slopes (non-calcarenite), marshes (saline)

Description

Flora Species rich, largely undisturbed vegetation including coastal heathland, primary dune scrub. Significant species: *Asplenium obtusatum* (v), *Cyathochaeta diandra* (r), *Darwinia camptostylis* (r), *Leucopogon esquamatus* (r), *Leucopogon microphyllus* var. *pilibundus* (r), *Logania pusilla* (r), *Mirbelia rubiifolia* (v), *Spyridium cinereum* (v), *Stackhousia nuda* (r).

Site No 73 (continued)

Fauna Caspian terns (rc) nest at Wingan Inlet. Coastal heathland provides critical habitat for ground parrots (r). Coastline provides habitat for waders and breeding seabirds. Significant species: Eastern bristlebird (v), turquoise parrot (r), diamond python (v) and swamp skink (r).

Source: Dorward (1976), Meredith and Isles (1980), Forbes *et al.* (1981), Norris and Mansergh (1981), Twyford (1992), Traill (1988), Bramwell *et al.* (in prep.), K. Twyford (*pers. comm.*,)

No	Name	Significance	Map (location)	Land status	Area (ha)
74	Goodwin Sands	**Flora** - **Fauna** S	Mallacoota 450430	Croajingolong National Park	120

Habitats: Sand shoal

Description
Flora None
Fauna Breeding colonies of crested (rc), Caspian (rc), fairy (v) and little tern (e).

Source: Menkhorst (see Chapter 4), J. Reside (*pers. comm.*), Norris and Mansergh (1981).

No	Name	Significance	Map (location)	Land status	Area (ha)
75	Gabo and Tullaberga Islands	**Flora** S **Fauna** S	Mallacoota 570390	Commonwealth Land (Gabo Is), Croajingolong NP (Tullaberga Is)	154 (Gabo Is), 8 (Tullaberga Is)

Habitats: Cliffs/slopes (non-calcarenite)

Description
Flora Significant species: *Asplenium obtusatum* (v), *Ziera cytisoides* (r).
Fauna Support breeding colonies of short-tailed shearwater and little penguin (Gabo Island), and white-faced storm-petrel (rc) (Tullaberga Island).

Source: Barson and Calder (1976), Norris and Mansergh (1981), Menkhorst (see Chapter 4), Twyford (1992a, b).

No	Name	Significance	Map (location)	Land status	Area (ha)
76	Mallacoota to Cape Howe	**Flora** N **Fauna** N	Mallacoota 550410	Croajingolong NP	2590

Habitats: Dunes (active, stable), marshes (saline, brackish/ freshwater)

Description
Flora Vegetation communities in excellent condition, including primary dune scrub, coastal banksia woodland and salt marsh. Salt marsh is of restricted distribution in East Gippsland; high quality examples occur at Howe Flat and Mallacoota Inlets.
Fauna Range of habitats relatively undisturbed by human activities. Mallacoota Inlet and associated islands provide habitat for migratory waterbirds and support breeding colonies of seabirds. Goat Island supports breeding colonies of crested tern (rc). Howe Flat provides important habitat for ground parrots (r). Significant species: hooded plover (v), eastern curlew (r), eastern bristlebird (v), diamond python (v), she-oak skink (v), swamp skink (r), Tyler's toadlet (i).

Source: Dorward (1976), Meredith and Isles (1980), Forbes *et al.* (1981), Norris and Mansergh (1981), DCNR (in prep.), K. Twyford (*pers. comm.*)

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Appendix VI

SELECTED SPECIES OF MARINE HABITATS

KEY

Groups

Green Algae	Annelida	Crustacea
Brown Algae	Bryozoa	Echinodermata
Red Algae	Chitons	Ascidians
Seagrasses	Gastropoda	Fish
Mangrove	Bivalva	Bird
Sponges	Cephalopoda	Mammal
Cnidaria		

Habitat Type

1 - Intertidal rocky shores
2 - Subtidal rocky reefs
3 - Seagrasses
4 - Sheltered intertidal flats
5 - Mangrove
6 - Sandy beaches
7 - Subtidal soft substrata
8 - Pelagic environments

Common Name	Scientific Name	Habitat type							
		1	2	3	4	5	6	7	8
Green algae									
	Cladophora sp.		2						
	Caulerpa sp.	1	2						
	Codium sp.	1	2						
Sea Lettuce	*Ulva lactuca*	1							
Short red algae	*Codium fragile*		2						
Brown algae									
	Caulocystis sp.		2						
	Cystophora sp.	1	2						
Bull kelp	*Durvillaea potatorum*	1	2						
Leather kelp	*Ecklonia radiata*		2						
	Gelidium pusillum	1							
Neptunes necklace	*Hormosira banksii*	1							
Southern giant kelp	*Macrocystis angustifolia*		2						
Bubble weed	*Phyllospora comosa*		2						
	Sargassum sp.	1	2						
Red algae									
	Bostrychia spp.					5			
	Caulerpa spp.		2						
	Catanella nipae					5			
	Champia sp.		2						
	Laurencia sp.		2						
	Plocamium sp.		2						
	Polysiphonia sp.		2						
Seagrasses									
Sea nymph	*Amphibolis antarctica*			3					
Paddle weed	*Halophila australis*			3					
	Heterozostera tasmanica			3					
Fire-ball weed	*Posidonia australis*			3					
	Zostera muelleri			3					
Mangrove									
White mangrove	*Avicennia marina*					5			
Sponges									
	Ancorina corticata							7	
	Ciocalypta sp.							7	
	Clathria sp.		2						
	Crella sp.		2						
Rose sponge	*Dendrilla rosea*		2						
	Iophon laevistylis		2						
	Phyllospongia calyciformis		2						
	Raspailia sp.		2						
	Spirastrella sp.		2						
Golf-ball sponge	*Tethya sp.*		2						
Cnidaria									
Sea anemone	*Actinia tenebrosa*	1							
Black feathery Hydroid	*Agalophenia divaricata*		2						
White feathery Hydroid	*Agalophenia whiteleggi*		2						
Hydroid	*Amphisbetia operculata*							7	
White-stripe anemone	*Anthothoe albocincta*		2						
Hydroid	*Clathrozoon wilsoni*		2						
Sea anemone	*Cnidopus verater*	1							
Hydroid	*Halocordyle wilsoni*		2						
Hydroid	*Halopteris buskii*		2						
Hydroid	*Halopteris campanula*		2						
Hydroid	*Halopteris sulcata*		2						

Appendix VI - Selected species of marine habitat (continued)

Common Name	Scientific Name	Habitat type							
		1	2	3	4	5	6	7	8
Brittle star	*Ophiacantha alternata*			3					
Brittle star	*Ophiocentris pilosus*							7	
Common brittle star	*Ophionereis schayeri*	1							
Brittle star	*Ophiura kinbergi*							7	
Purple sea star	*Patiriella brevispina*	1	2	3					
Common sea star	*Patiriella calcar*	1		3					
Small green sea star	*Patiriella exigua*	1		3					
Sea cucumber	*Pentacta ignava*		2						
Ascidians									
	Botrylloides magnoescius		2						
	Halocynthia hispida		2						
	Herdmania		2						
Pink throated ascidian	*Herdmania momus*		2						
	Polycitor gigantea		2						
Stalked ascidian	*Pyura australis*		2						
Yellow stalked ascidian	*Pyura spinifera*		2						
	Pyura stolonifera	1						7	
	Sycozoa cerebriformis		2						
	Sycozoa pedunculata							7	
Fish									
Common shore eel	*Alabes dorsalis*	1							
Yellow eyed mullet	*Aldrichetta forsteri*			3					
Long-snouted flounder	*Ammotretis rostratus*							7	
Southern sea carp	*Aplodactylus arctidens*		2						
Shaw's cowfish	*Aracana aurita*		2	3					
Ornate boxfish	*Aracana ornata*			3					
Bridled goby	*Arenigobius frenatus*			3					
Tasmanian clingfish	*Aspasmogaster tasmaniensis*	1							
Hardyheads	*Antherinosoma lentatherina*			3					
Hardyheads	*Atherinosoma microstoma*			3					
Dragonet	*Bovichthys variegatus*	1							
Butterfly sea perch	*Caesioperca lepidoptera*		2						
Barber's seaperch	*Caesioperca rasor*		2						
Elephant shark	*Callorhynchus milii*							7	
Draughtboard shark	*Cephaloscyllium laticeps*		2						
Magie morwong	*Cheilodactylus nigripes*		2						
Prickly toadfish	*Contusus brevicaudatus*							7	
Cardinal clingfish	*Creocele cardinalis*	1							
Dusky morwong	*Dactylophora nigricans*			3					
Long finned pike	*Dinolestes lewini*		2						
Globe fish	*Diodon nichthemerus*		2						
Anchovy	*Engraulis australis antipodum*								8
Old wife	*Enoplosus armatus*		2						
Leather jackets	*FAMILY Monacanthidae*		2						8
Long finned goby	*Favonigobius lateralis*			3					
Zebrafish	*Girella zebra*		2						
Cobbler fish	*Gymnopistes marmoratus*			3					
Common weedfish	*Heteroclinus perspicillatus*			3					
Port Jackson shark	*Heterodontus portusjacksoni*		2						
Sea horse	*Hippocampus abdominalis*			3					
Sea horse	*Hippocampus breviceps*			3					
Southern garfish	*Hyporhamphus melanochir*			3					
Eastern stargazer	*Kathetostoma laeve*							7	
Bastard trumpeter	*Latridopsis forsteri*		2						
Gummy shark	*Mustelus antarcticus*							7	
Tasmanian numbfish	*Narcine tasmaniensis*							7	
Tiger flathead	*Neoplatycephalus richardsoni*							7	
Saddled wrasse	*Notolabrus fucicola*		2						
Blue throat wrasse	*Notolabrus tetricus*		2						
Rainbow fish	*Odax acroptilus*		2						
Herring cale	*Odax cyanomelas*		2						
Tasmanian blenny	*Parablennius tasmaniensis*	1							
Varied catshark	*Parascyllium variolatum*		2						
Victorian scalyfin	*Parma victoriae*		2						
Common bullseye	*Pempheris multiradiata*		2						
Weedy sea dragon	*Phyllopteryx taeniolatus*			3					
Beardie	*Physiculus barbata*		2						
Senator wrasse	*Pictilabrus laticlavius*		2						
Southern sand flathead	*Platycephalus bassensis*							7	
Saw shark	*Pristiophorus nudipinnis*							7	
Silver trevalley	*Pseudocaranx dentex*								8
Greenback flounder	*Rhombosolea tapirina*			3	4			7	
Pilchards	*Sardinops neopilchardus*								8
Southern red scorpioncod	*Scorpaena papillosa*		2						
Sea sweep	*Scorpis aequipinnis*		2						
Silver sweep	*Scorpis lineolatus*		2						8

Appendix VI - Selected species of marine habitat (continued)

Common Name	Scientific Name	Habitat type							
		1	2	3	4	5	6	7	8
Bivalva									
Mud ark	*Anadara trapezia*				4				
Beaked mussel	*Austromytilus rostratus*	1							
	Barbatia sp.		2						
Bryozoan	*Cornucopina grandis*		2						
Narrow wedge shell	*Donacilla angusta*							7	
Pipi	*Donax deltoides*							7	
	Densipora corrugata			3					
Flame dog cockle	*Glycymeris flammeus*							7	
Stepped venerid	*Katelysia scalarina*			3				7	
	Katelysia rhytiphora			3					
Elongated lantern shell	*Laternula creccina*				4				
	Legrandina bernardi					5		7	
	Melliteryx helmsi			3		5			
	Mysella donaciformis			3				7	
Purple bivalve	*Neotrigonia margaritacea*							7	
	Nucula pusilla			3					
	Pahies (Amesodesma) angusta						6		
Commercial scallop	*Pecten fumata*							7	
	Plebidonax deltoides					4	6		
	Solemya cf.australis			3					
Chinine fingernail shell	*Solen vaginoides*							7	
Triangular tellin	*Tellina (Macomona) deltoidalis*			3	4				
Little black horse mussel	*Xenostrobus pulex*	1							
Cephalopoda									
Paper nautilus	*Argonauta nodosa*								8
Dumpling squid	*Euprymna tasmanica*			3					
Blue-ringed octopus	*Hapalochlaena maculosa*		2						
Pygmy squid	*Idiosepius notoides*			3					
Arrow squid	*Nototodarus gouldii*								8
Sand octopus	*Octopus kaurna*							7	
	Octopus maorum		2						
Southern giant cuttlefish	*Sepia apama*		2						
Southern calamary	*Sepioteuthis australis*		2	3					
Crustacea									
Snapping shrimp	*Alpheus euphrosyne*			3					
Giant rock barnacle	*Austromegabalanus nigrescen*	1							
European shore crab	*Carcinus maenas*			3		5			
Surf barnacle	*Catomerus polymerus*	1							
Honeycomb barnacle	*Chamaesipho tasmanica*	1							
Rough barnacle	*Chthamalus antennatus*	1							
Purple mottled shore crab	*Cyclograpsus granulosus*	1							
Acorn barnacle	*Elminius modestus*					5			
Small spider crab	*Halicarcinus ovatus*			3					
	Halicarcinus rostratus			3					
Semaphore crab	*Heloecius cordiformis*				4				
Mud crab	*Helograpsus haswellianus*					5			
Southern rock lobster	*Jasus edwardsii*		2						
Goose-neck barnable	*Lepas anserifera*								8
Hairy stone crab	*Lomis hirta*	1							
Sentinel crab	*Macrophthalmus latifrons*			3	4	5			
Soldier crab	*Mictyris longicarpus*				4				
Soldier crab	*Mictyris platycheles*				4				
	Nectocarcinus tuberculosus			3					
Sand crab	*Ovalipes australiensis*							7	
Rock pool shrimp	*Palaemon serenus*	1							
Grapsid crabs	*Paragrapsus gaimardi*			3		5			
Grapsid crabs	*Paragrapsus laevis*			3		5			
Notched shore crab	*Paragrapsus quadredentatus*	1							
	Parapandalus leptorhynchus			3					
Smooth pebble crab	*Philyra laevis*			3					
Xanthid crab	*Pilumnus fissifrons*			3					
Red bait crab	*Plagusia chabrus*	1							
	Pontophilus intermedius			3					
Red-fingered crab	*Sesarma erythrodactyla*					5			
Sand hopper	*Talorchestia quadrimara*						6		
Common surf barnacle	*Tesseropora rosea*	1							
Ghost yabby	*Trypaea australiensis*			3	4				
Echinodermata									
Common feather star	*Comanthus trichoptera*		2						
Eleven arm sea star	*Coscinasterias calamaria*	1	2						
Heart urchin	*Echinocardium cordatum*							7	
Purple sea urchin	*Heliocidaris erythrogramma*		2						
Small sea cucumber	*Leptosynaptera cf. dolabrifera*			3					

Appendix VI - Selected species of marine habitat (continued)

Common Name	Scientific Name	Habitat type							
		1	2	3	4	5	6	7	8
Narcomedusae	*Liriope sp.*		2						8
Orange gorgonians	*Mopsella spp.*		2						
Pink gorgonians	*Mopsella whiteleggei*		2						
Hydroid	*Nemertesia wattsi*							7	
Hydroid	*Obelia australis*							7	
Hydroid	*Orthopyxis caliculata*		2						
Wandering anemone	*Phlyctenactis tuberculosa*			3					
Blue bottle jellyfish	*Physalia physalis*								8
	Pseudogorgia goddefroeyi							7	
Pink Seapen	*Sarcoptilus grandis*							7	
Orange Seapen	*Sarcophyllum sp.*							7	
Hydroid	*Sertularia macrocarpa*		2						
Hydroid	*Sertularia unguiculata*		2						
Hydroid	*Silicularia rosea*		2						
By-the-wind-sailor	*Velella velella*								8
Zoanthid	*Zoanthus sp.*		2						
Annelida									
White tude worm	Galeolaria caespitosa								8
	Lumbrineris latrelli			3					
	Nephtys longipes				4				
	Orthopyxis caliculata		2						
Feather duster worm	*Sabellastarte spp.*		2						
Bryozoa									
	Adeona cellulosa							7	
	Amathia biseriata		2						
	Amathia tortuosa		2						
Soft blue bryozoan	*Bugula dentata*								
	Cornucopina grandis		2						
	Densipora corrugata			3					
	Lanceopora obliqua							7	
Sea mat	*Membranipora membranacea*		2						
Soft organge bryozoan	*Orthoscuticella ventricosa*		2						
Bryozoan	*Petralia undata*							7	
	Scuticella sp.		2						
	Vittacella sp.		2						
Chitons									
	Ischnochiton australis	1							
	Ischnochiton elongatus	1							
	Plaxiphora albida	1							
Gastropoda									
Ribbed top shell	*Austrocochlea constricta*	1				5			
Top shell	*Austrocochlea odontis*	1							
Black-mouthed conniwink	*Bembicium melanostomum*	1				5			
Striped-mouthed conniwink	*Bembicium nanum*	1							
Limpet	*Cellana tramoserica*	1							
Lineated cominella	*Cominella lineolata*	1							
Cone shell	*Conus anemone*	1							
Silver sea slug	*Glaucus atlanticus*								8
Greenlip abalone	*Haliotis laevigata*		2						8
Blacklip abalone	*Haliotis ruber*		2						8
Violet snail	*Ianthina janthina*								8
Wine-mouthed lepsiella	*Lepsiella vinosa*	1							
	Littorina praetermissa	1							
	Littorina unifasciata	1							
Blemished rock whelk	*Nassarius burchardi*							7	
Dog whelk	*Nassarius pauperatus*					5			
Black nerite	*Nerita atramentosa*	1							
	Notoacmea mayi	1							
	Notoacmea spp	1							
Ocean beach slug	*Oncchidella patelloides*	1							
Limpet	*Patelloida alticostata*	1							
Limpet	*Patelloida latistrigata*								
Pheasant shell	*Phasianella australis*		2						
Conical sand snail	*Polinices conicus*				4			7	
Flat sand snail	*Polinices incei*							7	
Gastropod snail	*Polinices sordidus*				4				
Fragile air breather	*Salinator fragilis*					5			
Solid air breather	*Salinator solida*					5			
Elephant snail	*Scutus antipodes*	1							
Pulmonate snail	*Siphonaria diemenensis*	1							
Dog winkle	*Thais orbita*	1							
Warrener	*Turbo undulatus*	1	2						
Southern mud welk	*Velacumantus australis*					5			
	Zeacumantus diemenensis					5			

Appendix VI - Selected species of marine habitat (continued)

Common Name	Scientific Name	Habitat type							
		1	2	3	4	5	6	7	8
Warehou	*Seriolella spp.*								
King George whiting	*Sillaginodes punctatus*			3	4			7	
School whiting	*Sillago bassenis*							7	
Southern school whiting	*Sillago bassenis flindersi*							7	
Angleshark	*Squatina australis*							7	
Pipefish	*Stigmatophora argus*			3					
Pipefish	*Stigmatophora nigra*			3					
Smooth toadfish	*Tetractenos glaber*			3	4			7	
Barracouta	*Thyrsites atun*		2						8
Roughy	*Trachichthys australis*		2						
Southern hulafish	*Trachinops caudimaculatus*		2						
Jack mackeral	*Trachurus declivis*								8
Red mullet	*Upeneichthys lineatus*		2						
Crossback stingaree	*Urolophus cruciatus*							7	
Sparsely-spotted stringaree	*Urolophus paucimacaulatus*							7	
Stingarees	*Urolophus spp.*				4			7	
Pipefish	*Vanacampus poecilolaemus*			3					
Southern gobbleguts	*Vincentia conspersa*		2						
Sweep		1							
Wrasses		1							
Bird									
Little penguin	*Eudyptula minor*								8
Mammals									
Southern right whale	*Balaena glacialis*								8
Common dolphin	*Delphinus delphis*		2						8
Humpback whale	*Megaptera novaengliae*								8
Bottlenose dolphin	*Tursiops truncatus*		2						8
False killer whale	*Pseudorca crassidens*								8
Killer whale	*Orcinus orca*								8
Pilot whale									8

Appendix VII

SEABIRD BREEDING COLONIES IN VICTORIA

KEY

\# denotes unconfirmed breeding at this site
* approximate

Sources:

1 Harris and Norman 1981;
2 Department of Conservation and Natural Resources unpublished data
3 Mattingley 1908
4 Learmonth 1965
5 Seabird Island Series, Corella 4: 65-112
6 Wheeler 1964;
7 Lane 1990
8 Menkhorst et al. 1988;
9 Lane and Battam 1980;
10 Lane 1979;
11 Penguin Study Group (unpublished data)
12 Gilham 1961;
13 Minton 1992b

Site	Breeding species	Breeding population		Source
		pairs	year of estimate	
Lawrence Rocks	Little penguin	100	1978	1
	Fairy prion	<200	1978	1
	Common diving-petrel	#		
	Australasian gannet	3 000	1993	2
	Cape gannet	0.5	1993	2
	Black-faced shag	formerly bred at this site	1907	3
Cape Grant	Short-tailed shearwater	#	1963	4
Point Danger	Short-tailed shearwater	#	1963	4
Portland area	Little penguin	100	1991	2
Lady Julia Percy Island	Little penguin	2 000	1979	1
	Short-tailed shearwater	15 000	1979	1
	Fairy prion	'1000s'	1979	1
	Common diving-petrel	substantial colony	1979	1
Griffith Island	Little penguin	small numbers		5
	Short-tailed shearwater	52 000	1978	1
Middle Island	Little penguin	200	1991	2
Merri Island	Little penguin	200	1991	2
Killarney Reef	Silver gull	500	1978	5
	Crestern tern	200	1978	5
Bay of Islands	Little penguin	20	1991	2
	Black-faced shag	8	1963	6
Twelve Apostles to	Little penguin	1 000	1989	2
London Bridge	Black-faced shag	#	1964	6
Muttonbird Island	Short-tailed shearwater	'1000s'	1978	1
Apollo Bay breakwater	Little penguin	20	1991	2
Moorlap Saltworks	Silver gull	1 500	1970s	2
	Fairy tern	70	1971	7
The Spit State Nature Reserve	Fairy tern	30	1986	7
Sand Island	Fairy tern	30	1988	7
Mud Islands	Little penguin	2	1988	8
	White-faced storm-petrel	5 600	1978	1,8
	Silver gull	50 000	1988	8
	Crested tern	2 000	1988	8
	Caspian tern	25	1988	8
	Fairy tern	25	1988	2,7

Appendix VII - Seabird breeding colonies in Victoria (continued)

Site	Breeding species	Breeding population		Source
		pairs	year of estimate	
Popes Eye Annulus	Australasian gannett	100	1993	2
Wedge Light	Australasian gannet	45	1993	2
	Cape gannet	0.5	1993	2
South Channel Fort	Little penguin	2	1988	2
	White-faced storm-petrel	6 800	1978	1
	Silver gull	200	1988	2
St Kilda breakwater	Little penguin	40	1991	2
Phillip Island	Little penguin	6 000	1978	1
	Short-tailed shearwater	542 000	1978	1
	Silver gull	700	1978	1
	Kelp gull	1	1978	1
Seal Rocks	Crested tern	6	1991	2
	Silver gull	200	1991	2
	Kelp gull	8	1991	2
French Island	Short-tailed shearwater	3 100	1978	1
Ram Island	Fairy tern	38	1984	7
Shellback island	Little penguin	'several hundred'	1978	1
	Short-tailed shearwater	110 000	1978	1
	Fairy prion	#	1978	5
	Pacific gull	*100	1978	1
Norman Island	Little penguin	400-500	1979	9
	Short-tailed shearwater	145 000	1980	1
	Fairy prion	#		1
	Common diving-petrel	3	1980	1
	Silver gull	85	1980	1
	Pacific gull	35	1980	1
Great Glennie Island	Little penguin	*500	1978	1
	Short-tailed shearwater	400 000	1978	1
	Silver gull	100	1978	1
	Pacific gull	3	1978	1
	Crested tern	20	1967	5
Dannevig Island	Little penguin	few	1980	1
	Short-tailed shearwater	44 600	1980	1
	Fairy prion	3	1978	10
	Common diving-petrel	5	1978	10
	Silver gull	12	1978	10
	Pacific gull	20	1980	1
	Black-faced shag	30	1978	10
Citadel Island	Little penguin	45	1979	1
	Short-tailed shearwater	111	1979	1
	Fairy prion	50	1979	1
	Common diving-petrel	#		1
	Pacific gull	2	1978	10
McHugh Island	Little penguin	1 000	1978	1
	Short-tailed shearwater	6 200	1978	1
	Fairy prion	3	1978	10
	Common-diving petrel	#		1
	Pacific gull	4	1979	1
Cleft Island	Black-faced shag	#		10
Kanowna Island	Little penguin	small numbers		1
	Short-tailed shearwater	52 000	1978	1
	Fairy prion	#		1
	Common diving-petrel	#		10
	Silver gull	1	1978	1
	Pacific gull	100	1978	1
Anser Island	Little penguin	several hundred	1978	1
	Short-tailed shearwater	252 000	1978	1

Appendix VII - Seabird breeding colonies in Victoria (continued)

Site	Breeding species	Breeding population		Source
		pairs	year of estimate	
	Fairy prion	1	1978	10
	Silver gull	1	1978	1
	Pacific gull	20	1978	1
Wattle Island	Little penguin	low hundreds	1991	11
	Short-tailed shearwater	83 000	1979	1
	Fairy prion	#	1979	5
	Silver gull	68	1979	1
	Pacific gull	30	1979	1
Rabbit Island	Little penguin	4 000	1991	11
	Short-tailed shearwater	131 000	1979	1
	Silver gull	100	1979	1
	Pacific gull	5	1979	1
Rabbit Rocks	Little penguin	100	1978	1
	Short-tailed shearwater	3 800	1978	1
	Pacific gull	2	1978	1
Bennison Island	Short-tailed shearwater	7 200	1978	1
Doughboy Island	Short-tailed shearwater	2 000	1978	1
	Silver gull	84	1978	1
Granite Island	Short-tailed shearwater	2 100	1978	1
	Black-faced shag	#		1
	Silver gull	100	1959	12
Shallow Inlet Barrier Islands	Caspian tern	55	1991	13
	Crested tern	420	1991	13
	Fairy tern	31	1992	13
Seal Island	Little penguin	200	1991	11
	Short-tailed shearwater	54 000	1978	1
	Fairy prion	several hundred	1978	1
	Common diving-petrel	#		
	Silver gull	20	1978	1
	Pacific gull	100	1978	1
	Crested tern	6	1978	1
Notch Island	Little penguin	*500	1978	1
	Short-tailed shearwater	6 000	1978	1
	Fairy prion	small colony	1978	1
	Common diving-petrel	small colony	1978	1
	Black-faced shag	120	1978	1
	Silver gull	5	1978	1
	Pacific gull	10	1978	1
Rag Island	Little penguin	several hundred	1978	1
	Short-tailed shearwater	18 000	1978	1
	Common diving-petrel	#		1
	Silver gull	20	1978	1
	Pacific gull	5	1978	1
	Short-tailed shearwater	6 300	1978	1
	Common diving-petrel	#		1
	Pacific gull	100	1959	13
Cliffy Island	Little penguin	#		1
	Short-tailed shearwater	6 300	1978	1
	Common diving-petrel	#		1
	Silver gull	100	1959	12
Crescent Island	Little tern	20	1986	2
Rigby Island	Little tern	100	1992	2
	Fairy tern	68	1990	2
Lake Tyers	Little tern	60	1992	2
Mouth of Snowy River	Little tern	small numbers	early 1980s	2
Sydenham Inlet	Little tern	small numbers	early 1980s	2
	Fairy tern	small numbers	early 1980s	2

Appendix VII - Seabird breeding colonies in Victoria (continued)

Site	Breeding species	Breeding population		Source
		pairs	year of estimate	
Tamboon Inlet	Little tern	20	1992	2
The Skerries	Little penguin	small numbers	1977	5
	Crested tern	up to 500	1976	5
	Silver gull	20	1977	5
Tullaberga Island	Little penguin	400	1978	1
	White-faced storm-petrel	20 000	1978	1
Goodwin Sands,	Crested tern	small numbers	1990	2
Mallacoota Inlet	Caspian tern	small numbers	1990	2
	Little tern	20-30	1990	2
	Fairy tern	small numbers	1990	2
Gabo Island	Little penguin	5 000-10 000	1978	1
	Short-tailed shearwater	7 350	1978	1

Appendix VIII

STATUS OF SEABIRDS RECORDED IN VICTORIAN WATERS

KEY:

Status: B - breeding in Victoria; R - regularly occurring but does not breed; P - passes through on migration; V - vagrant, outside its normal range. Note that so little is known of the movement patterns of most species that many of those listed as vagrant (V) may actually be passage migrants (P) or even regular visitors (R).

Relative abundance: A - abundant; N - numerous; F - few. Species categorised mainly on the basis of the number of records in Emison *et al.* 1987.

Conservation status: E - endangered; V - vulnerable; RC - restricted colonial breeding.

Species	Status	Relative abundance	Conservation status
King penguin	V		
Chinstrap penguin	V		
Adelie penguin	V		
Rockhopper penguin	V		
Fiordland penguin	V		
Erect-crested penguin	V		
Royal penguin	V		
Magellanic penguin	V		
Little penguin	B	A	
Wandering albatross	R	N	
Royal albatross	R	F	
Black-browed albatross	R	N	
Buller's albatross	R	F	
Grey-headed albatross	R	F	
Yellow-nosed albatross	R	N	
Shy albatross	R	N	
Sooty albatross	V		
Light-mantled sooty albatross	V		
Southern giant petrel	R	N	
Northern giant petrel	R	F	
Southern fulmar	V		
Antarctic petrel	V		
Cape petrel	R	N	
Snow petrel	V		
Great-winged petrel	R	F	
White-headed petrel	R	F	
Providence petrel	V		
Kerguelen petrel	R	F	
Soft-plumed petrel	V		
Mottled petrel	V		
White-necked petrel	V		
Gould's petrel	V		
Black-winged petrel	V		
Blue petrel	R	F	
Broad-billed prion	V		
Lesser broad-billed prion	V?	F	
Antarctic prion	V?	F	
Slender-billed prion	R?	N	
Fairy prion	B	N	RC
Fulmar prion	V		
Grey petrel	V		
Black petrel	V		
White-chinned petrel	V		

Species	status	Relative abundance	Conservation status
Streaked shearwater	P	F	
Flesh-footed shearwater	V		
Wedge-tailed shearwater	V		
Buller's shearwater	V		
Sooty shearwater	R	F	
Short-tailed shearwater	B	A	RC
Fluttering shearwater	P	N	
Hutton's shearwater	V		
Little shearwater	V		
Wilson's storm-petrel	P	F	
Grey-backed storm-petrel	V		
White-faced storm-petrel	B	N	RC
Black-bellied storm-petrel	V		
Leach's storm-petrel	V		
Common diving-petrel	B	F	RC
Australasian gannet	B	N	RC
Cape gannet	V		
Brown booby	V		
Black-faced shag	B	N	RC
Great frigatebird	V		
Least frigatebird	V		
Red-tailed tropicbird	V		
White-tailed tropicbird	V		
Great skua	V		
South polar skua	V		
Arctic jaeger	R	N	
Pomarine jaeger	R	F	
Long-tailed jaeger	R	F	
Silver gull	B	A	RC
Pacific gull	B	N	RC
Black-tailed gull	V		
Kelp gull	B	F	RC
Caspian tern	B	N	RC
Common tern	R	N	
Artic tern	P	F	
White-fronted tern	R	F	
Sooty tern	V		
Crested tern	B	A	RC
Fairy tern	B	F	V
Little tern	B	F	E
Common noddy	V		
Grey ternlet	V		