Assessment REPORT

Impacts

identifying disturbances



The South-east Regional Marine Plan

Title:
Impacts – identifying disturbances
The South-east Regional Marine Plan
Assessment Reports

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Executive summary

It is important to understand and manage human activities and actions and their effects on the marine environment if we are to develop an ecosystem-based South-east Regional Marine Plan.

The purpose of this assessment is not to duplicate existing work on specific impacts, but to consider the range of impacts across the whole South-east Marine Region. This calls for a new perspective.

We have developed new tools for analysing and presenting information on the links between impacts across an area of over two million square kilometres of water. The two matrices developed from the assessment process represent our approach to addressing these new challenges.

The work in this assessment has so far concentrated on the initial stage of 'identifying the risks'. This report includes impacts that may be negilgible, temporary and/ or localised, as well as impacts that are being mitigated by industry/ community practices. It does not measure the cumulative effects of the impacts, and it does not yet make any judgements about the relative risk or importance or consequences of those impacts, nor does it explain the many mitigation mechanisms in place. It also does not look at cumulative impacts.

The assessment process followed the *Australian and New Zealand Standard for Risk Management* as a general methodology for analysing information about impacts on the ecosystem. Standards Australia defines risk assessment as "...the process of risk analysis and risk evaluation...". Risk is defined as "...the chance of something happening that will have an impact upon objectives. It may be an event, action, or lack of action. It is measured in terms of consequences and likelihood..." (AS/NZS 4360). The report includes impacts that may be negligible, temporary and/or localised, as well as impacts that are being mitigated by industry practices.

The work reported here concentrates on the initial stage of 'identifying the risks'. To identify the broad range of impacts that affect the ecosystem, we developed specific tools:

- a classification of impacts into 12 disturbance categories
- a definition of where in the ocean environs disturbances occur and whether or not these are known to occur in the South-east Marine Region
- a definition of what causes disturbance and whether or not these known to occur in the South-east Marine Region.

This is a new way of analysing the information focusing on the ecosystem's perspective, rather than the more traditional approach of exploring the direct link between the activity itself and the disturbance it causes. As such, the analysis describes which parts of the ecosystem are affected by each disturbance category. The outcome of this analysis is illustrated in the matrix 'ocean environs and ecosystem components' (Matrix A, Section 3).

To help with this assessment, the Office established an Impacts Working Group, made up of expert representatives from industry, government and conservation (membership of this group is in Appendix 1). A broad range of additional experts from different sectors also provided information and advice for developing the matrices.

Having identified the range of impacts that occur in the Region, the Oceans Office will now seek an independent review of the matrices to ensure that they are an appropriate starting point for the further analysis and evaluation of impacts. We expect that the independent review will be undertaken in early 2002, and that prioritising, analysing and evaluating the impacts, within the context of current mitigating actions, will be carried out during the first half of 2002. Only then will we be able to determine the likelihood and consequences of the various impacts that have been identified in this report. The final risk assessment will be completed later in 2002.

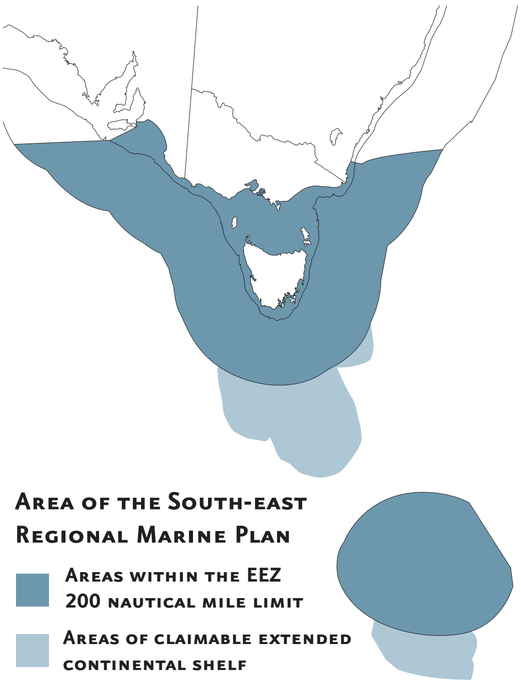
Preface

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

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

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

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



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

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

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

- biological and physical characteristics – identifying the key ecological characteristics in the Region, their linkages and interactions
- uses within the South-east Marine Region – describing our knowledge of the nature and dimension of human uses and their relationship with each other
- impacts on the ecosystem – providing an objective analysis of how activities can affect the Region's natural system
- community and cultural values – ensuring community wishes and aspirations are reflected in the planning process
- Indigenous uses and values – gaining an understanding of and support for Indigenous interests in the Region
- management and institutional arrangements – analysing current legislative and institutional frameworks to determine the best mechanism for implementing regional marine plans.

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

Moving forward

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

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

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

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

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

Assessing impacts in the South-East Marine Region

It is important to understand and manage human activities and actions and their effects on the marine environment if we are to develop an ecosystem-based South-east Regional Marine Plan.

A large amount of work has already been carried out by industry, researchers and governments to understand and manage impacts within the South-east Marine Region. Environmental impact assessments are routinely carried out for many proposed activities, involving industry and local, State and Commonwealth Governments. There are also established processes for reporting on the 'state of the environment' and for considering the sustainability of specific industries such as commercial fishing and petroleum exploration.

The purpose of this assessment is not to duplicate existing work on specific impacts, but to consider the range of impacts across the whole South-east Marine Region. This calls for a new perspective.

We have developed new tools for analysing and presenting information on the links between impacts across an area of over two million square kilometres of water. The two matrices developed from the assessment process (Matrices A and B) represent our approach to addressing these new challenges.

This is a new way of analysing the information focusing on the ecosystem's perspective, rather than the more traditional approach of exploring the direct link between the activity itself and the disturbance it causes. As such, the analysis describes which parts of the ecosystem are affected by each disturbance category. The outcome of this analysis is illustrated in the matrix 'ocean environs and ecosystem components' (Matrix A).

To help with this assessment, the Office established an Impacts Working Group, made up of expert representatives from industry, government and conservation (membership of this group is in Appendix 1). A broad range of additional experts from different sectors also provided information and advice for developing the matrices.

Together with a number of consultants, the office also compiled six short papers detailing impacts from specific activities within the Region:

- Impacts from the Ocean-Land Interface
- Impacts of Petroleum
- Impacts of Shipping
- Impacts of Aquaculture
- Risk Assessment
- Introduced Marine Pests.

Information from these reports is used throughout this report.

The scope of this report

This report outlines the process that the National Oceans Office is undertaking to assess impacts in the South-east Marine Region. For this assessment, we have defined 'impacts' as any human activity, action or process that has an effect, either positive or negative, on the ecosystem in the Region. In limiting this focus we do, however, acknowledge that natural processes (such as severe storms, tsunami and El Nino) can also have profound effects on the ecosystem.

The work in this assessment has so far concentrated on the initial stage of 'identifying the risks'. It does not yet make any judgements about the relative importance or consequences of those impacts, nor does it explain the many mitigation mechanisms in place. It does not focus on the potential for cumulative impacts. Information about management or institutional arrangements in place to remediate the impacts identified are described in detail in the report *Ocean Management – the legal framework*.

The next stage of the process will be to identify the relative risk of each impact. This will provide a basis for developing strategies to manage these risks. This report presents information according to the disturbance categories, allowing us to explore the direct link between the activity itself and the type of disturbance it causes. The outcome of this analysis is illustrated in the matrix 'activity and disturbances' (Matrix B).

For Indigenous customary use, discussions began with the Indigenous Working Group to further this area of knowledge so this report does not refer to these uses.

However, we hope this new information will be used in the future stages of the risk assessment.

For detailed descriptions of the uses, Indigenous use and values, or physical and biological characteristics of the Region, please refer to the separate assessment reports.

The next stage

An important feature of the risk assessment process is to involve industry, government, special interest groups and community stakeholders. This will build upon our understanding and assessment of activities that may affect the marine environment. In doing so, clear objectives and assessment criteria is adopted from the outset, useful input to identify all potential hazards is gained, and a consultative approach is taken to manage the risks being assessed.

Having identified the range of impacts that occur in the Region, the Oceans Office will now seek an independent review of the matrices to ensure that they are an appropriate starting point for the further analysis and evaluation of impacts. We expect that the independent review will be undertaken in early 2002, and that prioritising, analysing and evaluating the impacts, within the context of current mitigating actions, will be carried out during the first half of 2002. Only then will we be able to determine the likelihood and consequences of the various impacts that have been identified in this report. The final risk assessment will be completed later in 2002.

The final stage of the risk assessment will be a significant input into the development of the Regional marine plan, providing all stakeholders with a comprehensive analysis of the risks to the ecosystem from the various activities that occur in the Region.

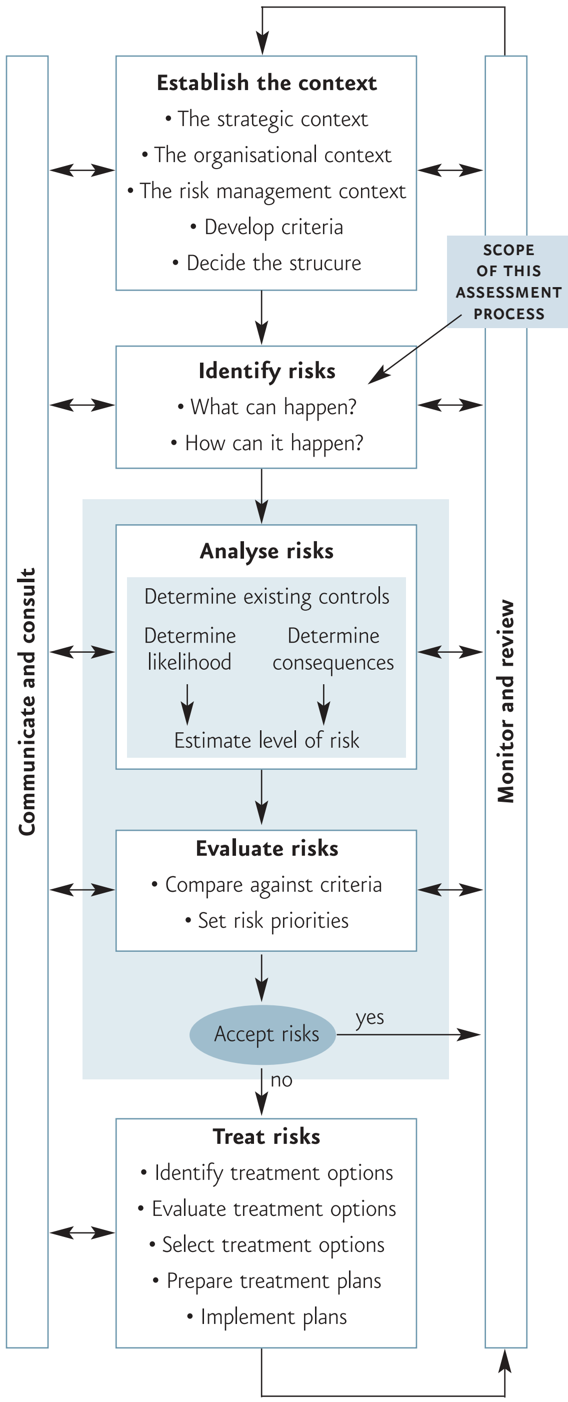
After the risk assessment is completed, it may also be necessary to apply a risk assessment framework to the overall South-east Regional Marine Plan. This would involve considering each of the objectives of the plan (which are currently being formulated) and applying a risk assessment process for analysing and prioritising issues and activities that could undermine the success of the final plan.

Categorising impacts in the South-East Marine Region

The methodology

The assessment process followed The *Australian and New Zealand Standard for Risk Management* as a general methodology for analysing information about impacts on the ecosystem.

Figure 1: *Risk Management Process* (*Adapted from AS/NZS 4360*).



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The work reported here concentrates on the initial stage of 'identifying the risks' and to identify the broad range of impacts that affect the ecosystem, we developed specific tools:

- a classification of impacts into 12 disturbance categories
- a definition of ocean environs where in the ocean environs disturbances occur and whether or not these are known to occur in the South-east Marine Region
- a definition of what causes disturbance into 13 categories and whether or not these known to occur in the South-east Marine Region.

Classifying impacts into 12 disturbance categories

Twelve disturbance categories are used throughout the report, to simplify the range of impacts that can occur into a useful subset of broad types (see Table 1).

Defining where the disturbances occur across the ocean environs

This analysis describes where the different types of disturbances occur across the ecosystem, using the same descriptions of ecosystem components as those in the assessment:

- bays and estuaries
- inshore (0-20 m water depth)
- inner shelf (benthic and demersal) (20-60 m)
- middle shelf (benthic and demersal) (60-150 m)
- outer shelf (benthic and demersal) (150-200 m)
- slope
- pelagic inner shelf
- pelagic shelf
- pelagic offshore
- seamount
- multiple ocean environs

Table 1:
The 12 disturbance categories used to define impacts to the South-east Marine Region.

Disturbance Category	Description
Chemical change	Changing the concentration or properties of compounds naturally occurring in the ocean, such as changes to salinity, nutrients, and dissolved oxygen.
Contaminants	Introducing substances that are not normally found in the marine environment, such as heavy metals, PCBs and litter.
Temperature change	Changing the marine environment's natural temperature range.
Mechanical change	Removing or changing structural (biological and physical) components of the ecosystem.
Nuclear radiation	Introducing radioactive isotopes into the marine environment.
Electromagnetic radiation	Introducing radiation that consists of electromagnetic waves.
Noise	Increasing the level or amount of sound in the marine environment beyond its natural range.
Biological interaction	Removing or damaging organisms.
Introduced pathogens	Introducing disease-producing organisms to the marine environment, either from terrestrial or marine sources.
Introduced marine species	Introducing species that do not occur outside of the naturally or historically.
Turbidity/light	Changing the extent to which light penetrates the water column.
Artificial light	Introducing a source of light that would not naturally occur in the marine environment.

'Bays and estuaries' was added to this assessment because a number of disturbances in the Region are known to occur in bays and estuaries, but not necessarily in other inshore areas. 'Multiple ocean environs' was added to cover disturbances that affect species moving throughout the ecosystem, such as seabirds, whales and seals.

To determine whether or not a disturbance is known to occur in the South-east Marine Region, we defined the following categories (Table 2).

Defining the sources of disturbances

This analysis describes which activities or uses of the Region cause the different types of disturbances under 13 broad categories of activities (Table 4).

Table 2:
Categories used to describe disturbance distribution in the South-east Marine Region.

Known

The disturbance is known to have an effect on this part of the ecosystem in the South-east Marine Region.

Possible

Possibly causes a disturbance, but there is no example in the Region.

Unknown

It is unknown if the disturbance has an effect on this component of the South-east Marine Region.

Known not to occur

The disturbance is known not to effect this component of the South-east Marine Region.

Table 3:
Categories used to describe disturbance sources in the South-east Marine Region.

Known

The activity is known to cause this type of disturbance in the South-east Marine Region.

Possible

Possibly causes a disturbance, but there is no example in the Region.

Unknown

It is unknown if the activity causes this type of disturbance in the Region.

Known not to occur

The activity is known not to cause this type of disturbance in the South-east Marine Region.

The two matrices in Section 3 are the outcome of, and summarise, the analysis detailed in this section. Matrix A plots the 12 disturbance categories against whether these are known to occur in the ocean environs of the Region. Matrix B plots the 12 disturbance categories against the 13 sources of disturbance and whether these are known to occur in the Region.

In the detailed analysis, each chapter in Section 3 outlines the disturbance category, and provides an overview of where disturbances are known to occur in the environment. The second part of each chapter provides information on those activities that are either 'known', or considered 'possible' to cause the disturbance.

In some instances repetition is needed since a particular disturbance may be relevant under more than one category. For example, an activity may cause both mechanical and chemical change to the ecosystem, so is discussed under both disturbance categories.

The report includes impacts which may be negligible, temporary and/or localised, as well as impacts that are being mitigated by industry practices.

What causes disturbances

Table 4:
Sources of disturbance in the South-east Marine Region.

Disturbance Source	Description
Aquaculture	Activities associated with cultivating the food resources of the sea or inland waters. Some specific activities include feeding, disposal of waste and physical location.
Defence	Activities specific to defence activities in the marine environment, (note all shipping related activities are measured under shipping), some specific activities include sonar, live firing exercises and underwater explosions.
Emerging	Activities which are new or recent to the marine environment, such as biotechnology.
Harvesting	Activities described that relate to fishing activities, including discgarding of fish, diving and fishing gear disturbance. Any shipping related activities are included under the shipping category.
Human changes coastal zone	Activities by humans that cause changes to the coastal zone such as coastal construction, dredging.
Indigenous customary use	Activities associated with indigenous customary use, including customary harvest and ceremonial activities.
Land-based	Activities that are distinguished from human changes by the types of input that they have to the environment, and include industrial discharge, sewage and urban discharge.
Ocean dumping	Activities that are associated with disposal of waste and other products (such as ammunition) at sea.
Petroleum	Activities that are associated with petroleum exploration and production in the marine environment, for example, seismic survey, rig establishment and produced formation water disposal. Ship-related activities are included in the shipping.
Recreational activities	Recreational activities that do not fit into the tourism category, and include collecting species and diving.
Shipping	All shipping-related activities, including those from harvesting, petroleum and defence. Shipping activities include hull-fouling, ballast water discharge and shipping maintenance.
Submarine cables	Activities associated with submarine cables and including the physical presence of cables.
Tourism	Activities associated with tourism (not including shipping, since these are covered under shipping) including interactions with wildlife, and development of tourism sites.

MATRIX A: *Ocean Environs vs Ecosystem Components*

Ocean Environs	Ocean Lifeforms	Chemical changes	Contaminants	Temperature	Mechanical	Nuclear radiation	Electromagnetic radiation	Noise	Biological interactions	Introduced pathogens	Introduced species	Turbidity/light	Artificial light
Bays and estuaries	Flora	Known to occur	Known to occur	Possible	Known to occur	Possible	Unknown	Known not to occur	Known to occur	Possible	Known to occur	Known to occur	Possible
	Fauna	Known to occur	Known to occur	Possible	Known to occur	Possible	Possible	Possible	Known to occur	Known to occur	Known to occur	Possible	Possible
Inshore (0-20m)	Flora	Known to occur	Known to occur	Possible	Known to occur	Possible	Unknown	Known not to occur	Known to occur	Possible	Known to occur	Known to occur	Possible
	Fauna	Known to occur	Known to occur	Possible	Known to occur	Possible	Possible	Possible	Known to occur	Known to occur	Known to occur	Possible	Possible
Inner shelf (approx 20-60m)	Flora	Possible	Known to occur	Possible	Known to occur	Possible	Unknown	Known not to occur	Known to occur	Possible	Possible	Known to occur	Known to occur
	Fauna	Possible	Known to occur	Possible	Known to occur	Possible	Unknown	Possible	Known to occur	Possible	Known to occur	Known to occur	Unknown
Mid shelf (approx 60-150m)	Flora	Unknown	Possible	Unknown	Possible	Possible	Unknown	Known not to occur	Possible	Possible	Possible	Possible	Unknown
	Fauna	Possible	Known to occur	Possible	Known to occur	Possible	Unknown	Possible	Known to occur	Possible	Known to occur	Known to occur	Unknown
Outer shelf (150-200m)	Fauna	Unknown	Possible	Unknown	Possible	Possible	Unknown	Known to occur	Known to occur	Possible	Known to occur	Possible	Unknown
Slope	Fauna	Known not to occur	Possible	Known not to occur	Possible	Possible	Unknown	Known not to occur	Known to occur	Possible	Possible	Possible	Unknown
Pelagic inner shelf	Planktonic	Known not to occur	Possible	Possible	Known not to occur	Possible	Unknown	Known not to occur	Possible	Unknown	Unknown	Unknown	Unknown
	Nekton	Known to occur	Unknown	Unknown	Unknown	Possible	Possible	Possible	Known to occur	Unknown	Unknown	Known to occur	Possible
Pelagic shelf (inc shelf break)	Planktonic	Known not to occur	Possible	Possible	Unknown	Possible	Unknown	Known not to occur	Possible	Unknown	Unknown	Unknown	Unknown
	Nekton	Known not to occur	Unknown	Unknown	Unknown	Possible	Unknown	Known to occur	Known to occur	Unknown	Unknown	Unknown	Possible
Pelagic offshore	Planktonic	Known not to occur	Possible	Possible	Unknown	Possible	Unknown	Known not to occur	Possible	Unknown	Unknown	Unknown	Unknown
	Nekton	Known not to occur	Unknown	Known not to occur	Known not to occur	Possible	Unknown	Known to occur	Known to occur	Unknown	Known not to occur	Unknown	Unknown
Seamount	Fauna	Known not to occur	Unknown	Unknown	Known to occur	Possible	Unknown	Unknown	Known to occur	Unknown	Unknown	Unknown	Unknown
Multiple ocean environs	Cetaceans	Unknown	Known to occur	Unknown	Possible	Possible	Unknown	Known to occur	Known to occur	Unknown	Known not to occur	Known not to occur	Unknown
	Pinnipeds	Unknown	Known to occur	Unknown	Unknown	Possible	Unknown	Known to occur	Known to occur	Unknown	Unknown	Unknown	Possible
	Seabirds	Unknown	Known to occur	Unknown	Unknown	Possible	Unknown	Known to occur	Known to occur	Unknown	Unknown	Unknown	Possible

Key

Known to occur	The disturbance is known to have an effect on this part of the ecosystem.
Possible	Possibly causes a disturbance, but there is no example in the South-east Marine Region.
Unknown	It is unknown if the disturbance has an effect on this component of the South-east Marine Region.
Known not to occur	The disturbance is known not to effect this component on the South-east Marine Region.

Please note: *This report lists the range of impacts on the natural system that occur in the South-east Marine Region, but does not make any judgements about the relative importance or consequence of those impacts or the activities that cause those impacts, nor does it explain the many mitigation mechanisms in place.*

MATRIX B: *Activity vs Disturbance*

This matrix does not measure the scale, likelihood or consequence of these activities	Activity = state of action; doing	Chemical changes	Contaminants	Temperature	Mechanical	Nuclear radiation	Electromagnetic radiation	Noise	Biological interactions	Introduced pathogens	Introduced species	Turbidity/light	Artificial light
Aquaculture	Feeding	Known to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Possible	Known not to occur	Known to occur	Known not to occur
	Disposal of waste	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Physical location	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Possible	Known to occur	Possible	Known not to occur	Possible	Known not to occur
	Stock escape	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Possible	Possible	Known not to occur	Known not to occur
	Translocation of pens	Possible	Possible	Known not to occur	Possible	Known not to occur	Known not to occur	Unknown	Possible	Unknown	Unknown	Possible	Known not to occur
	Sourcing stock	Known not to occur	Known not to occur	Known not to occur	Unknown	Known not to occur	Known not to occur	Unknown	Known to occur	Known to occur	Known to occur	Known not to occur	Known not to occur
	Maintenance	Possible	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible	Possible	Unknown	Possible	Possible	Known not to occur
	Sourcing feed	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
Defence (for ship related activities see shipping)	Radar/radio transmissions	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Sonar	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Underwater explosions	Unknown	Possible	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Live firing exercised	Unknown	Possible	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Possible
	Laser emitters	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible
	NPW passive radiation	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
Emerging	Bioprospecting	Unknown	Possible	Unknown	Unknown	Unknown	Known not to occur	Known not to occur	Known to occur	Unknown	Unknown	Unknown	Unknown
Harvesting (for ship related activities see shipping)	Finshing gear disturbance	Known not to occur	Known to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known to occur	Known to occur	Known not to occur	Known not to occur	Known to occur	Known to occur
	Stock exploitation	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Discarding of fish	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Unknown	Known not to occur
	Introduction of fish bait	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known to occur	Possible	Known to occur	Known not to occur	Known not to occur
	Harvesting	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Diving	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Possible	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur
Human changes coastal zone	Dredging	Known to occur	Known to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Possible	Known to occur	Known not to occur	Possible	Known to occur	Known not to occur
	Dam + weir contruction	Known to occur	Known to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Possible	Possible	Known not to occur
	Alter tidal flow	Known to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Possible	Known not to occur
	Coastal construction	Known to occur	Known to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Possible	Known to occur	Known not to occur
	Erosion	Known to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur
	Acid-sulphate soils	Known to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur
Indigenous customary use	Customary harvest	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Ceremonial	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur
	Commercial harvest	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Unknown	Unknown	Unknown
	Aquaculture	Possible	Possible	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Possible	Known not to occur
	Ecotourism	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible	Known not to occur	Known not to occur	Known not to occur	Possible
Land based	Industrial discharge	Known to occur	Known to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur	Known not to occur	Known to occur	Known not to occur
	Urban discharge	Known to occur	Known to occur	Unknown	Known not to occur	Known not to occur	Known not to occur	Unknown	Known to occur	Unknown	Unknown	Known to occur	Known not to occur
	Agricultural discharge	Known to occur	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Unknown	Known to occur	Unknown	Unknown	Known to occur	Known not to occur
	Sewage	Known to occur	Known to occur	Possible	Known to occur	Known not to occur	Known not to occur	Known not to occur	Known to occur	Known to occur	Unknown	Known to occur	Known not to occur
	Domestic waste disposal	Possible	Possible	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Known not to occur	Possible	Unknown	Unknown	Unknown	Known not to occur

Key

Known to occur	The activity is known to cause this type of disturbance in the South-east Marine Region.
Possible	Possibly causes a disturbance, but there is no example in the South-east Maring Region.
Unknown	It is unknown if the activity cause this type of disturbance in the South-east Marine Region.
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***Please note:** This report lists the range of impacts on the natural system that occur in the South-east Marine Region, but does not make any judgements about the relative importance or consequence of those impacts or the activities that cause those impacts, nor does it explain the many mitigation mechanisms in place.*

MATRIX B: *Activity vs Disturbance*

This matrix does not measure the scale, likelihood or consequence of these activities		Activity = state of action; doing	Chemical changes	Contaminants	Temperature	Mechanical	Nuclear radiation	Electromagnetic radiation	Noise	Biological interactions	Introduced pathogens	Introduced species	Turbidity/light	Artificial light
Ocean Dumping			Unknown	Known	Unknown	Known	Unknown	Known not	Known not	Unknown	Unknown	Unknown	Known	Known not
Petroleum (for ship related activities see shipping)	Exploration	Seismic	Known not	Known not	Known not	Known not	Known not	Unknown	Known	Known	Known not	Known not	Known not	Known not
		Refuelling	Known not	Known	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not
		Rig establishment	Known not	Possible	Known not	Known	Known not	Known not	Known not	Known	Possible	Possible	Known	Known
		Drilling	Known not	Known	Known not	Known not	Known not	Known not	Known	Known	Known not	Known not	Known	Known not
	Subsea installation	Development Drilling	Known not	Known	Known not	Known not	Known not	Known not	Known	Known	Known not	Known not	Known	Known not
		Rig establishment	Known not	Known	Unknown	Known	Known not	Known not	Known not	Known	Possible	Possible	Known	Known
		Pipeline installation	Known not	Known not	Known not	Known	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not
	Operation	Production	Known not	Known	Known not	Known	Known not	Known not	Possible	Known	Known not	Known not	Known not	Possible
		Waste disposal	Known not	Known	Possible	Known not	Possible	Known not	Known not	Known	Known not	Known not	Known	Known not
		Produced formation water	Known not	Known	Known	Known not	Possible	Known not	Known not	Known	Unknown	Unknown	Known not	Known not
		Petroleum off loading	Known not	Known	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not
		Decommissioning	Known not	Possible	Known not	Known	Possible	Known not	Known not	Known not	Known not	Known not	Known not	Known not
Recreational activities		Collection of species	Possible	Known not	Known not	Known	Known not	Known not	Known	Known	Known not	Known not	Unknown	Known not
		Boating	Known not	Known	Known not	Known	Known not	Known not	Known	Known	Known not	Known	Unknown	Known not
		Aquarium collection	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known	Possible	Known	Possible	Unknown
		Diving	Known not	Known not	Known not	Known	Known not	Known not	Known not	Known	Known not	Known not	Possible	Unknown
Shipping (including shipping related activities from harvesting, petroleum, tourism and defence)		Hull fouling (including prevention)	Known not	Known	Known not	Known not	Known not	Known not	Known not	Known	Possible	Known	Unknown	Known not
		Shipping maintenance	Known not	Known	Known not	Unknown	Unknown	Known not	Possible	Known not	Known	Known	Known not	Known not
		Dredging channels	Possible	Possible	Known not	Known	Unknown	Unknown	Known	Known	Unknown	Unknown	Known	Known not
		Ballast water discharge	Known not	Possible	Known not	Known not	Known not	Known not	Known not	Known not	Known	Known	Known not	Known not
		Noise	Known not	Known not	Known not	Known not	Known not	Known not	Known	Known not	Known not	Known not	Known not	Known not
		Chemical spills	Known not	Known	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not
		Oil spill	Known not	Known	Known not	Known not	Known not	Known not	Known not	Known	Known not	Known not	Possible	Known not
		Air emissions	Possible	Known	Known	Known not	Known not	Known not	Known	Possible	Known not	Known not	Known not	Known not
		Groundings/sinking	Known not	Known	Known not	Known	Known not	Known not	Unknown	Known	Unknown	Unknown	Known	Known not
		Loss of containers	Known not	Possible	Known not	Possible	Known not	Known not	Known not	Known not	Known not	Known not	Known not	Known not
		Garbage discharges	Known	Known	Known not	Known not	Known not	Known not	Known not	Known	Known not	Known not	Known not	Known not
		Sewage discharges	Known	Known	Known not	Possible	Known not	Known not	Known not	Known	Possible	Known not	Known not	Known not
		Grey water discharge	Known	Known	Possible	Known not	Known not	Known not	Known not	Known	Possible	Known not	Known not	Known not
		Oily waste	Known	Known	Known not	Known not	Known not	Known not	Known not	Known	Known not	Known not	Known not	Known not
		Propeller action	Known not	Known not	Known not	Known	Known not	Known not	Known	Known not	Known not	Known not	Known not	Known not
		Cooling water	Known not	Known not	Known	Known not	Known not	Known not	Known not	Possible	Known not	Known not	Known not	Known not
Submarine cables		Laying of cable	Possible	Known not	Known not	Known	Known not	Possible	Known	Possible	Known not	Known not	Known	Known not
		Physical presence	Known not	Known not	Known not	Possible	Known not	Possible	Known not	Possible	Known not	Unknown	Known not	Known not
Tourism (see shipping for impact from cruise vessels)		Interactions with wildlife	Known not	Known not	Known not	Known	Known not	Known not	Known not	Possible	Known not	Known not	Known not	Known not
		Development of tourism site	Possible	Possible	Known not	Possible	Known not	Known not	Possible	Possible	Known not	Known not	Possible	Possible
		Physical presence of infrastructure	Possible	Known not	Known not	Known	Known not	Known not	Known not	Possible	Known not	Known not	Known not	Possible

Key

Known to occur	The activity is known to cause this type of disturbance in the South-east Marine Region.
Possible	Possibly causes a disturbance, but there is no example in the South-east Maring Region.
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Chemical changes

Chemical changes – changing the concentration or properties of compounds naturally occurring in the ocean, such as changes to salinity, nutrients, and dissolved oxygen.

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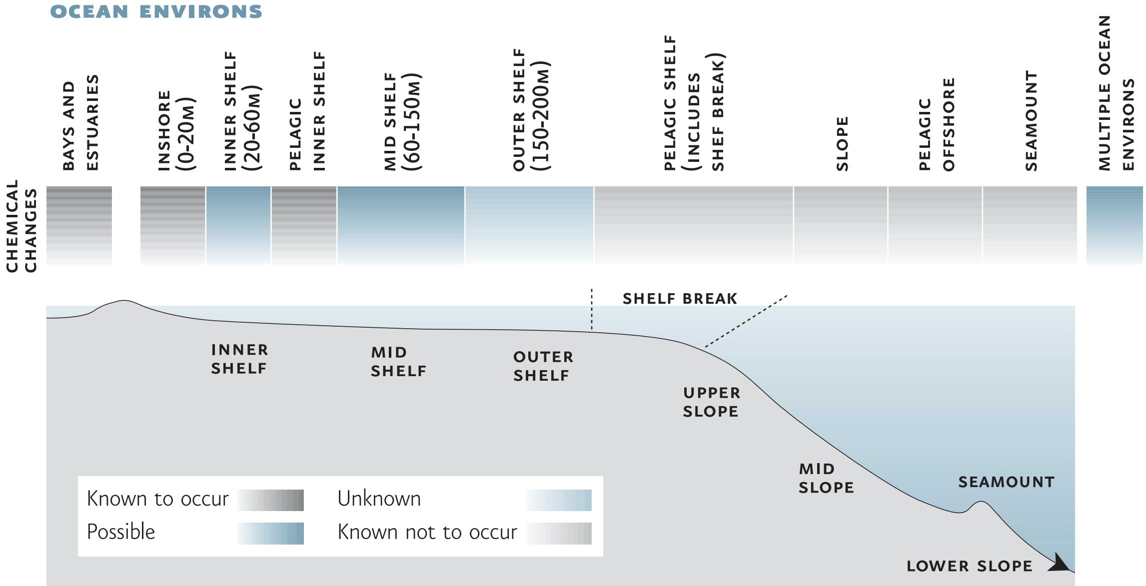

Chemical changes include the alteration of nutrient levels, such as carbon, nitrogen and phosphorous. Changes in sediment and water chemistry can cause changes in the species composition, diversity and size of benthic and pelagic communities. High levels of nutrient input can reduce species diversity and cause a few species to dominate. It is often difficult to separate the impact of chemical changes from those of turbidity/light and contaminants. This Chapter describes disturbances where chemical changes are the main cause. Disturbances caused by turbidity and light are discussed under 'Turbidity/light'.

KNOWN TO OCCUR

Bays and estuaries

Bays and estuaries throughout the Region are known to be affected by chemical changes. In moderation, nutrients can benefit sea life, but problems arise when there is too much enrichment in too small an area (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection 2001). Increased levels of nitrogen and phosphorus entering bays and estuaries from surrounding catchments cause a number of impacts (Environment Protection Authority 2001b). A common occurrence is increased growth of cyanobacteria and nuisance plants, which can dominate and change the dynamics of an aquatic ecosystem (Australia and New Zealand Conservation Council 2000, Environment Protection Authority 2001a). This can lead to clogged water filtration systems, diminish light availability to other species, displace endemic species and create odours (Australia and New Zealand Conservation Council 2000).

Nutrient enhancement also enriches the water and sediments with organic matter. This stimulates an increase in oxygen-consuming microbes, which may kill marine organisms, either directly by anoxia (an absence of oxygen), or by related hydrogen sulfide production (Australia and New Zealand Conservation Council 2000). For example in the Derwent Estuary (Tasmania) where there is a documented input of nutrients, losses of seagrass have been reported (Tasmanian Department of Environment and Planning 2001). Similar impacts from

increases in nutrients have also occurred in Western Port Bay (Brodie 1995). Eutrophication (excessive nutrient input) is also known to cause algal blooms. These have been recorded in a number of bays and estuaries in the Region including Gippsland Lakes (Victoria) and the Derwent and Huon estuaries (Tasmania) (Brodie 1995).

Reduced river flows also indirectly affect estuarine ecosystems such as salt marshes and mangroves. Increases in salinity cause stress in marsh plants and loss of mangroves through fungal infections (Macdonald 1995, Edgar 2001).

Chemical changes can modify dissolved oxygen concentrations that affect the marine environment. The oxygen demands of marine species vary across species, life stages, and life processes (Australia and New Zealand Conservation Council 2000). Maintaining dissolved oxygen concentrations within natural ranges is important for ecosystems (Environment Protection Authority 2001a).

Further reading

A better understanding of water quality and the impact of these chemical changes is being developed through a number of studies and reports in the Region including:

- The Australian and New Zealand Water Quality Guidelines
- Port Phillip Bay Water Quality - Long term trends in Nutrient status and clarity, 1984 - 1999
- The Derwent Estuary Program
- Protecting the Waters of Western Port and Catchment.

Inshore/pelagic inner shelf

Discharges containing elevated levels of nutrients modify benthic invertebrate communities. Scavengers and deposit-feeding species dominate sediments near outfalls, reflecting the high organic fractions and nutrient levels (Poore & Kudenov 1976, Poore & Kudenov 1978a). Research has shown that large brown algal kelp communities of temperate shorelines in the Region are sensitive to effluent discharges (Burridge et al. 1999).

Coastal activities cause chemical changes in the sediment and water column of the inshore environment in the Region. Sewage outfalls in the coastal zone also cause nutrient enrichment and eutrophication (Environment Protection Authority 2001b). A study commissioned by Melbourne Water on the impact of sewage effluent at Boags Rocks in Bass Strait found that the combination of freshwater and ammonia in effluent affects the rocky platforms in the surrounding environment (Melbourne Water 2001).

Soluble nutrients in the water column can alter the species composition and density of phytoplankton, increasing the risk of toxic algal blooms (Tasmanian Department of Primary Industry and Fisheries 1997). Accumulating organic matter on the seabed, especially in areas of poor current flow, can produce major changes in the sediment chemistry. Changes typically associated with severe organic enrichment are a reduction in sediment oxygen levels and the subsequent production and release of methane and toxic hydrogen sulphide (Pearson & Rosenberg 1978). Changes in sediment chemistry effects the benthic ecosystem, and may result in major changes to the species composition of sediment flora and fauna in affected areas (eg Ritz et al. 1989).

Sources of disturbance

Activities	Chemical Changes
Aquaculture	Known to occur
Defence	Known to occur
Emerging	Unknown
Harvesting	Known not to occur
Human changes	Known to occur
Indigenous	Possible
Land-based	Known to occur
Ocean dumping	Unknown
Petroleum	Known not to occur
Recreational	Possible
Shipping	Known to occur
Submarine cables	Possible
Tourism	Possible

Key

Known to occur — Unknown
Possible — Known not to occur

KNOWN TO OCCUR

Aquaculture

Within the Region, shellfish and finfish aquaculture occurs in a number of places. The effects of aquaculture vary according to the type of farm and the surrounding environment.

For example, fish farms release a number of wastes into the environment. Wastes causing chemical changes include uneaten faeces and fish food. Finfish farming adds nutrients in the form of fish food (Tasmanian Department of Primary Industry, Water and Environment 1999). Shellfish farming does not require additional feeding but may result in the build-up of excretions below the racks or longlines (Tasmanian Department of Primary Industry, Water and Environment 2000). These wastes enter the water column causing nutrient enrichment and accumulations of organic matter on the seabed, or both. The major components of solid and dissolved wastes are various forms of carbon, nitrogen and phosphorous (Canadian Environmental Assessment Office 1998, Ritz & Lewis 1989). This may result in toxic algal blooms (Tasmanian Department of Primary Industry, Water and Environment 2000). Modifications to the macrobenthic fauna from these increased nutrient levels have been documented in Tasmania (Department of Primary Industry, Water and Environment 1999).

Human changes

Dredging

Many estuarine and coastal environments in the Region, particularly near commercial ports, have a long history of dredging to increase capital development in coastal areas, and to maintain existing channels. The largest dredging programs have been performed in Port Phillip Bay, where more than 200 million m^3 of sediments have been removed since the nineteenth century to maintain port access and navigation channels (Currie et al. 1998, Coleman et al. 1999). Spoil from dredging activities is deposited in specified dumping grounds generally located in deep water, although tidal flats have also been used (Pirzl & Coughanowr 1997).

Dam and weir construction

Impounding and diverting freshwater flows has led to reduced water quality (Harris 1984, Davies & Kalish 1989, Edgar et al. 1999). This affects the flora and fauna in the impoundment, and downstream. Periodic high flow levels are important in maintaining the health of estuaries and water quality frequently deteriorates as a result of low flows (Davies & Kalish 1989).

Impoundments may also create barriers to fish migration and cause fish death. Retained floodwaters are generally colder and deoxygenated and can contain compounds such as hydrogen sulphide (Adam et al. 1992). The sudden release of this water may result in diseased or dead fish, marine vegetation and invertebrate species.

Altered tidal flow

Changes in tidal flow affect the distribution of plants, invertebrates and fish by altering salinity, nutrients and the amount of dissolved oxygen. Changes in tidal flows are commonly caused by modified river flows. For example, flow restrictions in upper catchments periodically close estuary mouths, which prevents tidal incursions and fish migration (Edyvane 1995). In estuaries where the mouth is not obstructed, reduced river flows allow tidal waters to penetrate further up some rivers. This alters the distribution of invertebrates, fish, and vegetation according to their tolerance to salinity, and may also kill aquatic vegetation (New South Wales Fisheries 1999).

In estuarine and coastal areas, structures such as bridges, causeways, culverts, floodgates, fords and weirs can all influence tidal flow. Artificial closure of coastal lakes and lagoons has reduced tidal flushing, leading to a build up of nutrients, eutrophication and lower salinity. This may cause loss of seagrass, excessive algal growth, blooms of toxic algae, oxygen depletion and lower diversity of aquatic life. An example of these impacts is in Orielton Lagoon (Tasmania) where reduced tidal flushing allowed nutrients to accumulate, causing eutrophication and algal blooms (Brett 1992, Jones et al. 1994).

Artificially opening waterways to tidal flow can lead to water stratification, reduced dissolved oxygen levels and blooms of toxic algae. An example is the Gippsland Lakes (Victoria), where nutrient release and water stratification created by opening Lakes Entrance caused toxic algal blooms (Bremner 1988). The blooms lowered the level of dissolved oxygen and killed fish and other aquatic life (Winstanley 1995).

Coastal construction

Reclaiming coastal land for development has resulted in major changes to biological and physical characteristics. Habitat and biological productivity are permanently lost by the removal of intertidal and near-shore sections of the seabed. The loss of seagrass, mangrove, wetland and salt marsh habitats has degraded the water quality in some areas. Reclamation has also caused acid drainage in susceptible areas as well as increased erosion and sedimentation (Macdonald 1995, Watchorn 2000).

Acid sulphate soils

When exposed to air, acid sulphate soils react to form sulphuric acid, which has potentially lethal effects on aquatic species (Cook et al. 2000). Activities that drain or disturb waterlogged acid-sulphate soils (such as reclamation, grazing, mining and urban development near the coast) can facilitate this conversion, leading to acid sulphate run-off. This acidic run-off can cause disease and mortality of fish, loss of diversity in benthic communities and long-term habitat degradation (New South Wales Fisheries 1999, Cook et al. 2000).

Acidic soils have been recorded near Adelaide (South Australia), Westernport Bay (Victoria) northwestern Tasmania and various other localities in southeastern Australia (Department of Environment, Sport and Territories 1997). Where mining has caused acid sulphate soils, acid mine drainage is prevalent in areas such as Macquarie Harbour (Tasmania). Acidic run-off into this harbour, combined with high metal concentrations, has caused mortalities in fish during periods of high rainfall (Tasmanian Department of Environment and Planning 1990).

Land-based

Industrial discharge

Industrial discharge is often linked to the disposal of toxic chemicals. Toxic chemical discharges are discussed under 'Contaminants'. Non-toxic impacts are associated with chemical changes, including increased levels of suspended solids, nutrients, biological oxygen demand, and, in the case of timber and paper mills, woodchip fibre (Davies & Kalish 1994, Coughanowr 1997). These non-toxic components alter habitats and degrade water quality.

The impacts of pulp and paper mill contaminants on biota depend on the mill technology, treatment processes, types of effluent types and the nature of the receiving environment (Keough & Mapstone 1995). In estuaries, direct impacts include: accumulating wood fibre sludge; declining water quality; and declining benthic flora and fauna (Horwitz & Blake 1992, Davies & Kalish 1994).

Urban discharge

Stormwater discharges and run-off from diffuse sources pollute estuaries and coastal environments in the Region. Urban run-off is characterised by high sediment and nutrient levels (Williams 1980, Edgar et al. 1999).

The effects of urban discharge on estuarine and coastal waters include nutrient enrichment and eutrophication, bacterial contamination, oxygen depletion, elevated turbidity and siltation (Scott 1996). Nutrients from stormwater have been linked to the nuisance growth of green macroalgae such as sea lettuce (*Ulva* sp., *Gracilaria* sp. and *Giffordia* sp). off metropolitan Adelaide and other urban centres. Under certain conditions, these algal growths can accumulate in beach areas, forming large decomposing drifts, and smothering benthic habitats (Edyvane 1995).

Agricultural

Land clearance for agriculture and other rural industries, such as forestry, significantly increases catchment run-off. This run-off contains a combination of animal wastes, fertilisers, pesticides, agricultural chemicals and soil. It is a major source of elevated sediment and nutrient loadings in estuaries and coastal waters (New South Wales Fisheries 1999, Edgar et al. 1999).

High levels of dissolved solids and nutrients in agricultural run-off degrade water quality and sedimentary habitats, and have been implicated in the loss of seagrass (Rees 1994, Edgar 2001). Nutrient enrichment may trigger algal blooms, which are periodically severe in parts of the Region. While algal blooms are a natural phenomenon, they appear to be increasing in frequency and extent as a result of increasing nutrients from agricultural areas. These blooms may cause considerable environmental damage. In the Gippsland Lakes (Victoria), for example, oxygen depletion caused by eutrophic conditions has killed fish and other aquatic life (Winstanley 1995). In addition, the elevated nutrients stimulate the growth of microalgae and other nuisance flora. Sedimentation caused by catchment run-off is reducing the population size of some important native algae, such as the giant kelp *Macrocystis pyrifera* (Sanderson 1999).

Sewage

More than 100 sewage treatment plants discharge wastes into coastal, estuarine and embayment waters in the Region (Parks and Wildlife Service 1995, Winstanley 1995, South Australia Environment Protection Authority 1998b, New South Wales Environment Protection Authority 2000). Most sewage treatment plants use secondary or tertiary treatment, although primary-treated or untreated wastes are still commonly discharged at ocean outfalls, including an outfall at Macquarie Island, due to the higher dispersion and dilution forces at these sites (New South Wales Environment Protection Authority 2000). Raw sewage discharges during heavy rainfalls remain a problem in many areas of the Region through overloaded treatment plants and illegal stormwater connections (Edyvane 1995, Coughanowr 1997).

Sewage effluent is very high in organic matter and nutrients, which reduces water quality primarily through eutrophication, oxygen depletion and elevated turbidity (Coughanowr 1995, Zann 1995). Discharges stimulate large growths of nuisance algae, which sometimes extend a number of kilometres from the outfall and lead to species loss and reduced diversity among natural algal communities (Connolly 1986, Brown et al. 1990). Blooms of cyanobacteria and toxic microalgae triggered by the high nutrient loads subsequently contaminate shellfish and, in some cases, cause their death (Parry et al. 1989, Cannon 1990, Hallegraeff 1995).

Sewage discharges are also directly linked to widespread seagrass loss and mangrove dieback. For example, the disappearance of more than 4000 ha of seagrass and 68 ha of mangroves in Gulf St Vincent (outside the Region in South Australia) has been primarily attributed to excessive nutrient levels and turbidity from sewage (Neverauskas 1987, Bayard 1992, South Australian Environment Protection Authority 1998a).

Recreation

Recreational activities are also sources of chemical changes in the marine environment. Sewage from recreational boating and coastal caravans and foreshore parks all flows directly into the marine environment (Environment Australia 2001).

Shipping

Ships dispose of rubbish, galley wastes, and wastewater (from toilets, sinks and showers). These change the water quality, particularly in coastal and semi-protected bodies of water. The chemical changes include a decrease in dissolved oxygen, changes to salinity and higher levels of nutrients. Excess nutrients deplete oxygen in coastal waters, and reduce the biodiversity of sea life communities.

Contaminants

Contaminants – introducing substances that are not normally found in the marine environment, such as heavy metals, PCBs and marine debris such as litter.

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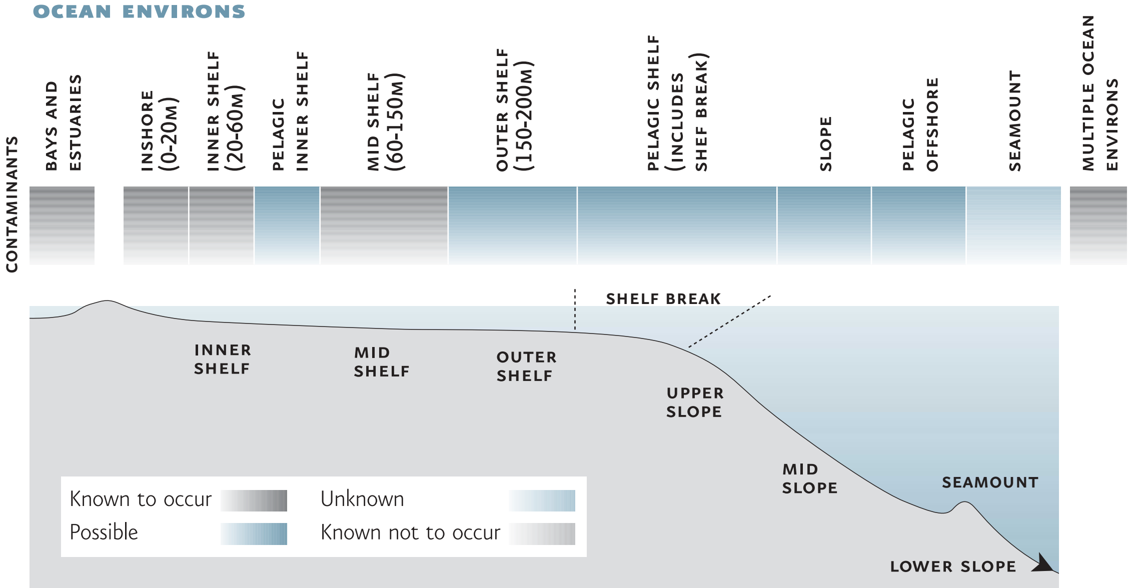


Marine debris is defined as pollution from human activities. The most frequent sources are plastics and other synthetics, such as glass and metal. Marine debris has been identified by the International Oceanographic Commission as one of the five major marine pollutants (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection 2001).

Contaminants from a wide range of sources disturb marine environments throughout the world. Different substances have different impacts on species. For example, species can ingest litter, which may cause illness, heavy metals may accumulate in tissue, which may cause lesions, and in some instances contamination can cause death. The National Pollution inventory database (www.npi.gov.au) records the most recent input of contaminants into the marine environment from land-based sources.

This Chapter summarises the types of contaminants that occur in the South-east Marine Region ocean environments and the source of those contaminants.

KNOWN TO OCCUR

Bays and estuaries

These environments, highly modified through urban and industrial development, are often the point at which pollutants enter the sea. Localities affected in and around the Region are Port Phillip Bay (incorporating Corio Bay and bordered by Melbourne and Geelong, Victoria), the Port River Estuary and Gulf St Vincent coastline (South Australia), and the Tamar and Derwent estuaries at Launceston and Hobart (Tasmania) respectively.

Some specific types of contaminants that are known to occur in this Region include heavy metals, hydrocarbons, and organic chemicals. An impact known to occur is accumulations of heavy metals in the tissue of species that occupy the seabed or filter particles from the water column. The effects of this can be lethal, causing changes in species composition and reduced biodiversity near sources of heavy metal emissions (Young 1982, Newell et al. 1987). However, many species experience sub-lethal or non-lethal effects

at certain concentrations. These species are commonly used as bio-indicators to track heavy metal pollution (Nicholson et al.1992a, Dineen & Noller 1995).

A heavy metal commonly found in the marine environment is Tributyltin (TBT), an antifouling paint. Studies have shown a link between TBT antifoulants and deformities in oysters (de Mora in Lewis 2001) and imposex (the formation of male sex characteristics in females) in gastropods (Australia and New Zealand Conservation Council 2000). Shellfish cannot metabolise TBT and even low concentrations may cause malformations (Lewis 2001).

Other common heavy metal contaminants are organochlorine pesticides, which affect marine and estuarine life. These chemicals remain in the environment and become concentrated along food chains (Australia and New Zealand Conservation Council 2000). Evidence of bio-concentration of organochlorines in the Region has been collected for numerous invertebrate species including crustaceans and molluscs (Steen 1970, Mann & Ajani 1991, Nicholson et al. 1991).

Inshore

Inshore species are also susceptible to contaminants.

Oil from various sources stranded in intertidal or shallow subtidal waters has a direct impact on seaweeds. Oil also affects marsh and mangrove communities and to a lesser extent, seagrasses. Within the Region, salt marshes and mangroves occur in the west, around Wilson's Promontory (Victoria), in Tasmania and on Bass Strait islands (including Flinders Island). While oil dispersants damage seagrasses, they do reduce impacts to highly sensitive intertidal environments by breaking up the oil (United States National Oceanographic and Atmospheric Agency 2001).

Some marine invertebrates exposed to oil show changes in burrowing depth (which may lead to higher predation rates of some species) and reduced growth, recruitment and reproductive capacity (Fukuyama et al. 1998). It is likely that some species of sediment-dwelling organisms will suffer adverse effects for several years (Payne 1992).

Both oil and oil dispersants can be toxic to crustaceans, limpets, bivalves and seastars (Michel et al. 1992, Fukuyama et al. 1998, Jewett et al. 1999). Other invertebrates, such as lobsters or scallops, may become tainted or suffer from sub-lethal effects.

Fish may accumulate high levels of metals in their tissues and become unsafe for human ingestion. Food safety guidelines are periodically exceeded for some species (de Blas 1994, Nicholson et al. 1992b).

Elevated concentrations of metals such as mercury and cadmium can also occur in the flesh of large and wide-ranging predatory fishes due to bioaccumulation and biomagnification (Howarth et al. 1982, Kemper et al. 1994, Edgar 2001).

Chemicals such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) have been recorded at elevated levels in fish within the Region (Nicholson et al. 1991, Fabris et al. 1992).

In severe cases of contamination, fish have been killed by metal accumulations in gill tissue which interferes with oxygen uptake (Department of Environment and Planning 1990). Impacts on fish health, such as lesions, eye damage and high external parasite loads, have also been documented (Gibbs et al. 1986).

Inner shelf/mid shelf

Planktonic species, which are physiologically unable to move against currents, are affected by contaminates in the Inner Shelf.

Relatively low concentrations of hydrocarbons are toxic to both phytoplankton and zooplankton. However, as plankton are widely distributed and dispersed throughout the upper layers of the water column, currents could bring new populations to replace any affected by oil (Payne 1992). An oil film on the surface could temporarily suppress primary productivity, which may affect animals that feed on phytoplankton.

Multiple ocean environs

Species that occupy multiple ocean environments are affected by various contaminants, including chemicals from land- and sea-based activities and marine debris. This topic is well documented in scientific papers, and is summarised here using the examples of seabirds, pinnipeds (seals and sea lions) and cetaceans (whales and dolphins).

What are organotins?

Organotins are a group of chemicals compounds containing at least one bond between tin and carbon. TBT is an organotin.

Seabirds and oil

The effects of oil and hydrocarbons on seabirds are well documented. In the event of an oil spill, or of seabirds coming into contact with residual oil from land-based activities, seabirds foraging or surfacing to breathe can become coated with hydrocarbons. This affects the waterproofing and insulating properties of the bird's plumage and can cause hypothermia and an inability to remain afloat or fly (Walraven 1992, Brown 1992). Other external effects include irritation or ulceration of eyes, skin and mucous membranes such as nares, mouth and cloaca (Walraven 1992). Ingested or inhaled oil following preening can also cause internal organ damage (liver, kidney and other tissues) or pneumonia.

Non-flying seabirds such as penguins are vulnerable to oil contamination when they return to land and move through oiled areas. The amount of oil affects the survival of Little Penguins that are cleaned and rehabilitated. Research has demonstrated that the survival rate of a penguin was halved for every extra quarter of body oiled (Goldsworthy & Geise 1996). There are also indirect effects of oiling, with rehabilitated birds having a lower breeding success rate (Goldsworthy & Geise 1996). Hydrocarbons can also have an indirect impact on seabirds by destroying food sources, particularly species restricted to a small area for foraging.

Cetaceans and chemicals

The effects of many chemicals on marine life are not well understood. However bioaccumulation in marine mammals has been linked to reduced breeding success (Gorman 1993). High doses of organotins damage the central nervous system and reproductive mechanisms in mammals. The most widely used organotin, tributyltin (TBT), disrupts the endocrine system in mammals (Linley-Adams 1999).

Organochlorines may cause death, reproductive impairment or greater susceptibility to disease (O'Shea 1999). A number of marine mammals in the Region are documented as containing levels of these toxic substances. This includes *Arctocephalus pusillus*, the Australian fur seal, *Delphinus delphins*, the common dolphin and *Caperea marginata*, the pygmy right whale (Bacher, G.J 1985, Bacon et al. 1992, Kemper et al. 1994, Smillie et al. 1987).

Organotins can move up through the food chain, increasing in concentration each time contaminated prey is eaten – a process known as biomagnification (Environment Australia 2000). Through biomagnification, animals high in the food chain, such as dolphins and whales, can be exposed to high concentrations of organochlorines. Post-mortem testing of these mammals has revealed high levels of organochlorines in blubber and organs (Environment Australia 2000).

Pinnipeds and marine debris

Marine debris is known to affect pinnipeds in many ways, including entanglement and ingestion. Marine debris can come from a number of activities on land and sea. Table 5 outlines some of the effects from marine debris.

A frequent occurrence is fur seal entanglement (Hucke-Gaete et al.1997). Seals are inquisitive creatures and often end up with rope, fishing net or packaging strap wrapped around their necks which gradually strangles the seal as it grows. Before it dies, the seal may starve if the entanglement restricts movement or stops it swallowing food. Entanglements cutting through the skin, blubber and muscle to reveal the oesophagus have been observed in Tasmanian waters (www.dpiwe.tas.gov.au).

The Action Plan for the Australian Fur Seal (Shaughnessy 1999) documents many of the materials known to entangle seals, including plastics, non-biodegradable debris such as free-drifting trawl net, packaging straps and monofilament gill net. Plastic litter discharged from stormwater outlets may have a similar impact on other marine mammals (Winstanley 1995).

Table 5:
Potential biological impacts of marine debris.

Potential Impact	Description
Entanglement	• Recorded on the sea floor, ocean surfaces and surrounding terrestrial habitats such as rookeries, mudflats, mangrove habitats, and islands. • Causes mortality and has an impact population levels of endangered species. • Impairs swimming and feeding behaviour (causes drag which results in inability to catch prey). • May cause wounds that become infected.
Ingestion	• Ingestion material is six to seven times more abundant than entanglement material. • About 166 species world wide (including 99 seabird, 24 marine mammal, and six turtle species) have been recorded to ingest debris, mainly plastic. • Ingestion can cause physiological problems such as gastric blockage, starvation, ulceration, reduced absorption of nutrients, and transfer of toxins from plastics into tissues and blood.
Plastic substrates	• Synthetic debris provides a substrate for epiphytic organisms, potentially promoting the long distance transfer of organisms, which may contaminate foreign environments. • There is concern that persistent marine debris could augment the natural processes of colonisation on islands, threatening these ecosystems.
micro plastic pieces and smothering of bottom fauna and beach infauna	• Micro-plastic particles can become part of beach sand and be incorporated in low trophic levels such as by benthic filter feeders. The plastic particles can transfer toxins or contain heavy metals. • Debris may smother communities in soft strata and abrade against hard substratum communities. • Smothering of coastline prevents establishment of flora which contributes to loss of habitat and erosion. • Buried plastic may limit the vertical transfer of oxygen and water in soils and sediments.
Ecosystem health	• Debris may be contributing to declining ecosystem health. Evidenced by increasing numbers of species of marine vertebrates presenting with immuno-suppression disorders such as lesions, tumours, and infection.

Adapted from: ANZECC 1996a.

SOURCES OF DISTURBANCE

Activities	Contaminants
Aquaculture	Known to occur
Defence	Known to occur
Emerging	Possible
Harvesting	Known to occur
Human changes	Known to occur
Indigenous	Possible
Land-based	Known to occur
Ocean dumping	Known to occur
Petroleum	Known to occur
Recreational	Known to occur
Shipping	Known to occur
Submarine cables	Known not to occur
Tourism	Possible

Key

Known to occur	Unknown
Possible	Known not to occur

KNOWN TO OCCUR

Aquaculture: disposal of waste/ maintenance

Contaminants from aquaculture may originate from the chemicals used in operating finfish and shellfish farms, and from chemicals used to treat sick animals – chemotherapeutants (antibiotics).

The use of antibiotics can result in residue not absorbed by the fish entering the environment in uneaten feed and in faeces. Information regarding the environmental effects of this is limited (National Pollution Inventory 2001), although accumulation adjacent to farms is a concern (Canadian Environmental Assessment Office 1998). In Tasmania in recent years antibiotics have been used irregularly in very small quantities and not at all on some farms (Tasmanian Department of Primary Industry and Fisheries 1997). This is because virtually none of the major salmonid diseases occur in Tasmania (Tasmanian Department of Primary Industry and Fisheries 1997).

We do not sufficiently understand the impacts of chemotherapeutant compounds used in aquaculture (Kevin Ellard, Tasmanian Department of Primary Industry, Water and Environment, pers. comm.). Regardless, the National Pollution Inventory has stated that the growing concerns over potential environmental effects means we need to select chemicals/compounds carefully (National Pollution Inventory 2001).

Chromium-, copper- and arsenic-treated pine is frequently used for intertidal racking in shellfish farms, but the treatment process prevents these heavy metals from accumulating in the environment (Crawford 2001).

Antifoulants are an important part of maintaining nets and cages in marine farms (Canadian Environmental Assessment Office 1998). Clean nets allow unimpeded flows of oxygen and water through the net cage, and allows excreted material and other wastes to be flushed. Copper-based antifoulants are currently the standard global practice (Dr S. Hodson, Wattyl Aquaculture, pers. comm.). Copper is an essential trace element in fish metabolism, so is normally found in the environment. Increased levels result in damage to natural or farmed organisms. The extensive use of copper for antifouling of boats may increase environmental levels (Lewis & Metaxas 1991).

Defence

Defence activities that could release contaminants into the environment accidentally or intentionally include:

- manufacturing, using, storing, testing and disposing of explosives, chemicals and armaments, and related activities
- storage, distribution and use of fuels, including bulk and packaged quantities, and mobile appliances
- management practices such as applying agricultural sprays
- training exercises and operations that involve moving assets
- handling, storing and using resources, armaments and equipment as well as producing wastes
- waste handling and disposal practices, such as landfills and liquid waste treatment facilities
- constructing, operating and maintaining facilities
- handling, storing and disposing of equipment containing intractable wastes such as PCBs
- migration of contamination to or from neighbouring properties
- unexploded ordinance

- pre-existing contamination on new sites acquired by Defence.

(www.defence.gov.au/demg/6environmental_guidance/default.htm)

Harvesting

Contaminants associated with harvesting include vessel waste (covered in the section on shipping activities) and fishing gear. Lost fishing gear during harvesting may litter beaches or entangle mammals or continue to catch species with potentially fatal consequences.

The following examples provide an overview of marine debris from both land and sea activities.

Multiple activity disturbance – land based/shipping/harvesting

A study by the Tasmanian Parks and Wildlife Service between 1990 and 1993 found that 23% of all debris items could be attributed to commercial and recreational fishing and boating (Tasmanian Department of Environment and Land Management 1996). In some remote areas of Tasmania, fishing and boating debris constituted the majority of the waste. For example, in the South-west Tasmanian World Heritage Area, 80 per cent of debris recorded was attributed to fishing and boating (Tasmanian Department of Environment and Land Management 1996).

Plastics comprise the highest percentage of marine debris items. In the same Tasmanian study, more than 112 000 debris items were recorded, of which 74% were plastic. The plastic debris included fishing nets and monofilament line, 'six pack' holders, fibreglass, pots, strapping bands, bags, floats and buoys.

Human changes

A number of human modifications to the environment have the potential to introduce contaminants.

The spoil from dredging activities sometimes contains high concentrations of heavy metals and other contaminants, and is deposited in specified spoil dumping grounds generally located in deep water, although tidal flats have also been used (Pirzl & Coughanowr 1997).

Coastal wetlands are particularly vulnerable to damage and have frequently been reclaimed for industrial and agricultural activities or used as disposal sites (Coughanowr 1997). The effects of these activities include degraded water quality through leaching of pollutants from dumped wastes and acid drainage in susceptible areas (Macdonald 1995, Watchorn 2000).

Land-based

Land-based activities contribute to the types of contaminants introduced into the marine environment. Contaminants include a number of different types of substances including heavy metals, a range of chemicals discussed here, litter and domestic waste.

Land clearance for agriculture and other rural industries results in a significant increase in catchment run-off. This run-off, a combination of animal wastes, fertilisers, pesticides, agricultural chemicals and soil, is a major source of elevated sediment and nutrient loadings in estuaries and coastal waters (New South Wales Fisheries 1999, Edgar et al.1999).

Industrial discharge

Heavy metals enter estuarine and marine environments from a range of sources. However the main sources of emissions are industrial, sewage and stormwater discharges and mining operations near coastal rivers. Heavy metal concentrations in the Derwent Estuary (Tasmania) remain amongst the highest in Australia (Coughanowr 1997), and up to 600 km^2 of marine seabed has been contaminated with heavy metals in the Spencer Gulf (outside the Region in South Australia) (Edyvane 1995).

Some of the metals in the Region are mercury, copper, cadmium, lead and zinc (Edgar 2001), with concentrations frequently exceeding the water and sediment quality guidelines prescribed by Australia and New Zealand Conservation Council (2000) and the Australian Food Standards Code of the National Health and Medical Research Council 1996 (eg Ward et al. 1986, Carpenter et al. 1991, Garland & Statham 1991). In many cases, industrial wastes are discharged to municipal sewage treatment plants (Winstanley 1995, Crawford et al. 2000) where they are combined and treated with sewage wastes.

The range of industrial chemicals released is extensive, including dioxins, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides, resin acids and organic halogens (Fabris et al. 1992, Richardson et al. 1995, Australian Paper 2001).

Urban discharge

Stormwater discharges and diffuse run-off are sources of pollution in estuaries and coastal environments in the Region. Urban run-off is characterised by high sediment loads and nutrient levels (Williams 1980, Edgar et al. 1999) and contains a wide range of pollutants, including domestic wastes and litter, pesticides, heavy metals, faecal bacteria, hydrocarbons, PCBs and organic matter (Environment Protection Authority 1993, Green 1997).

Agricultural discharge

While pesticide and herbicide chemicals are frequently contained in urban run-off and industrial discharges, agricultural run-off contributes to their concentrations in coastal watercourses (New South Wales Fisheries 1999).

Ocean dumping

Materials dumped at sea include ammunition, dredge spoil, jarosite, chemicals, industrial waste, obsolete equipment including boats, material for artificial reefs, food scraps, treated water and human bodies.

Ammunition was dumped at sea until the early seventies, with a large amount dumped after the end of World War II, including shells, cartridges, guns, bombs and missile parts. Other material dumped by the defence forces included medical stores, scrap metal, tyres, boats and other surplus or obsolete material. Spent munitions from exercises, gunfire and torpedo practice in various ports are also scattered across the seabed.

Petroleum

Drilling

Drill fluids and cuttings are a source of contaminants. Water-based drilling fluids are generally used in Australia (Swan et al. 1994) and contain 40–70% water with the largest mineral component usually barite. Drilling fluids discharged to the marine environment may contain elevated levels of several metals, and small amounts of petroleum (Swan et al. 1994). When drill cuttings are discharged, the rock cuttings and any associated fluid form a plume, from which solids fall to the ocean floor (Swan et al. 1994).

Drilling fluids

Drilling fluids are mixtures of natural clays, weighting agents (usually barite), barium sulfate and other ingredients (including ploymers, biocides and agents such as lime) either dissolved or suspended in fresh or salt water. Its function is to carry cuttings to the surface, to provide hydraulic power to the drill bit and to suspend cuttings and weight material when circulation is interrupted. Other functions are to exert a hydrostatic head to help prevent caving or sloughing of the formation and to prevent blowouts.

Drill cuttings

Drill cuttings are crushed rock particles generated by the drill bit as it penetrates rock.

From Swan et al. 1994

Industry findings on the toxic effects of drill cutting and fluid disposal on the marine environment (Australian Petroleum Production and Exploration Association 1998) generally concur with other research (eg Hinwood et al. 1994) in that "...major contamination is limited to 250 m from the well site. It is difficult to detect any effects beyond 250 m elevated concentrations of heavy metals or hydrocarbons associated with drilling fluid are generally not detectable beyond 1000 m from the well site...".

Rig establishment/operation

Accidental releases of hydrocarbons during drilling operations may be associated with leaks from equipment, a well blowout, or diesel fuel spills from the rig or supply vessels.

Almost 1100 wells have been drilled and approximately 3100 million barrels of oil have been produced in coastal and offshore Australia. Only about 600 barrels have been spilt in the marine environment from exploration and production operations. Most of these spills have involved less than 19 barrels of oil and in only a very few cases has the oil reached the shore. It should be noted that major oil spills in Australian waters were from tankers.

Accidental discharge may result from: leaks or rupture from engines, equipment or streamer cables; spills or leaks during diesel/fuel oil transfer operations; and spills or leaks from bulk or packaged storage areas.

In the event of a collision, most spill fluids consist of light hydrocarbons (diesel). Diesel is a light and highly-evaporative petroleum product. It disperses relatively rapidly after spillage to form a thin sheen. Under typical conditions, up to 95% of the volume of an initial spill can be lost by weathering during the first five days (Global Environmental and Modelling System, Santos Ltd 2001). Residual fractions normally continue to weather through processes of dissolution, biodegradation, photo-oxidisation and sedimentation. Potential impacts are short-lived and confined to the water column.

Other activities that may cause hydrocarbons to enter the marine environment are associated with shipping, harvesting and defence activities.

Produced formation water disposal

Produced formation water (PFW) is a by-product of petroleum operation in the marine environment. It originates from two sources: fossil water brought to the surface from within the rock; and injection water put into a well to increase reservoir pressure (Swan et al. 1994).

PFW contains residual hydrocarbons and other chemicals added in the production process (Burns 1997). Studies into the toxicological effects of PFW undertaken by BHP Petroleum and Esso in Bass Strait found that at dilution levels greater than 1:100, there were no detectable effects on reef building corals and planktonic species (Black et al. 1994). Acute toxicological effects are likely to be confined to an area with a radius less than 150 m where the dilution is less than 1:1000 (Black et al. 1994). Bioaccumulation of metal and oils is expected to be confined to marine species that colonise the facility.

Waste discharges

Waste discharges occur continuously during drilling operations and are biodegradable matter such as food scraps, brine from desalination process (for drinking water) and sewage. Food scraps and other solid waste are generally transport to land for disposal (Swan et al. 1994), sewage is disinfected and released from the platform along with brine from desalination processes (Swan et al. 1994). This matter results in localised increases in nutrient levels, which may stimulate microbial activity and therefore act as a food source for scavenging birds and/or marine animals.

Decommissioning

The first stage of decommissioning oil platforms includes shutdown, purging and cleaning the production systems, process equipment and pipework. This may lead to a short-term increase in discharges of chemical products and oily wastes that are recovered and disposed of appropriately onshore.

Dismantling topside facilities may also cause releases of chemical and metallic wastes.

Recreational activities

Recreational fishing, diving and beach use activities may add litter to the environment. Oil and fuel from motor boats is also a source of contamination.

Shipping

Hull fouling

Antifouling paints are designed to stop marine organisms from settling and growing on the hulls of vessels (Australia and New Zealand Conservation Council 1996a). The toxic substances in antifouling paints can include cuprous oxide, mercuric oxide, and tributyltin (TBT). The benefits of these antifouling paints such as preventing organism growth, which reduces ship fuel consumption, are offset by releases of toxins to the wider marine community.

While TBT degrades naturally in enclosed waters to less toxic compounds and ultimately to inorganic tin, the rate of leaching from vessel hulls may exceed the capacity of the marine environment to degrade TBT. The effect of antifouling compounds in semi-enclosed bodies of water such as bays and estuaries where many boats are moored can result in accumulations of toxic substances in water, biota and sediments.

Shipping maintenance

Slipway operations are a concentrated source of antifouling compounds and heavy metals, oil, fuel and litter.

Oil and noxious hazardous spills

The introduction of oil and other hazardous substances can occur from a number of other activities including fuel spills from fishing vessels, defence activities and movements of non-petroleum vessels.

Shipping is a source of oil spills, both from normal operations and from accidental discharges by oil tankers (Zann 1995) and other types of ships. Few large oil spills from shipping accidents have occurred in Australian waters but there is potential for damage if a spill happens in a sensitive area. Oil spills are also caused by accidents during vessel fuelling (Zann 1995).

Air emissions

Diesel and fuel oil engines produces air emissions. Vapours and dusts are emitted from bulk storage tanks but these sources are controlled to avoid any significant loss.

Groundings/sinkings

Shipping accidents may involve groundings or sinkings resulting in a pollutant release into marine habitats. Spills that have occurred in the Region include the Arthur Phillip spill (1990, 100 km slick) off Cape Otway (Victoria) and the Iron Baron (1995, about 300 t) in the mouth of the Tamar River (Tasmania). The Iron Baron oil spill resulted from the ship running aground on Hebe Reef in the approaches to the Tamar River (Tasmania), on 10 July 1995.

Waste and sewage

Marine wastes from shipping operations include fuel, oil, human wastes, galley wastes, waste water (from toilets, sinks and showers), garbage, cans, bottles and other solid wastes.

Loss of containers

Containers are periodically lost overboard from cargo vessels, particularly during bad weather. The types of contamination depend on the container and its contents.

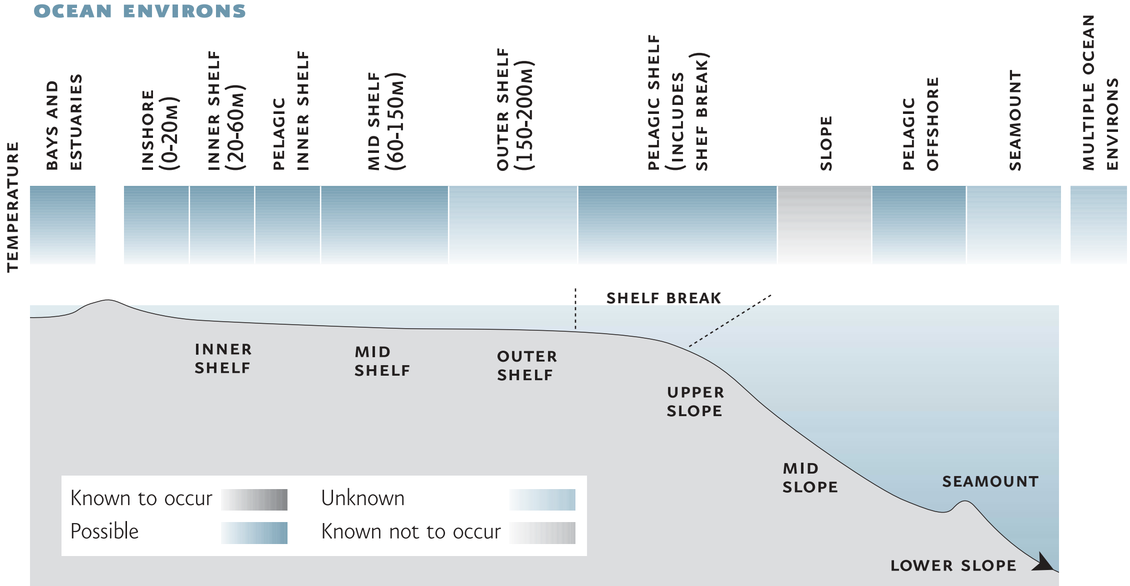
Container incidents have occurred in some of Australia's major ports with responses usually occurring as a result of leaking containers due to poor storage of containers with leaking valves (Australian Maritime Safety Authority 2001).

Tourism

Tourism operations have the potential to introduce contaminants, particularly litter, into the marine environment that are similar to those released by recreational, shipping and land-based activities.

Temperature

Temperature – changing the marine environment's natural temperature range.



Thermal discharges alter the sedimentary environment and water clarity and leads to increases in microalgae, epiphytic algae and other nuisance flora. A number of activities are known to cause temperature change within the Region, however the limited data available on the response of Australian aquatic biota to temperature change means that the effects of temperature changes on Australian aquatic ecosystems is not fully understood (Australia and New Zealand Conservation Council 2000).

A number of activities in or around the marine environment can change water temperatures, one of the factors important to marine fauna and flora survival (Australia and New Zealand Conservation Council 2000, Edgar 2001).

This Chapter summarises the effects of temperature discharges in the South-east Marine Region.

POSSIBLE

Bays and estuaries

Thermal discharges cause plumes of heated water in near-shore coastal and estuarine environments. While the impact is most likely to occur within 100m of the discharge (Aquenal 2001a), changes in community structure may occur over several kilometres (Thomas et al. 1986). These plumes adversely affect sessile species, such as seagrasses and a range of bottom-dwelling invertebrate species. Invertebrate communities exhibit changes associated with environmental stress – a small number of highly tolerant, opportunistic fauna becoming abundant, replacing more diverse communities (Thomas et al. 1986). The effects of thermal discharges on benthic invertebrates can be lethal or sub-lethal, altering species composition and diversity.

As well as altering temperature regimes, thermal discharges change the sedimentary environment and water clarity. They frequently increase microalgae, epiphytic algae and other nuisance flora. All of these factors affect seagrass beds, although impacts are not always noticeable where the effluent temperature is within the tolerance range of the species present (Ainslie et al. 1994). Dieback of seagrass beds during unusually warm conditions in parts of Victoria and South Australia indicates that tolerances could be exceeded as a result of thermal effluents (Jenkins et al. 1992, Seddon et al. 2000).

Thermal pollution affects native fish species distribution and abundance in estuarine and coastal systems (Australia and New Zealand Conservation Council 2000). While fish can move away from thermal waters, their behaviour may change. Fish may not follow their normal migration to spawning sites, reducing their breeding success. A number of species avoid the discharges, reducing fish diversity near thermal outfalls

(eg Jones et al. 1996). At certain times of the year, some species of fish are attracted to thermal outfalls and exposed to any toxic contaminants contained in the discharge (Jones et al. 1996, Aquenal 2001b).

Inshore/shelf

Thermal discharges also affect the inshore environment. The cumulative effect of the various sources of thermal discharges is that water quality frequently does not meet recommended criteria for the protection of aquatic ecosystems (Rozenbilds 1991, Coughanowr 1997). This means that marine plants and animals cannot tolerate the changes to water temperature created by these thermal discharges.

The effects of thermal discharge can also extend to the Inner and Mid Shelf.

Pelagic (inner shelf/shelf,/offshore)

Thermal discharges creating plumes of warmer water can affect plankton (Swan et al. 1994). Fish and invertebrates in the pelagic system may also be affected.

Sources of disturbance

Activities	Temperature
Aquaculture	Known not to occur
Defence	Known not to occur
Emerging	Unknown
Harvesting	Known not to occur
Human changes	Known not to occur
Indigenous	Known not to occur
Land-based	Known to occur
Ocean dumping	Unknown
Petroleum	Known to occur
Recreational	Known not to occur
Shipping	Known to occur
Submarine cables	Known not to occur
Tourism	Known not to occur

Key

Known to occur · Possible · Unknown · Known not to occur

Known to occur

Land-based

Industrial discharge

Thermal waters are discharged from a number of power stations and a wide range of industrial sites in and around the Region (Miller 1982, Winstanley 1995). These include sites in the Port River Estuary and northern Spencer Gulf (South Australia), and Port Phillip Bay (Victoria). The Tamar Estuary (Tasmania) will also receive very large and on-going thermal discharges following the conversion of the Bell Bay power station to gas (Wood & Associates 2001).

Petroleum operations

Produced formation water (PFW)

Produced formation water is a by-product of petroleum operations in the marine environment (see page 21) (Swan et al. 1994). This water contains a number of chemicals (see 'Contaminants') but may also differ in temperature from the surrounding environment. Produced formation water ranges in temperature from near ambient to near boiling point (Swan et al. 1994, URS 2000).

Shipping

Cooling water

Cooling water is seawater passed once through ship cooling pipes and systems. It generally contains no toxic substances and only a small amount of dissolved metal, so ships discharge their cooling water directly to the environment. However, it is usually warmer than seawater and is a local source of thermal discharge.

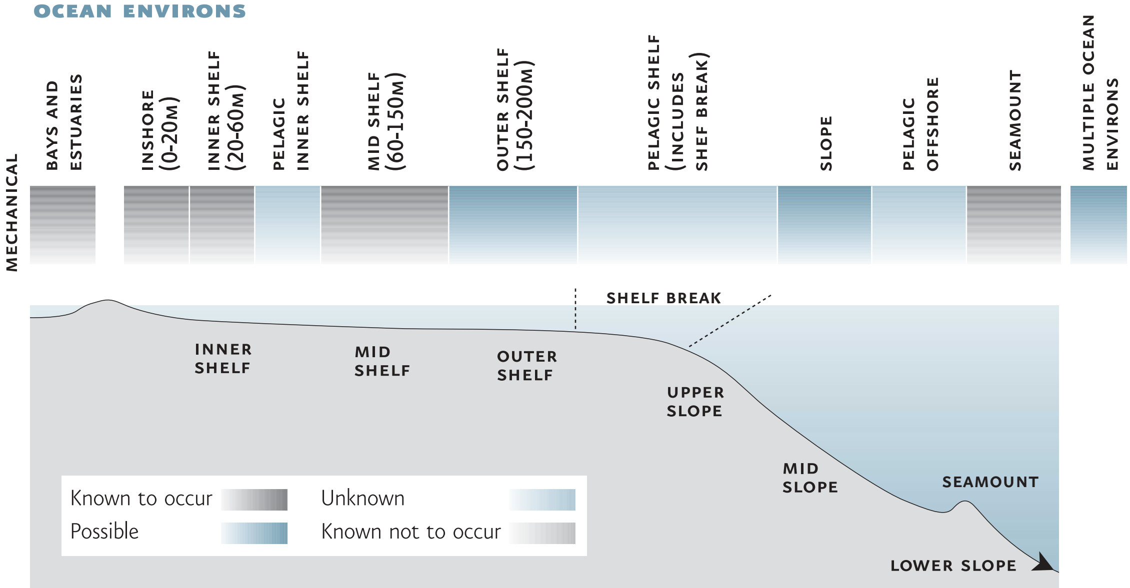
Air emissions

Exhaust from diesel engines is hot, and is a thermal discharge. Some petrol-powered outboard engines have underwater exhaust systems (National Pollution Inventory 1999), which also produce a thermal discharge. Other air emissions include vapours and dusts emitted from bulk storage tanks, but these sources are controlled to avoid any significant loss.

Mechanical

Mechanical – removing or changing structural (biological and physical) components of the ecosystem.

OCEAN ENVIRONS



Mechanical changes occur naturally through actions such as wave action, transport of materials via river systems and natural seismic activity. Human activities are also a major cause of mechanical or physical changes in the marine environment. Examples include dredging, dumping, fishing, aquaculture, prospecting and mining. The effects can include loss of or damage to habitats and benthic flora and fauna.

KNOWN TO OCCUR

Bays and estuaries

Extensive habitat loss and modification in bays and estuaries is the result of drainage and reclamation, port and marina construction, dredging, flow alterations and urban development (Zann 1995). The impacts of these changes include reductions or loss of seagrass, wetlands flora, mangrove and salt marsh habitat, as well as local extinctions of fish populations, destruction of natural spawning and nursery grounds, loss of benthic communities, loss of seabird breeding sites and a reduction in nesting habitat within the Region (Kirkman 1997, Edgar 2001, Zann 1995).

The impacts on marine and estuarine habitats from land reclamation are greatest at major ports and industrial complexes, where there has been extensive loss and modification of foreshore environments (Winstanley 1995). Land reclamation is a significant contributing factor to declining estuarine resources, particularly seagrass beds, and is also one of the most obvious causes of mangrove and salt marsh declines (Burton 1982, Shepherd et al. 1989). Habitat and biological productivity are permanently lost by the removal of intertidal and near shore sections of the seabed.

Coastal wetlands are particularly vulnerable. They have frequently been reclaimed for industrial and agricultural activities, and used as disposal sites (Coughanowr 1997). This results in loss of habitat for aquatic species and wetland birds.

Artificial barriers prevent fish passage and fish migration in the Region (Cappo et al. 1998). Effects of artificial barriers can include habitat destruction, loss of access to nursery areas, and declining fish stocks (Pollard & Hannan 1994).

Inshore

Activities such as fishing disturb the seabed and affect benthic habitats (Hall 1999).

Erosion and coastal development have significant impacts on seabirds, such as *Thinornis rubricollis* the threatened hooded plover, that nest in beach and dune environments (Buick & Paton 1989).

Many artificial reefs such obsolete vessels, have been constructed in the Region. These disturb the seabed when they settle and provide a site that attracts fish and encrusting organisms (Plunkett 2001). They also modify the localised community structure, and modify current water circulation patterns.

Inner shelf/mid shelf/outer shelf

On the continental shelf disturbances to the seabed can be short- or long-term through fishing, drilling, submarine pipe laying and other activities. They may physically damage benthic species and the species that rely on them for food or physical protection. Exposed pipelines and cables, and hard materials (such as rocks or mattresses) used to cover them, provide hard substrate that is colonised by benthic biota (Sinclair Knight Merz 1999). Offshore platform facilities contribute to the formation of physical artificial reef habitats. Platforms can be colonised by a diverse range of encrusting marine biota and higher trophic levels such as seastars, crustaceans, fish and roosting birds.

Seamount

Seamount fauna in the Region has been affected by fisheries targeting corals for the jewellery trade and indirectly by trawl fisheries targeting seamount-associated fish species (Koslow et al. 2000). These activities have had a destructive effect on fragile coral environments, damaging or destroying slow-growing deep-water corals, encrusting benthic organisms and invertebrates, and exposing animals that live among the corals to predators (Koslow et al. 2000).

POSSIBLE

Multiple ocean environs

Seals and sea birds in the Bass Strait are routinely observed on and near offshore platforms, however, there are no studies to assess the impacts to the populations of seals or other species. There are benefits they provide resting places and increase the available food sources, by increasing areas of growth for other species.

Marine mammals can be injured or killed in collisions with shipping vessels. This is not well documented in Australian waters (Bannister et al. 1996).

SOURCES OF DISTURBANCE

Activities	Mechanical
Aquaculture	Known to occur
Defence	Known to occur
Emerging	Unknown
Harvesting	Known to occur
Human changes	Known to occur
Indigenous	Possible
Land-based	Known to occur
Ocean dumping	Known to occur
Petroleum	Known to occur
Recreational	Known to occur
Shipping	Known to occur
Submarine cables	Known to occur
Tourism	Known to occur

Key

Known to occur — Unknown

Possible — Known not to occur

Decommissioning

Decommissioning of a rig can include the use of explosive cutting charges to dismantle the steel jacket, because parts of the structure may be embedded in the seafloor. This has a direct physical impact on the sediments and benthic organisms (Australian Petroleum Production and Exploration Association 1996, AURIS Environmental Pty Ltd 1995).

KNOWN TO OCCUR

Aquaculture

Physical location

The local hydrodynamics of an area are altered by aquaculture structures such as intertidal racks, trestles, long–lines, wharf facilities and fish cage infrastructure (Kaiser et al. 1998). Farm structures and the use of machinery and boats can alter benthic communities by modifying and disturbing habitats. Sediment accretion and compaction can result from heavy machinery used in shellfish growing areas (Crawford 2001).

Harvesting

Fishing methods that alter the seabed habitat directly affect the animals living within or on the substratum and may indirectly influence scavenger populations (Kaiser 2000). Trawling and scallop dredging disturbs sediments and can damage or destroy benthic fauna (Currie & Parry 1999; Koslow et al. 2000). By gradually flattening the habitat over time, trawling can affect juveniles of demersal fish on continental shelves that benefit from a

high abundance of relatively small physical features, such as sponges, empty shells and small rocks (Hall 1999).

Harvesting beach-strewn kelp occurs on King Island and some parts of the west coast of Tasmania (Tasmanian Department of Primary Industry, Water and Environment 2001). Harvesting the kelp removes habitat and food for small littoral invertebrates and other organisms, either encrusting or within its fronds and food for seabirds (Edgar 2001).

Human changes

Dredging

Biota is obliterated during dredging and may take months or years to recover (Coleman et al. 1999). Species directly affected in the Region include invertebrates, fish and seagrass, although mangrove and salt marsh communities are indirectly affected through altered water flows within estuaries (Edgar 2001). Dredging has been implicated in the disappearance of some invertebrates from port environments, such as a number of hydroid species whose loss has been recorded in Hobsons Bay (Victoria) since the advent of dredging programs (JE Watson, pers. comm., cited in Poore & Kudenov 1978). Studies elsewhere have shown that the long-term influences of dredging on benthic infauna occur through permanent modification of the sedimentary environment (Jones & Candy 1981).

Dam and weir construction

Impounding and diverting freshwater flows for generating hydroelectricity,irrigating agricultural lands, supplying domestic or industrial water and for flood mitigation works has affected many estuarine and coastal waters in the Region (Crawford et al. 2000). Dams, weirs and other man-made barriers cause reduced and unseasonal flows, lower flood frequencies, modify habitat, create barriers to fish migration or fish passage and reduce water quality (Harris 1984, Davies & Kalish 1989, Edgar et al.1999).

Altered tidal flows

Changes in tidal flows are commonly linked to modified river flows, for example where flow restrictions in upper catchments periodically close estuary mouths and preventing tidal incursions and fish migration (Edyvane 1995). Where estuary mouths are not obstructed, reduced river discharges cause deeper penetration of tidal waters into some rivers, altering the distribution of invertebrates, fish, and aquatic vegetation (New South Wales Fisheries 1999, Streever & Genders 1997). Coastal construction in the Region has altered algal communities as a consequence of reduced or increased tidal incursion, with the growth of nuisance species in poorly flushed conditions. For example blue-green algal blooms in Orielton Lagoon (Tasmania) were partly linked to decreased tidal flow at a causeway (Jones et al. 1994).

Constructions in estuaries and coastal regions influence tidal flows independently of modifications in upper catchments. Various structures that may reduce tidal flows include bridges, causeways, culverts, floodgates, fords and weirs (Williams and Watford 1997). The impact of these barriers include preventing fish migration, altered water quality and associated changes to distributions of invertebrates, fish and aquatic flora (Cappo et al. 1998, Zann 1995, Pollard & Hannan 1994).

Coastal construction

Most large urban centres on the coasts and estuaries of the Region have been highly modified through reclamation for industrial, residential and port development, establishing refuse disposal sites and constructing roads and other public utilities (Watchorn 2000). These activities have resulted in the loss of habitat, impacts on benthic communities and fewer spawning and nursery sites for fish and nesting sites for seabirds in the Region (Zann 1995).

Environmental impacts of constructing port facilities include destruction of aquatic habitats; loss of seagrass beds, salt marshes and mangroves; and sedimentation or erosion caused by altered bathymetry and water circulation patterns (Edyvane 1995, Edgar et al. 1999).

There is an increasing number of marinas and associated structures, such as jetties and boat ramps, along the Region's coast (Zann 1995). In some areas, such as the Gippsland Lakes (Victoria), the proliferation of marinas and related facilities has altered the nature of the shoreline and inshore habitats (Winstanley 1995). Marinas can be more susceptible to reduced flushing and anoxia due to their shallower depth (Edgar et al. 1999).

Sediment transport processes are altered at coastal ports through wave reflection from port structures and hydrographical modifications caused by dredging. This has changed seabed habitats and marine communities in areas such as Portland Harbour (Victoria) where protective works are now required to prevent continual erosion of the adjacent coast (Winstanley 1995).

Permanent loss of habitat and biological productivity occurs where structures occupy the foreshore or seabed, or where major dredging occurs to establish harbours and shipping channels (Coleman et al. 1999). Studies elsewhere indicate that shading caused by wharves may reduce the long-term sustainability of seagrass and algal beds through reduced light attenuation (Fitzpatrick & Kirkman 1995, Burdick & Short 1999). Changes in benthic communities also occur when native habitats are replaced with artificial structures. These artificial substrates attract exotic communities that may subsequently invade other habitats in the port environment, resulting in reducing the diversity of native communities (Hewitt et al. 1999).

Erosion

The pressure of human activity, combined with the natural processes of wind and water, has altered and accelerated coastal erosion in the Region and most beaches are retreating (Brass 1984). Retreating dunes and beaches is a natural phenomenon and has been associated with sea level rise (Zann 1995), however human interference, such as residential development, recreational access, grazing and engineering works, has altered and accelerated the process (Bird 1985).

A major factor contributing to erosion problems is the removal or damage to dune vegetation, since this exposes sands to high coastal winds and wave action, causing dune blowouts and sand drifts. Constructing buildings too close to beaches and foreshore commonly causes loss of protective vegetation cover and consequent erosion (Dobson & Williams 1978, Crawford et al. 2000).

Ocean dumping

Around 20 permits for sea dumping are issued in Australia each year, mainly for the dumping of uncontaminated dredge spoil (Environment Australia 2001). Most disposal sites for dredge spoil are concentrated near ports where the material is loaded for disposal. Obsolete vessels are occasionally included in materials used to create artificial reefs. Ocean dumping has a mechanical impact through disrupting underlying sediments. Establishing artificial reefs results in permanent alterations of sediments and marine communities (Environment Australia 2001).

Petroleum

Rig establishment/pipeline installation/ production

Mechanical disturbance to the seabed and potential impacts on marine ecosystems occur during a number of petroleum industry operations that include rig anchoring and establishment, drilling, pipeline installation and production. Increased sedimentation occurs near the rig, smothering benthic organisms and reducing the abundance of some species (Currie 1995). The duration of the disturbance and the area of seabed affected depend on the activity. The disturbance from anchoring a rig depends on the duration of the drilling program (Sinclair Knight Merz 1999).

Drilling rigs and pipelines create a local artificial hard substratum that marine species including invertebrates and seaweeds colonise (Currie &Jenkins 1994). The extent to which pipelines attract biota depends on the length of pipe that is not self-buried (Ecos Consulting 2001).

Pipeline installation disturbs unconsolidated sediments and benthic communities in Bass Strait (Duke Energy 2001, Black et al. 1994). Burrowing species and other habitats may therefore suffer some death or direct disturbance.

Shipping

Shipping operations and associated port activities identified as having a mechanical impact on the marine environment are dredging and disposal of dredged waste (spoil), and the physical damage to marine habitats by ship hulls through grounding or sinking.

Dredging channels

Dredging channels for shipping in the Region has a clear physical impact on benthic communities removing both species and habitat (Newell et al. 1998). In Port Phillip Bay (Victoria) dredging to maintain shipping channels can effect the seabed and its inhabitants.

(http://www.nre.vic.gov.au/coasts/coastkit/ch3/ports.htm#3.331).

Groundings/sinkings

Physical damage from shipping operations includes the grounding or sinking of vessels and collisions with marine mammals. The concern with whale collisions stems from anecdotal reports of such occurrences (Environment Australia 1999), a collision was report during the Sydney to Hobart yacht race in 1995/96. The impact of physical damage can include the loss of habitat, at least in the short term, depending on the location. For example, in 1995 when the *Iron Baron* grounded on Hebe Reef in the Tamar Estuary (Tasmania), physical abrasion from the ship's hull completely destroyed the subtidal reef community within an area of approximately 170 m by 20 m (Department of Primary Industry, Water and Environment 2001).

Recreational activities

Boating

Frequent occupation of popular anchorages for both recreational and commercial vessels has caused mechanical impacts on sensitive benthic habitats in the Region. For example, in Bathurst Harbour (Tasmania) frequent anchorage has damaged fragile benthic fauna in some areas (Environment Australia 2002).

POSSIBLE

Aquaculture

Physical Location

De Graves et al. (1998) concluded that the compaction and dispersal of sediments by heavy vehicle traffic around aquaculture farms may affect the composition and abundance of benthic species.

Defence

Surrounding the Region defence trials and exercises are generally held in, but not limited to, two areas.
The East Australian exercise area is located off the coast of New South Wales approximately from Tathra to Newcastle, in depths from inshore environments to the abyssal plain (>4000 m deep). The South Australian exercise area is directly south of Kangaroo Island, from coastal areas out to the abyssal plain (Department of Defence 2001). Shock and acoustic waves from defence activities have the potential to destroy marine habitats by physically disturbing bottom sediments (Lewis 1996).

Harvesting

Diving

Dive fisheries for abalone and sea urchins involve removing the target species and the potential for localised mechanical disturbance, particularly on soft sediments.

Land-based

Industrial/urban/agricultural discharge/sewage

Changes in land-based uses may change run-off patterns and lead to either increased or decreased mechanical disturbance in the marine environment.

Submarine cables

Cable laying

Laying submarine cables may disturb the seabed and their presence can have a lasting impact by providing hard substrate for encrusting organisms. It can also potentially cause mortality and some direct disturbance.

Tourism

Interactions with wildlife

Tourism activities that focus on interactions with wildlife are likely to disturb the wildlife. Direct impacts occur when trampling occurs in areas where seabirds such as little penguins and short-tailed shearwaters have nests or burrows. Observing these birds is a popular tourist activity and their habitat may therefore be at risk.

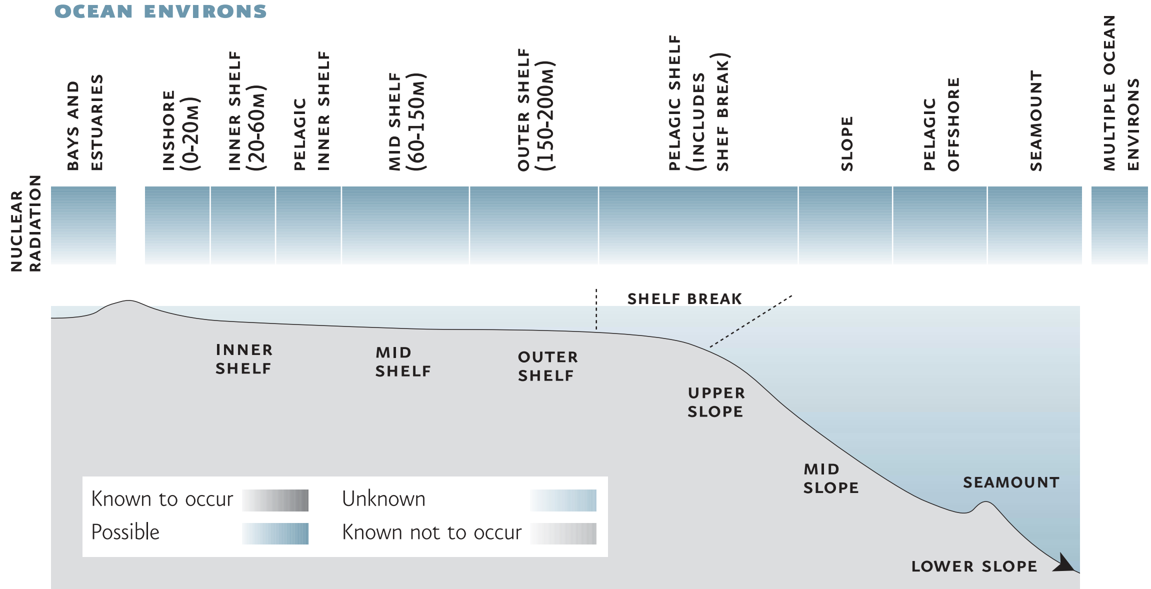
Physical presence of infrastructure

As with other forms of coastal construction, tourism developments in coastal environments may cause loss of or disturbance to marine habitats.

Nuclear radiation

Nuclear radiation – introducing radioactive isotopes into the marine environment.

OCEAN ENVIRONS



The Global Programme of Action (GPA) for protecting the marine environment from land-based activities, considers radioactive substances to be a hazard to the environment (see http://www.gpa.unep.org/pollute/radioactive.htm).

> Nuclear radiation means all particles and radiations emanating from an atomic nucleus due to radioactive decay and radiation.

The term nuclear radiation was originally used to denote ionizing radiations observed from naturally-occurring radioactive materials. Ionizing radiation is widely used in the community in medicine, research and industry (eg smoke detectors and analytical instruments) and Australia's only nuclear reactor is at Lucas Heights near Sydney (New South Wales).

Although threats from accidental releases cannot be ruled out, radionuclides are considered less of a threat than any other category of marine pollutants (Joint Group on the Scientific Aspects of Marine Environmental Protection 2001).

POSSIBLE

Bays and estuaries/inshore/shelf/slope/pelagic/multiple ocean environments

All marine environments are potentially at risk if nuclear radiation is released into the environment. In the South-east Marine Region very little research has been completed on the effects and levels of nuclear radiation. Research in the Northern Hemisphere is discussed to provide an understanding of the impact of nuclear radiation on the marine environment.

Ionizing radiation can produce a broad spectrum of injuries to mammals at the molecular, cellular, organ and organism levels. It can affect behaviour, growth and development and can cause mutations and cancer. Human-induced radionuclides that contaminate ecosystems come primarily from the fallout from nuclear weapons testing (which peaked 30 to 50 years ago), the Chernobyl accident in 1986, nuclear reactor operations, nuclear fuel processing and disposal, and applications in medicine, industry, agriculture, and research (Reynolds & Rommel 1999).

Only a few studies have examined marine mammals to determine the extent of contamination by

radionuclides, and none of these have reported any associated effects. Anderson et al. (1990) found low levels of caesium-137 (^{137}Cs) in the milk and tissues of grey seals from the North Sea and North Atlantic. About 70 per cent was attributed to the nuclear reprocessing industry in England, the rest to the Chernobyl accident. The radioactive elements plutonium and americium were barely detectable. Studies have concluded that there was no evidence of excessive concentrations of radionuclides in fish prey, and that the radiation doses received by seals were below the limit for human radiation workers, but probably higher than limits set for the general public (Reynolds & Rommel 1999).

Calmet et al. (1992) collected muscle and liver tissues from spotted, spinner, and common dolphins from the eastern Pacific and determined levels of caesium (^{137}Cs) concentrations as well as potassium (^{40}K) and lead (^{210}Pb). They concluded that the concentration of these chemicals in seawater was about the same as in fish, and that the radiation doses measured are unlikely to affect dolphin populations. Other marine mammals in which radionuclides have been measured include fin whales (Osterberg et al. 1964, Samuels et al. 1970), harp seals (Samuels et al. 1970), sperm whales, spotted seals, and bearded seals (Holtzman 1969). (All cited in Reynolds & Rommel 1999).

SOURCES OF DISTURBANCE

Activities	Nuclear Radiation
Aquaculture	Known not to occur
Defence	Possible
Emerging	Unknown
Harvesting	Known not to occur
Human changes	Known not to occur
Indigenous	Known not to occur
Land-based	Known not to occur
Ocean dumping	Unknown
Petroleum	Possible
Recreational	Known not to occur
Shipping	Known not to occur
Submarine cables	Known not to occur
Tourism	Known not to occur

Key

Known to occur	Unknown
Possible	Known not to occur

There have been no reported releases of radioactive materials in Australian waters.

While the Port of Hobart (Tasmania) accepts visits by US nuclear-powered military vessels, the transport of nuclear material is not permitted through the South-east Marine Region.

POSSIBLE

Defence

There is a possibility of low levels of background radiation from nuclear-powered vessels when US nuclear-powered military vessels visit the Port of Hobart (Tasmania). Internationally, a number of nuclear-powered and armed vessels have been lost at sea (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection 2001). Spacecraft, with nuclear reactors or radioisotope thermoelectric generators have also been lost in the sea. Radioactive debris has been recovered from Russian satellites lost at sea (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection 2001).

Petroleum

Naturally Occurring Radioactive Material (NORM) is a common output of oil and gas production worldwide. NORM sludges (called scale) are produced when radium dissolves in water. It typically accumulates in offshore equipment such as separators and flash tanks.

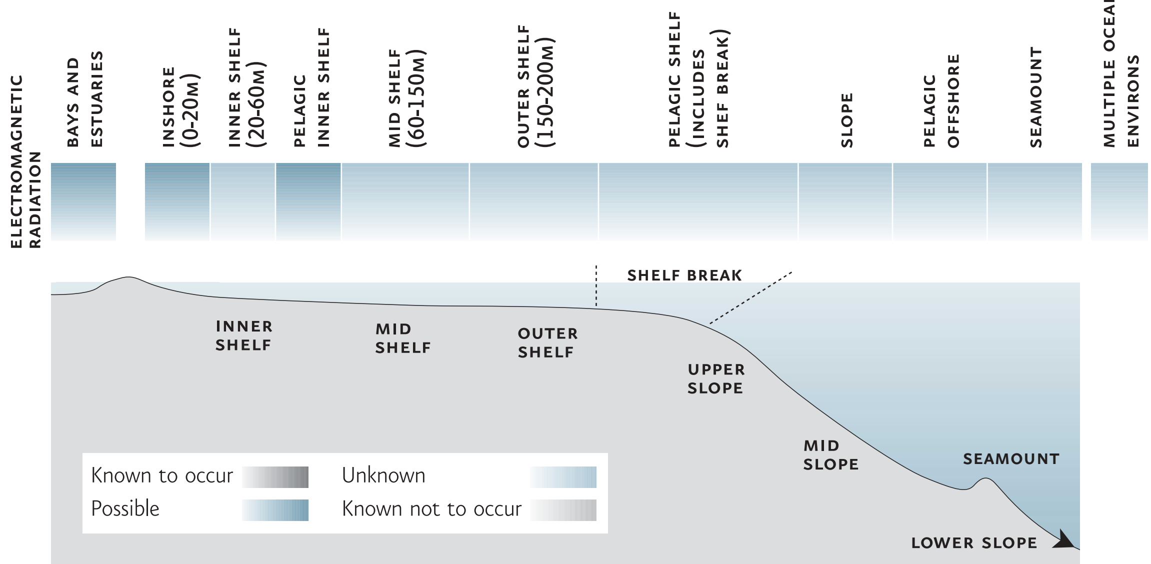
The disposal method used depends on the chemical makeup of the waste and the environment and safety assessment. Controlled discharge of scale to the sea may slightly raise radiation doses, however, levels are expected to be only slightly elevated above the natural radiation background. Strong currents and deep water assist discharged scale particles to disperse on the seabed. Generally, sealing the low-level radium material between concrete plugs (by injecting them into a plugged and abandoned well) will prevent it contaminating the marine environment (BHP 1996).

Some other methods for disposal of NORMs include injecting it into a formation where it can be isolated, dilution and disposal in produced formation water, land fill disposal and storage in a low level radioactive waste repository. The Australian Radiation Protection and Nuclear Safety Agency favours disposal in dedicated landfill (not likely to be feasible for offshore operations) or by injection into wells. The method used will depend on case by case circumstances.

Electromagnetic radiation

Electromagnetic radiation – introducing radiation that consists of electromagnetic waves.

OCEAN ENVIRONS



Sources of electromagnetic radiation include gamma rays, X-rays, ultraviolet, light, infra-red and radio waves. Most of these are present naturally in the environment. This Chapter focuses on magnetic and electrical sources of radiation from human activity.

The intensity of the earth's magnetic field strength increases with latitude from about 30 μT near the equator to 70 μT at the poles. In Bass Strait geomagnetic variation produces a local magnetic high (about 79 μT) over the Bass Basin. The movement of ocean currents through the earth's magnetic field induces an electric field in seawater. The field varies according to water velocity and geomagnetic variability and is estimated to average about 30 (V/m in Bass Strait (Basslink 2001).

POSSIBLE

Bays and estuaries/ inshore/ pelagic inner shelf (fauna)

Submarine cables used for conducting electricity produce magnetic fields that may be detected by fish (sharks, skates and rays) and cetaceans that can sense the earth's magnetic field. The effects of artificial magnetic fields have been described for overseas species such as eels (Westerberg & Begout-Anras 2000, Souza et al. 1988). Pacific eels move through Bass Strait and are potentially affected.

Multiple ocean environs

The earth's magnetic field may provide directional information to marine mammals capable of sensing it. Human-produced magnetic fields may affect species of cetaceans that undertake long, open-sea migrations. A number of cetaceans are found within the Region. Southern right whales (*Eubalaena australis*) frequent the waters of Bass Strait and the coasts of Victoria and Tasmania during winter-spring to calve. Small numbers of humpback whales (*Megaptera novaeangliae*) now

regularly enter Bass Strait and some pass through in autumn and spring on their seasonal migrations to and from breeding grounds in tropical waters. Other migratory species that occasionally enter Bass Strait include the blue whale (*Balaenoptera musculus*), minke whale (*B. acutorostrata*), sperm whale (*Physeter macrocephalus*), false killer whale (*Pseudorca crassidens*) long-finned pilot whale (*Globicephala melas*), pygmy right whale (*Caperea marginata*) and killer whale (*Orcinus orca*).

SOURCES OF DISTURBANCE

Activities	Electromagnetic Radiation
Aquaculture	Known not to occur
Defence	Known to occur
Emerging	Known not to occur
Harvesting	Known not to occur
Human changes	Known not to occur
Indigenous	Known not to occur
Land-based	Known not to occur
Ocean dumping	Known not to occur
Petroleum	Unknown
Recreational	Known not to occur
Shipping	Unknown
Submarine cables	Possible
Tourism	Known not to occur

Key

Known to occur	Unknown
Possible	Known not to occur

KNOWN TO OCCUR

Defence

The defence force and other ships in the Region use radio and radar for communication purposes (S Cole pers. comm. 29/11/01).

POSSIBLE

Submarine cables

Submarine cables in the Region are a potential source of electromagnetic radiation but their impacts are unknown.

There is a current proposal to install a monopolar high voltage direct current (HVDC) submarine electrical cable linking the Tasmanian and Victorian power grids (Basslink). A joint assessment process is currently underway for this development and a draft environmental impact statement has been completed.

> The draft environmental impact statement for Basslink can be obtained via the Basslink website: http://www.basslink.com.au/

The proposed monopolar transmission method uses the earth and/or seawater for the return electrical path whereas a bi-polar transmission system uses a return cable, eliminating the need to use the earth/sea water as part of the circuit.

The proposed earth return to complete the electrical circuit in the Basslink submarine cable is in the form of two seabed electrodes. The cathode (negative electrode) will be in Victoria in the form of a copper conductor buried in the seabed 5-10 km off Ninety Mile Beach (Victoria) in a circle about 1 km in diameter. The anode (positive electrode) will be located in the seabed off Stony Head on Tasmania's north coast.

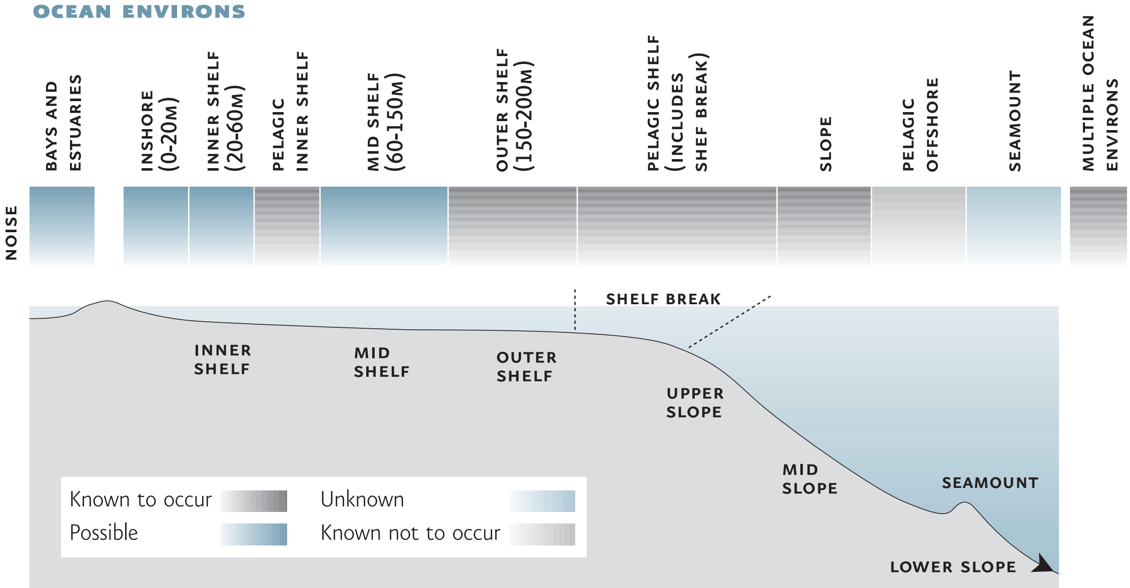
The HVDC cable, electrode cables and, to a lesser extent, the sea electrodes generate magnetic fields caused by, and proportional to, the current flowing through the cable. The cables' magnetic fields are likely to be noticeable to magneto-sensitive fish and cetaceans (Westerberg & Begout-Anras 2000, et al. 1988, Gould 1986, Gould 1998).

The presence of a HVDC cable may also interfere with shipping by disrupting magnetically-controlled ship-steering autopilots (Akke & Lampe 1995).

Noise

Noise – increasing the level or amount of sound in the marine environment beyond its natural range.

OCEAN ENVIRONS



Many of the natural noises in the marine environment provide biological 'cues' for marine organisms, acting as navigational guides and allowing them to detect other species. Noise emissions that interfere with natural sounds in the marine environment may affect the timing of social and reproductive behaviour (McCauley 1994), particularly if the disturbance to vulnerable or endangered animals coincides with very short breeding or spawning periods.

KNOWN TO OCCUR

Pelagic shelf

A number of activities that occur in the pelagic environment emit noise. The effect of noise on species is not well documented except in fish.

The potential impacts of noise on fish are influenced by their anatomy, hearing and behaviour.

Studies have shown that although some intense sounds cause limited damage to the sensory hair cells in the ears of fish, these cells can regrow (unlike in marine mammals), so hearing may eventually recover.

Most fish have swim bladders that are a buoyancy device as well as a hearing aid. Acoustic noise has the potential to damage or destroy this bladder, causing death or stunning, disorientation and a decreased ability to vocalise and hear (McCauley 1994). Fish may be more susceptible to impacts if their swim bladder's resonant frequency is similar to the acoustic source (McCauley 1994). The resonant frequency of the swim bladder depends upon the length of the fish.

Multiple ocean environs

Activities may occur close to nesting, breeding or haul-out areas for marine mammals. These have the potential to directly disturb seabirds and marine mammals or their habitats (Robinson & Scott 1999). Over time, these activities may interrupt natural behavioural patterns or reduce the available habitat for seabirds and marine mammals that depend on islands for breeding, nesting and resting.

Noise is known to affect different oceanic species in different ways. Two examples are used here to demonstrate the different types of noise-related activities that affect seabirds and cetaceans (whales and dolphins).

Seabirds

The effects of noise on birds range from increased heart rate to failed breeding and disturbances to foraging. Noise that affects seabirds comes from a variety of sources. A number of studies have noted disturbance to colonies of sea birds by approaching aircraft. One study (McCauley 1994) has reported a 'wave' of severe disturbance through a colony caused by a banking aircraft.

Controlled studies using helicopters indicate that some bird species will tolerate a helicopter at 350–400 m altitude, but begin to show signs of disturbance when the altitude is decreased to 200–250 m. At an altitude of less than 200 m many birds left their colony (McCauley 1994).

Cetaceans

Physical damage to the auditory systems of cetaceans is believed to occur at noise levels of about 230–240 dB within 1–2 m of the energy source (Gausland 2000). However, it is unrealistic to attribute one single sound level as damaging to the auditory system of all marine mammals (National Research Council 2000). Recent experiments on several smaller whale species exposed to intense signals found only temporary effects on hearing (Schlundt et al. 2000) with no long-term damage detected.

A brief summary of noise disturbance to cetaceans has been summarised by McCauley and Duncan (2001). The authors concluded that:

- there is definitive evidence of behavioural responses by great whales to various noise sources, ranging from no response to active avoidance
- there is evidence that whales of the same species may respond differently to a given noise depending on their behavioural state or habits at that particular time
- there is evidence that the response of a whale species to artificial noise may change through time due to familiarisation or sensitisation to the noise.

Baleen whales communicate by low frequency sounds and are therefore also sensitive to these sounds (Richardson et al. 1995). They are considered to be the most sensitive of the marine mammals to specific low frequency sounds. Their low frequency hearing capability is thought to overlap the low frequency output of seismic noise. Yet it is also thought that baleen whales may be quite tolerant of low- and moderate-level noise pulses from distant seismic surveys (greater than 8 km) (Richardson et al. 1995). Lower frequency sounds may affect surfacing, respiration and diving patterns (Richardson et al. 1995).

The intensity and duration of sound that might cause permanent or temporary damage to whale auditory and other organs is not known. Baleen whales are thought to receive some hearing damage from seismic noise (Richardson et al., 1995). Within several kilometres of a noise, baleen whales may exhibit strong avoidance behaviour for an hour or more (Richardson et al. 1995).

Toothed cetaceans produce echolocation clicks that have the highest source levels of any recorded sounds from marine mammals, ranging up to 220-230 dB re 1µPa-m. Most components of these social sounds are well above the low frequency range where marine seismic survey noise is concentrated (Richardson et al. 1995). Little published information is available about the reactions of smaller toothed cetaceans to seismic noise (McCauley 1994).

Echolocation - the method of locating objects by determining the time for an echo to return and the direction from which it returns, either by radar or by sonar.

Some key sound terms:

- dB – decibels – a unit expressing the ratio between a power, voltage, current or sound intensity and a reference value
- 1µPa-m – microPascals referenced to 1m – where a pascal is a unit of pressure equal to 1 newton per square metre.

The hearing capability of larger toothed whales (such as the sperm whale) is unknown, but it is possible that they can hear better in the lower frequencies than the smaller toothed cetaceans.

If this is the case, their reactions to seismic survey vessels may be similar to those of the baleen whales (McCauley 1994). Furthermore, species-level effects are only likely to be caused near critical habitats, as recognised in the section on pinnipeds.

POSSIBLE

Bays and estuaries

Temperate rocky reefs and seagrass ecosystems are all highly sensitive to noise disturbance because of the fragile nature of these ecosystems and the diverse range of flora and fauna they support (Department of Defence 2001).

Inner shelf

Shock waves and acoustic waves have the potential to destroy marine habitats by disturbing bottom sediments. This physical disturbance can change the redox potential (see box below) of the sediment, releasing toxins. Sediments suspended in the water column decrease the level of light penetration, reducing the amount of energy available for photosynthesis and causing a secondary turbidity/light disturbance (see 'Turbidity/light').

Settling sediment can also smother marine flora. Such changes in the structure of the marine community can modify the habitat so that it is suitable to different species, can selectively remove particular food sources, or increase the chances of predation (Lewis 1996).

> Redox potential – a measure in volts of the affinity of a substance for electrons (its electronegativity) compared with hydrogen (which is set at zero).

Outer shelf

Species that occur below 80 m deep may be subjected to noise from a number of sources. While many of these species do not have sensory organs capable of perceiving sound pressures (McCauley 1994), many species have mechanoreceptors - elaborate arrays of tactile hairs sensitive to hydro-acoustic disturbances. The hearing frequency of these receptors is thought to be less than 100 Hz, with little capacity to hear distant noises (McCauley 1994).

Multiple ocean environs

Pinniped

Little data exists for low frequency thresholds and hearing sensitivities of Australian pinnipeds. Seals and sea lions, due to their poor hearing in the low frequencies, may tolerate noise of high intensity. However, noise may affect seal and sea lion breeding success by influencing prey abundance or behaviour (McCauley 1994). It has been recognised that high intensity noise will only be a threat to pinnipeds when it is emitted close to critical habitats (Shaughnessy 1999).

Seal breeding colonies are known to be highly sensitive to noise and intruder disturbances. The seals' breeding success depends on an undisturbed environment Bryant & Jackson 1999). The level of disturbance is highly dependent on its distance from the colony, the level of noise impact and its duration.

SOURCES OF DISTURBANCE

Activities	Noise
Aquaculture	Possible
Defence	Known to occur
Emerging	Known not to occur
Harvesting	Known to occur
Human changes	Possible
Indigenous	Known not to occur
Land-based	Known to occur
Ocean dumping	Known not to occur
Petroleum	Known to occur
Recreational	Known to occur
Shipping	Known to occur
Submarine cables	Known to occur
Tourism	Possible

Key

Known to occur · Unknown · Possible · Known not to occur

Zones of influence

The sound and the pressure of accoustic waves are attenuated as they move away from the sonar source. Literature sources define four conceptual zones of acoustic wave influence radiating from a sonar source. Starting clostest to the source, they are the zones of:

- hearing loss, discomfort or injury
- masking
- responsiveness
- audibility.

KNOWN TO OCCUR

Defence

A number of defence force activities cause noise disturbances in the marine environment. The principal source is from underwater sonar activities. Sonar 'explosions' produce shock waves and all sonar devices produce acoustic waves. Both have the potential to affect the surrounding marine biophysical environment.

Underwater charges or explosions can encompass a wide spectrum of frequencies at high levels. Damage to marine life by explosions can be the result of both the shock and acoustic waves from the blast. Generally, the heavier the charge the greater the impacts.

Shock waves have the potential to cause pathological damage and behavioural responses in marine fauna. Impacts from acoustic waves vary in intensity from behavioural responses to injuries, increasing the likelihood of indirect mortality.

Controlled research into the pathological impacts of shock waves on marine fauna has been conducted but information about the effect of shock waves on behaviour is mostly anecdotal. More extensive studies of acoustic wave impacts have been undertaken by the petroleum industry and are covered in the petroleum section of this Chapter.

Harvesting

Most of the noise associated with harvesting is caused by vessel and on-board operations. Depending on the type of harvesting activities that occur, noise may also be associated with operating fishing gear.

Human changes

Dredging

Dredging operations are a prolonged source of noise disturbance, similar to vessel operations, except that the source of the noise remains in one area for a long time.

Petroleum

Seismic

High-intensity noise discharges from seismic surveys are considered to affect marine systems. Research carried out in 1994 by the Independent Scientific Review Committee (ISRC), found that environmental issues relating to seismic surveys are largely concerned with:

- pathological effects (lethal and sub-lethal injuries) – immediate and delayed mortality and physiological effects to nearby organisms
- behavioural change to populations of marine organisms
- disruptions to feeding, mating, breeding or nursery activities of marine organisms that affect the vitality or abundance of populations
- disruptions to the abundance and behaviour of prey species for marine mammals, seabirds and fish
- changes in behaviour or breeding patterns of commercially targeted marine species, either directly, or indirectly that compromise commercial or recreational fishing activities.

Seismic surveys using air guns as the sound source elicit avoidance reactions in most mobile marine organisms. Reactions vary with different marine organisms and with distance from the sound source. Humpback whale cows and calves appear sensitive, exhibiting avoidance at up to 12 km from the sound source. Other animals tested, including turtles and squids, exhibited avoidance reactions between 2–5 km from the sound sources (URS Pty Ltd 2001).

Fish disturbance is believed to stop at noise levels below 180 dB re 1Pa. There is some evidence to suggest that seismic surveys may cause physical damage to fish auditory systems, no evidence of direct mortality resulting from seismic shots is known. See (http://www.dme.wa.gov.au/minpetrol/safety/fish.htm).

Drilling, sub-sea installations, production

Noise is also associated with drilling, sub-sea installations, daily operational activities and activities related to petroleum shipping.

Noise generation is a part of offshore production. There is little published data on underwater noise levels near production facilities and on the effects on marine species near the facilities. However, underwater noise levels are often low, steady and not disruptive. A stronger reaction would be expected when sound levels are elevated by support vessels or other sources of noise (Richardson et al. 1995). Rig tender vessels may generate higher levels of noise, especially if they are using engines to hold their position alongside the platform for supply or transfer operations.

The noise levels associated with drilling are much less than those associated with seismic surveys. An underwater noise survey, commissioned by Shell Development Australia and carried out by Curtin University during the drilling of Evans Shoal-2 well in July 1998 concluded that: peak noises generated from normal drilling activities was well below the highest components of humpback whale song; that noise decreased rapidly with distance from the wellhead; and that the lack of any threatening stimuli accompanying the noise from the drill rig would allow for rapid habituation, greatly reducing the impact of the noise (McCauley 1998). Some avoidance behaviour may be exhibited due in part to the high mobility of these animals, but this is likely to be extremely localised and very short term, and is not likely to affect an ecologically significant proportion of a population.

Recreational activities

Recreational activities involving boat traffic are known to cause a noise disturbance.

Shipping

The impact of shipping noises varies depending on the subject's proximity to the source. Within the immediate vicinity, sounds may be erratic, from machinery such as propellers and flow noise with a frequency between 10 Hz and 1 kHz. From a distance, ships emit a continuous, low frequency noise ranging from 1 Hz to 500 Hz with 70±5 dB (dB re 1 μPa^2/Hz over a stated frequency range) (McCauley & Duncan 2001).

Submarine cables

The main source of noise during pipeline installation comes from the lay vessel and support vessel engines. Lowering the pipeline to the sea floor emits only a small amount of noise because construction crews aim to avoid vibrations and physical impacts to the constructed pipeline.

POSSIBLE

Aquaculture

Possible behavioural responses of fauna may result from disturbances in and around the farm, for example from the increased boating activity.

Harvesting

Diving is a possible source of noise if it is associated with motor vessel activity.

Human changes

Development projects can be a source of sustained or intermittent noise during construction operations.

Shipping

Slipway activities such as water blasting to remove antifouling and other paints can be a source of noise.

Tourism

Interactions with wildlife

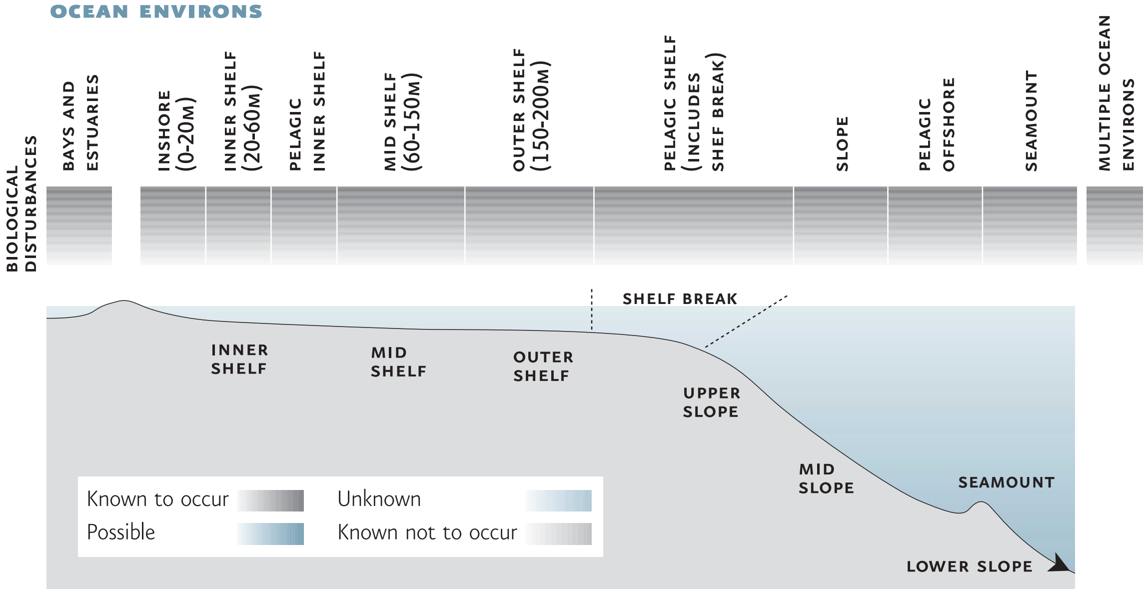
Tourism activities that interact with wildlife are likely to cause a noise disturbance. Preliminary studies by Geise (2001) indicate that humans viewing seabirds and seals on Macquarie Island may disturb these breeding colonies.

Development of tourism site

Tourism sites, like any other coastal developments, can be a source of sustained or intermittent noise during construction operations.

Biological interaction

Biological interactions – removing or damaging organisms.



Removing or damaging organisms can have a direct and immediate effect on habitats by disrupting marine ecosystems. Interactions that disturb the marine environment can come from a number of sources. This Chapter focuses on sources that are directly biological in nature.

KNOWN TO OCCUR

Bays and estuaries

In bays and estuaries of the Region, affected areas occur next to major coastal cities where habitats have been modified by urban and industrial development (Edgar 2001). Habitat loss and disturbance to tidal flats, seagrass, benthic communities, fish spawning and nursery areas have widespread effects on the ecosystem. Impacts are direct, through the loss of organisms (by harvesting, habitat loss or modification) and indirect (through lost breeding opportunities).

Coastal and estuarine fisheries around the world are either fully exploited or over-exploited (Blaber et al. 2000). As a part of the Victorian Marine Coastal and Estuarine Investigation (2000), the public raised concern about the pressure placed on intertidal and shallow subtidal communities along the Victorian coastline. Studies in Victoria summarised by Keough (1996) argue that more information is required about intertidal areas, to develop a better understanding of the sensitivity and recovery rates of these environments.

Removal of species for bioprospecting also occurs in this environment (Volkman 1999). Sponges, such as *Trachycladus laevispirulifer* and *Phorbas* species have been collected from the Region (McNally & Capon 2001, Vuong et al. 2001).

Inshore

There are direct and indirect effects from the consistent removal of fish from an ecosystem.
The immediate effects of most harvesting processes in sedimentary environments include reductions in the abundance of many benthic species and in the total benthic biomass in the areas where sediment is disturbed (Hall 1999). In the Region, a number of fisheries operate in the inshore environment, removing species for food and for bait, including snapper, yellow-eyed mullet, Australian salmon and sand flathead (Victorian Department of Natural Resources and Environment 2000). Even species that are not directly exploited by a fishery can be affected by the removal of a substantial proportion of their prey, predator or competitor biomass (Hall 1999). For example, in the Region, *Haliotis sp* abalone is fished in a number of places, and its overfishing has been linked to an increase in abundance of sea urchins, leading to habitat change that has resulted in a more favourable environment for sea urchins (Bruce et al. 2002).

An example of overfishing in the Inshore environment in the South-east Marine Region.

The problems of overfishing and habitat are illustrated by the history of the scallop industry in Tasmania. The commercial scallop was first harvested in large numbers from the Derwent Estuary and Ralphs Bay about the turn of the century. These areas eventually became depleted. During the 1930s efforts shifted to the D'Entrecasteaux Channel, where dredges with metal teeth that dig into the seabed were used. These dredges crush sponges, bryozoans, gorgonians and the shells of juvenile scallops and also turn over sediments, producing an environment where decomposing bacteria with a high demand for oxygen flourish. The Channel industry eventually closed because the catch had collapsed to a small fraction of previous annual catches of around 500 t. Parts of the seabed changed from sand to silt during the period of the fishery's operation, a transformation also presumably affected to an unknown extent by increasing development along the foreshore. Numbers of commercial scallops have shown little recovery in the Channel region during the last 50 years.

From Edgar. G 2001. Australian Marine Habitats in Temperate Waters.

Other issues in the inshore environment include bycatch and the interaction with species not being caught, such as species coming into contact with fishing vessels or aquaculture sites but not being killed by these encounters. Interactions in the inshore environment are known to occur with seals and turtles (Ford 2001), and bycatch of crustaceans, finfish, molluscs and echinoderms has also been recorded (Ford 2001).

Shelf

The biological disturbances on the continental shelf are similar to those for inshore environments – affecting the target stocks, non-target species, seabed habitats and benthic communities. However the species and the communities involved are very different. For more information on the composition of the different ocean environments, see the report *Ecosystems – nature's diversity*.

Habitat disturbance results in damages to, changes in, or loss of, benthic communities. Changes in habitat architecture (eg removal of small features such as sponges and empty shells from the seafloor) can have effect small demersal fish and other organisms that use these features for protection. This can contribute to changes in the fish community structure. For example, in a survey of the Bass Strait Central Zone Scallop fishery (Semmens et al. 2000) pieces of both sponges and seaweed were dislodged from the substrate, and many *Leptomithrax gaimardii* (giant spider crabs) captured had a damaged carapace and/or legs.

Two food sources are generated by towed gear for benthic scavenging species – dead discarded material and exposed and damaged fauna (Hall 1999). These increased sources of food can lead to changes in the community structure of areas that are repeatedly trawled. This favours scavenging species and those that feed on benthic invertebrates. Fragile species (such as anemones, shrimps, sponges, nudibranchs and tubeworms) can become less abundant. The sponge gardens in Bass Strait are particularly vulnerable to seabed disturbance. Many animals live within and around them, though their particular function in the bottom community is not yet well understood.

Discarding of non-target species

Discarding of species in the Region occurs for both trawl and non–trawl fisheries. Different species are accidentally captured by different techniques, and because no commercial market exists for these species, they are discarded (Liggins and Knuckey 1998). Other reasons for discarding the catch include illegal size, exceeding quota or poor market price (Liggins and Knuckey 1998). Discarding also results in unnatural cycling of large amounts of biomass, affecting the behaviour of other species (Moore and Jennings 2000). In the past, little information has been collected on discard rates. Recent research has also found that discarding in recreational fishing is also a concern (McGlennon and Lyle 1998).

Pelagic

Pelagic fish species are taken in both longline and seine fisheries in the Region. The main pelagic fisheries in the Region are the South-east Non-Trawl Fishery, the tuna and billfish fisheries. More information on the management of this fishery can be found in the report *Resources – using the ocean*.

The direct impact of harvesting pelagic schooling species can be more profound than harvesting benthic fish species that generally do not form dense aggregations. It is possible for fishers to hunt for schools of schooling species, such as tuna, and maintain high catch rates until most of the stock has been caught (Hall 1999). There may also be little understanding of the role that these species play in the ecosystem. For example, the blue shark, which is a bycatch species in the tuna and billfish long-line fisheries, is likely to be a key species in oceanic ecosystems, however the ecological effects of removing sharks is poorly understood (Bruce et al. 2002).

Seamount/slope

Species endemism (being peculiar to a specific location) is high on offshore seamounts and rises. Recovery rates of disturbed or damaged communities are unknown but believed to be slow (Bruce et al. 2002). Deep-sea species are particularly vulnerable to over-exploitation due to their slow growth rates, the long time it takes for them to reach reproductive maturity and their long life span. In the South-east Marine Region, depletions have occurred in several species including orange roughy and some deepwater dogfish species (Bruce et al. 2002). For example, the Patagonian toothfish, *Dissostichus eleginoides*, which can grow up to 2 m in length and live for 50 years, is caught in deep waters off Macquarie Island (Harris & Ward 1999). An issue for this species is the illegal and unreported catches (Lack & Sant 2001).

For more information on illegal and unreported fishing of the Patagonian toothfish, see the following internet resources:

- http://www.traffic.org/toothfish
- http://isofish.org.au/about.htm

One of the clearest impacts of deepwater fisheries is on benthic habitats. The removal and damage to benthic species has been observed in areas when new areas are fished (Koslow & Gowlett-Holmes 1998). The benthic fauna of seamounts is typically distinct from that on the surrounding seafloor because the intensity of currents leads to a fauna dominated by suspension feeders, including scleractinian, antipatharian, and gorgonian corals (Environment Australia 2001). This fauna has been affected by both by fisheries directly targeting corals for the jewellery trade and indirectly by trawl fisheries targeting seamount-associated fish species (Koslow et al. 2000).

Large aggregations of orange roughy have been fished from seamounts, and deep plateaus at 700–1200 m depth around Tasmania, greatly depleting the local fish stocks, which may affect the reproductive success and sustainability of the species.

These activities have a destructive effect on fragile coral environments, damaging or destroying slow-growing deep-water corals, encrusting benthic organisms and benthic invertebrates, and exposing animals that live among the corals to predators. There could also be indirect effects for other organisms that rely on the attached epifauna for food or shelter (Hall 1999).

Multiple ocean environs

In Multiple ocean environs, a number of species are directly affected by biological interactions or accidental capture. One of the most well known and well documented interactions has been the accidental death and damage to seabirds in the longline fisheries. Bycatch during longline fishing occurs when seabirds are attracted to fishing vessels by discards and bait (Environment Australia 1998). Other interactions include turtle entanglements in fishing gear (Bone 1998), seal entanglements and interactions with aquaculture and oceanic fisheries, and marine mammal trophic interactions, including mammals eating food in direct competition with humans (Goldsworthy et al. 2001).

However, in the Region, and elsewhere in Australia, there is little understanding of the ecological role of marine mammals and their interactions with commercial fisheries (Goldsworthy et al. 2001).

More information on bycatch of birds and threat abatement plans and recovery plans for endangered species can be found at:

- http://www.ea.gov.au/biodiversity/threatened/recovery/albatross/index.html
- http://www.ea.gov.au/biodiversity/threatened/tap/longline/index.html

Sources of disturbance

Activities	Biological Disturbances
Aquaculture	Known to occur
Defence	Possible
Emerging	Known to occur
Harvesting	Known to occur
Human changes	Known to occur
Indigenous	Known to occur
Land-based	Known to occur
Ocean dumping	Unknown
Petroleum	Known to occur
Recreational	Known to occur
Shipping	Known to occur
Submarine cables	Possible
Tourism	Possible

Key

Known to occur · Unknown · Possible · Known not to occur

Known to occur

Aquaculture

Aquaculture in the Region includes finfish and shellfish farming. The intensity and type of environmental impacts of aquaculture depend on the species farmed, the intensity of production and on the farm location.

Feeding

Increased food resources near farm cages attract large concentrations of escaped and wild fishes, which may transfer disease and parasites to other native fish (Carss 1990). Seals, fish and sea birds may be attracted to or avoid the cages and altered food sources, causing changes to population distribution, species composition and abundance.

Stock escape

Eexotic species that escape from finfish and shellfish farms may prey on native fish, competition for resources and disease transmission (Canadian Environmental Assessment Office 1998).

Introduced commercial shellfish species potentially allow feral populations of these species to become established. For example, pacific oyster spat from shellfish farms can settle in areas of rocky coastline and compete with native species. There are also associated impacts including unintentional translocation of associated species. As hatchery production of shellfish seed increases, and the best possible genetic traits for aquaculture are selected, the potential to alter the genetic characteristics of wild stocks will increase (Crawford 2001).

Sourcing of stock

Sourcing stock from the wild for aquaculture has the potential to affect wild populations. For example, in mussel cultures, collecting native stocks may decrease or alter local populations (Gavine & McKinnon 2001, Christine Crawford Tasmanian Aquaculture and Fisheries Institute, pers. comm.). This is not an issue for the salmon industry in the Region, where fry are hatched in freshwater facilities using brood stock maintained by the aquaculture industry (National Pollution Inventory 2001).

Emerging

Bioprospecting involves collecting organisms to search for new chemicals that might have some beneficial use. It may have biological impacts similar to harvesting, because trawls and bottom grabs are sometimes used. Opportunistic collections are also sometimes made from fisheries bycatch.

Marine species from the Region are collected for the bioprospecting industry (Volkman 1999) and while it is still an emerging activity, there have been some records of species being collected for these purposes in the Region (McNally & Capon 2001, Vuong et al. 2001).

Harvesting

Ecosystem effects may be direct or indirect. Direct effects include: the fishing mortality of target populations (overfishing); the fishing mortality of non-target populations (bycatch); and the physical impacts caused by towed gears on benthic organisms and on the seabed.

Indirect effects include: impacts mediated by biological interactions; the environmental effects of dumping discards and organic detritus (offal); modifications to the food chain; and the mortality caused by lost gear (ghost fishing and marine debris) (Goni 1998). Marine debris is discussed in more detail in the pinnipeds and marine debris section of 'Contaminants'.

In the South-east Marine Region the long-term effects of the South-east Trawl Fishery (SETF) and South–East Non-Trawl Fishery (SENTF) are poorly documented. Interactions between many species and other members of their associated assemblages, their habitat and how these change during different stages of their life history is poorly known (Bruce et al. 2002). The size structure of several exploited species is documented for several target species in the Region, however the implications and extent of effects of fishing are largely undocumented (Bruce et al. 2002).

Stock exploitation

Fishing usually attempts to remove the older age groups from a stock, although many age groups may be caught depending on the fishing gear used. Fishers tend to target species in sequence as a fishery develops and this leads to changes in the composition of the fished communities over time (Jennings & Kaiser 1998).

Overfishing (in a biological sense) may be divided into recruitment overfishing and growth overfishing. Recruitment overfishing occurs when stock levels are depleted to such a level that there may be too few adults to produce enough offspring to maintain the stock. This is most likely to occur in pelagic species where the individuals often form dense aggregations. Easily detected as a group, catches and catch rates can remain high even when the stock is severely depleted. Another group particularly prone to recruitment overfishing are species that are economically valuable but have low reproductive capacities (eg turtles, marine mammals and elasmobranchs).

Growth overfishing is harvesting fish too early in their life. This occurs most often for demersal species (Hall 1999).

Discarded fish

Non-target species, fish and other animals are often caught incidentally and are usually discarded as bycatch, which can include both dead or live animals. Apart from the direct impact on the caught species, there is a flow-on effect of locally increasing nutrients when dead animals are discarded, which often attracts predators such as seabirds, seals and other fish (Moore and Jennings 2000). This can affect the distribution and abundance of scavenging species.

An associated issue is highgrading - discarding lesser-value species or catches for more valuable species or catches that would provide a larger return (Australian Fisheries Management Authority 2001). For example, in the South-east Marine Region, highgrading occurs in the tuna and billfish fisheries, as operators may highgrade due to market returns. More valuable, preferable fish for the market, which would provide a larger return, are therefore given higher priority in the limited storage space available in vessels. Juvenile fish, damaged fish or fish in poor condition would also be highgraded (Australian Fisheries Management Authority 2001).

Petroleum

Offshore petroleum activities may cause a number of interactions with species. Within the Region, a number of studies have identified the species that these activities interact with (Woodside 2001, Ecos 1999, BHP 1996, Gill 2000). As the definition of biological interactions for this report is the removal of or damage to organisms, the types of initial disturbances that occur are covered in other chapters including noise, turbidity, and mechanical disturbances.

Recreational activities

There are a number of biological interactions with the environment caused by recreational activities. These include: retaining undersized fish; bycatch and discard during fishing and collecting bait; habitat degradation by boat, foot, and vehicular traffic; and shoreline harvesting for bait (Monash 2000). A number of studies indicate that these activities occur on the intertidal areas of the Region (Keough 1996).

Collecting species

Collecting bait for fishing, or collecting shellfish for human consumption (by hand, digging or using pumps) usually involves removing worms or shellfish. These activities are concentrated near large urban centres and often cause trampling and damage to rocky shorelines or tidal flats which damages or destroys flora and fauna (Keough 1996).

Collecting species for aquarium collections involves removing animals potentially disturbing the habitat.

Diving can cause trampling and habitat disturbance, particularly at entry and exit points.

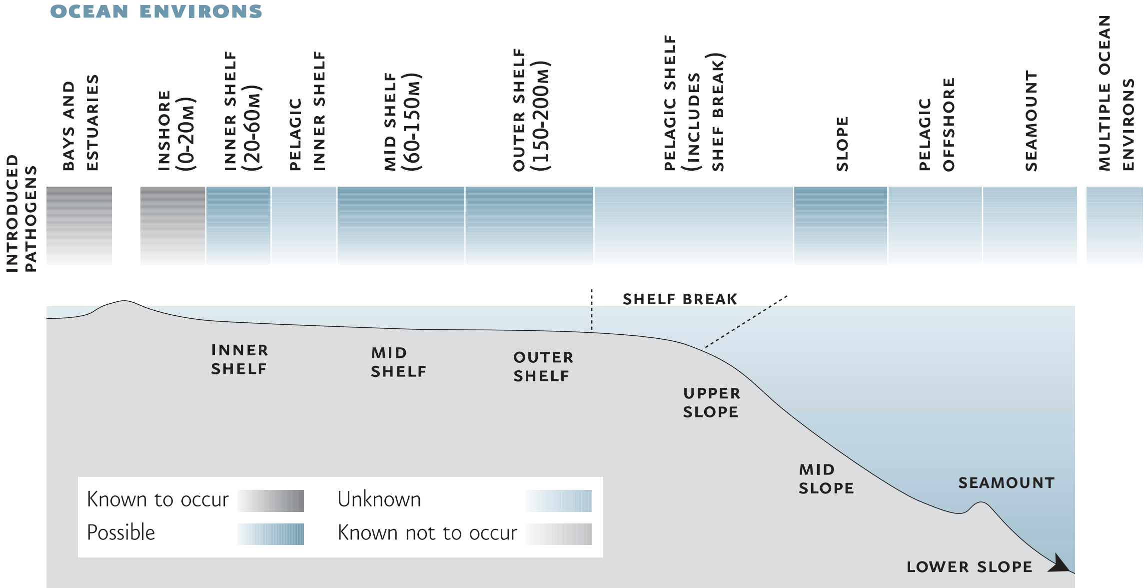
Shipping

The primary sources of disturbance to species from shipping activities are covered in the chapters on contaminants, mechanical disturbances and introduced species.

Introduced pathogens

Introduced pathogens – introducing disease-producing organisms to the marine environment, either from terrestrial or marine sources.

OCEAN ENVIRONS



Pathogens are organisms that cause harmful effects such as disease. Pathogens in marine and estuarine environments can include a number of natural and introduced soil and faecal bacteria and viruses. Toxic algae can also be classified as pathogens as they cause illnesses such as paralytic shellfish poisoning.

KNOWN TO OCCUR

Bays and estuaries/inshore

Terrestrial sources, in particular stormwater run-off, introduce pathogens into bays and estuaries, the inshore and shelf ecosystems. Bacterial counts from stormwater outfalls during storm flow can be high – exceeding standards for primary water contact (swimming) and sometimes secondary contact (boating) (Tasmanian State of the Environment 1996). Total faecal coliform counts are often very high (eg Prince of Wales Bay, Tasmania outfall) with dog faeces rather than human faeces being a major source (Tasmanian State of the Environment 1996).

Some seafood species, such as oysters and mussels, are filter-feeders and can concentrate pathogens. Some pathogens kill estuarine and marine organisms. For example, diseases affecting oysters in Georges River (New South Wales) are a well-known recurring event (Australian State of the Environment 1996).

POSSIBLE

Bays and estuaries/inshore

People can come into contact with marine and estuarine pathogens by eating contaminated seafood or through recreational water sports – especially in enclosed water bodies such as bays and estuaries. The microbes can cause illnesses such as gastroenteritis, hepatitis, conjunctivitis and upper respiratory tract and wound infections (Ashbolt 1995).

Several viruses have been associated with swimming-related illness (Dufour 1986), with various viruses reported to persist in marine waters. The viruses include enteroviruses (polio viruses, coxsackie viruses, echoviruses), hepatitis A and E, adenoviruses, rotaviruses and caliciviruses (including Norwalk and small round structure viruses).

The spread of exotic pathogens can reduce the tolerance of endemic species to any introduced pathogen. This may cause a decline in flora and fauna population size and diversity. In particular, sessile plants and animals (such as seagrass and benthic infauna) are most directly affected because they have a higher rate of exposure to the pathogens. Due to trophic and other ecological links, impacts of pathogens have extended to

many parts of the marine ecosystem (Jenkins et al. 1992). Biotoxins in shellfish and faecal bacteria are of the main concern to human health. Detailed water and shellfish quality monitoring programs are established in many areas to monitor these effects (eg South Australian Environment Protection Authority 1997, Callan et al. 1993).

Introducing exotic pathogens or bacteria into a natural or wild population of free-living organisms such as fish means it can spread throughout the natural range of the species, even out into the slope ecosystem.

SOURCES OF DISTURBANCE

Activities	Introduced Pathogens
Aquaculture	Possible
Defence	Known not to occur
Emerging	Unknown
Harvesting	Possible
Human changes	Known not to occur
Indigenous	Known not to occur
Land-based	Known to occur
Ocean dumping	Unknown
Petroleum	Possible
Recreational	Possible
Shipping	Known to occur
Submarine cables	Known not to occur
Tourism	Known not to occur

Key

Known to occur	Unknown
Possible	Known not to occur

KNOWN TO OCCUR

Land-based

Sewage

Sewage outfalls into the ocean have affected the water quality in many areas of the Region, introducing faecal bacteria or associated toxins. In 1997 a significant outbreak of hepatitis A (444 cases) was directly attributed to farmed shellfish (oysters) from the Wallace Lakes area (New South Wales) contaminated by sewage (Victorian Department of Environment and Natural Resources 2000).

Urban discharge

Urban run-off/stormwater is a source of pathogens in the marine environment, faecal coliforms are particularly common in stormwater (Tasmanian State of the Environment 1996).

Shipping

Ballast water discharge/hull fouling

Ships can transport pathogens by discharging ballast water and fouled hulls. Some pathogens are known to be transported in this way, including disease-causing dinoflagellates (Hallegraeff & Bolch 1991). The toxic dinoflagellate, *Gymnodinium catenatum*, which has caused toxic blooms in the Huon and Derwent estuaries (Tasmania), is thought to have been introduced by shipping (McMinn et al. 1997).

POSSIBLE

Aquaculture

Feeding/translocation/sourcing feed/stock escape

Aquaculture feed and equipment have the potential to introduce bacteria and other pathogens to the environment. Disease-carrying fish, particularly escaped stock, may introduce pathogens to the environment. Pathogens and diseases may be transferred from farmed fish to seabirds and vice versa, and seabirds may act as intermediate hosts to parasites (Canadian Environmental Assessment Office 1998). It is possible for pathogens to be transmitted via the faeces of birds (eg Willumsen 1989).

Amoebic gill disease is a significant problem for salmon aquaculture in the Region (Commonwealth Scientific and Industrial Research Organisation 2001). Stock translocation has the potential to spread this pathogen.

Physical location

Aquaculture operations may act as a reservoir of pathogens, which could increase the level of pathogens in the wild, particularly where high densities of cultured animals have contact with wild stocks (West Australian Department of Fisheries 1998).

Sourcing stock

Non-endemic, pathogenic organisms may be introduced into an area by aquaculture species from other areas (Australian Fisheries, Forestry and Agriculture 1999). Accidental introductions of exotic pathogens and infections of existing native species pose a threat to the marine environment.

Exotic pathogens may be introduced with the commercial species itself, or alternatively, shellfish culture may transfer endemic pathogens to new areas.

Harvesting

Introduction of fish bait

Introducing fish bait into the marine environment has the potential to introduce associated pathogens.

In other parts of the world, it is thought that disease transmission from fish species to species is possible as a byproduct of discarding of species (more info on bycatch and discarding can be found under 'Biological interactions'). This is thought to occur when small mobile scavenging species eat discarded species, enhancing the disease-transmission pathway between individual commercial specieis (Moore and Jennings 2000). For example, the transmission pathway for the pathogenic dinoflagellate *Hematodinium sp*. which infects Norway lobsters (in British and Scandinavian waters), has yet to be established but could involved such organisms (Moore and Jennings 2000).

Land-based

Agricultural discharge

Sewage and wastes from animals and animal processing industries contain very high numbers of bacteria and viruses. Some of these organisms can cause illnesses, including hepatitis and gastroenteritis. Inadequate treatment of these wastes could result in the introduction of these pathogens to the marine environment (Victorian Environment Protection Authority 2001).

Domestic waste disposal

Domestic waste disposal is another potential source of pathogens in the marine environment.

Recreational

Aquarium species

Accidental or intentional releases of aquarium species may result in pathogens harmful to native species being released into the marine environment.

Petroleum

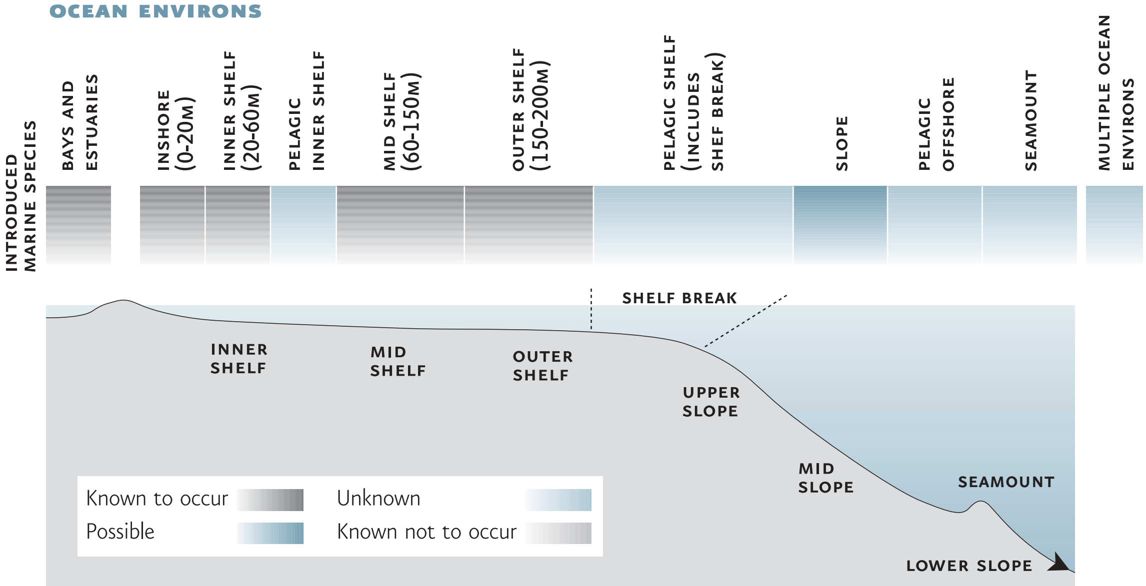
Rig establishment/waste disposal/decommissioning

Establishing, maintaining and decommissioning drilling rigs has the potential to introduce or transfer pathogens to a new environment. Ships associated with the oilrig construction may carry pathogens in hull-fouling organisms or ballast water. Supply vessels for drilling rigs may also transport pathogens.

Introduced marine species

Introduced Marine Species – introducing species that do not occur outside of the naturally or historically.

OCEAN ENVIRONS



Introduced marine species are known to occur in the Region. Movements of marine species by intentional or accidental human intervention can be much more frequent and rapid than natural processes. In the Region, 115 species are known to be introduced and an additional 84 are considered to be possible introductions or 'cryptogenic' species. Several introduced marine species are known to have caused environmental impacts in the Region and eleven of these species have been recognised as introduced marine pests.

KNOWN TO OCCUR

Bays and estuaries/inshore

A number of bays, ports and estuaries in the Region are known to contain introduced marine species. Impacts from some of these species are well documented and include habitat modification and destruction, changes in biodiversity, increased pressures on native marine communities from predation and competition, and impacts on coastal amenities and human health.

The introduced species in the Region are a wide variety of flora and fauna including dinoflagellates, seaweeds or macroalgae, polychaete worms, bryozoans, nudibranchs, hydrozoans, seastars, sponges, ascidians, barnacles, amphipods, isopods, chitons, bivalves, molluscs, gastropods, shrimp, crabs and fish.

The introduced *Asterias amurensis* (Northern Pacific Seastar) feeds on a wide range of native animals, including native shellfish, and has the potential to alter the structure of natural benthic communities (Turner 1992). It is a voracious predator and forms aggregations of up to 10 individuals per square metre. In Japan, it is a well-known predator of scallops and other bivalves, which it can easily prise open with its arms. In Australia its diet includes tunicates, bryozoans, sponges, crustaceans, other seastars and molluscs. It is such a productive species that its larvae dominate the zooplankton in the Derwent Estuary during winter (Bruce et al. 1995).

The adult *A. amurensis* has few known natural predators in Australian waters, although some seastars have been found with missing arms, indicating sublethal predation by some local species (probably crabs or other sea-stars). Various animals prey on larval and juvenile seastars (Ross & Johnson 1998). From an ecological perspective, *A. amurensis* has the potential to significantly alter the structure of natural benthic communities (Turner 1992). The seastar feeds on a wide range of native animals and can have a major effect on the recruitment of native shellfish populations that form important components of the marine food chain. Young *A. amurensis* (one-year old) eat almost as much as two to four-year olds and since the younger age class dominates aggregations the potential to devastate natural bivalve populations is a concern. *A. amurensis* may also out-compete both local seastars and demersal fish for prey items.

Predation of native crabs by the *Carcinus maenas* (European Shore Crab) has decreased some native crab populations in the Region (Ruiz & Rodriguez 1997).

The introduced bivalves *Corbula gibba* and *Musculista senhousia* have both become dominant in parts of the Region since their introduction (Wilson et al. 1998, Currie et al. 1998). These species disturb the local trophic and benthic dynamics of native populations and have the potential to out-compete local species. *M. senhousia* alters the habitat structure and community assemblages of soft sediments (Crooks & Khim 1999).

Dense aggregations of the introduced oyster *Crassostrea gigas* on rocky areas limit the amount of food and space available for other species. These aggregates also reduce the aesthetic and amenity value of coastal regions (Mitchell et al. 2000).

The intertidal salt marsh plant rice grass *Spartina anglica* was intentionally introduced to numerous estuaries in the Region. Extensive infestations have colonised native mudflat, salt marsh, seagrass and mangrove habitat, particularly the estuaries of south east Gippsland (Victoria) and the north coast of Tasmania. Infestations dramatically alter sediment and water dynamics and the structure and integrity of intertidal communities of flora and fauna (Hedge 1998, Hedge & Kriwoken 2000, Kriwoken & Hedge 2000).

The introduced fan worms *Sabella spallanzanii* and *Euchone limnicola* have also become abundant in the areas where they have been introduced (Talman et al. 1999). These species have the capacity to restructure the ecosystem and out-compete native species for habitat and food supply (Talman et al. 1999, Currie et al. 1999).

The known toxic dinoflagellates in the Region are *Alexandrium catenella, A. minutum, A. tamarense and Gymnodinium catenatum* (Hallegraeff 1992). Toxins produced by these dinoflagellates are harmful to some zooplankton. The toxins pass through the food chain and bioaccumulate in fish, barnacles, crabs, starfish, tubeworms, copepods and bivalves. Eating these organisms can cause potentially lethal paralytic shellfish poisoning in mammals including humans.

The introduced broccoli weed (Codium fragile ssp. tomentosoides) is recognised as one of the most highly-invasive species in the world due to its broad habitat and physiological tolerance (Trowbridge 1999). Within the Region *C. fragile* ssp. tomentosoides is not an attractive food source to most grazers and can alter grazer populations. It is also able to displace native C. fragile populations and shellfish such as scallops, oysters and mussels (Campbell & Hewitt 1999).

The seaweed *Undaria pinnatifida* out-competes native macroalgae and displaces native weed habitat and associated fauna including abalone and sea urchin (Sanderson & Barrett 1989).

Shelf (inner/mid/outer)

Many introduced species can tolerate depths that allow them to extend their distributions to the continental shelf region. One example is the New Zealand screw-shell *Maoricolpus roseus*. The screw-shell can live at depths from 1 to 130 m (Allmon et al. 1994) and since its introduction to Tasmania has spread north across Bass Strait (Bax et al. 2001).

The primary impact of this species is through habitat modification. *M. roseus* is so abundant in some areas that the benthic habitat has been altered from fine sand or mud to a dense cover of live and dead shells (Bax et al. 2001). Mucus produced by *M. roseus* may also consolidate sediments and lead to increased bacterial levels, affecting the larvae settling of a variety of benthic organisms. There is evidence that native screw shells and commercial scallop species have declined since *M. roseus* was introduced, probably through direct competition for food and space (Bax et al. 2001). An indirect impact of *M. roseus* results from their robust shells providing excellent homes for hermit crabs. This has the potential to increase the abundance of hermit crabs and therefore result in greater predation pressure on native species (Bax et al. 2001).

POSSIBLE

Bays and estuaries/inshore/shelf

The impacts of introduced species can be difficult to detect since they primarily influence species interactions and some changes may be subtle. Other possible impacts include the introduction of disease into native populations, increased fouling on shipping, ports and aquaculture infrastructure; changes in nutrient cycling patterns; decline in fisheries stocks; increased pressure on vulnerable or threatened species; and general changes in ecosystem health and biodiversity.

SOURCES OF DISTURBANCE

Activities	Introduced Marine Species
Aquaculture	
Defence	
Emerging	
Harvesting	
Human changes	
Indigenous	
Land-based	
Ocean dumping	
Petroleum	
Recreational	
Shipping	
Submarine cables	
Tourism	

Key

Known to occur — Unknown

Possible — Known not to occur

KNOWN TO OCCUR

Aquaculture

It is known that salmon escape from fish farms through net openings and accidents. When released into the wild, the farmed salmon may affect the environment. The establishment of wild populations is not documented in the Region.

Concerns with escaping species include predation on native fish, competition for resources and transmission of disease (Canadian Environmental Assessment Office 1998). In the Northern Hemisphere, farmed fish can escape and interbreed with wild stocks, which some scientists believe is endangering the genetic integrity of wild salmon (BBC website 2001). The conditions in the Region are not highly compatible with the endemic range of this species, so reproductive colonisation by Atlantic salmon outside their endemic range is considered improbable, but not impossible (Canadian Environmental Assessment Office 1998).

Farming of *Crassostrea gigas* the Pacific oyster occurs in Tasmania, New South Wales and South Australia. Escapes from farms have resulted in feral populations becoming established outside the oyster farm enclosures. This leads to the loss of aesthetic and amenity value of coastal zones, competition with native species for space and food sources, and the introduction of the parasitic copepod (*Mytilocola orientalis*) to commercial mussels (Joint Standing Committee on Conservation / Standing committee on Fisheries and aquaculture1999). The environmental issue attributed to aquaculture in South Australia are breeding populations of the exotic Pacific Oyster in areas adjacent to farm sites (Edyvane 1995).

Historically, the export of oysters from New Zealand to Tasmania introduced an associated group of species, which are now established in Tasmanian waters (Centre for Research on Introduced Marine Pests 2001).

Recreational

Boating

Recreational vessels have the potential to transport species that attach to the hull of the vessel (hull fouling), as well as transport on other gear. Introduced species are spread by boats, trailers, fishing equipment, etc that are not cleaned and washed after leaving an infested area (Tasmanian Department of Primary Industry, Water and Environment website 2001). Recreational vessels can spread an introduced species from its initial point of infestation to other parts of the Region, and recreational vessels have been implicated in transporting the introduced seaweed *Undaria pinnatifida* around Tasmania.

Aquarium collection

The aquarium fish *Gambusia* is now found in the Tamar Estuary (Tasmania) since its introduction from the aquarium industry.

Shipping

Shipping activities are known to have caused introductions of marine species in the Region. A number of activities within the shipping industry are known pathways for introducing species, including the exchange of ballast material and hull fouling from both wood-boring species, and species that attach to ship hulls (Centre for Research on Introduced Marine Pests 2000).

Biological material is transported in the ballast water of steel ships, and in the dry and semi-dry ballast material of wooden ships (sand, gravel, cobbles and rocks). Wooden ship ballast has been an important transport mechanism in the past. For example *Maoricolpus roseus* (New Zealand screw shell) is thought to have arrived in Tasmania either in semi-dry ballast (boulders collected from coastal New Zealand shores) or with oyster imports from New Zealand destined for the Tasmanian fish market.

Modern ships are primarily made of steel and carry ballast water. In many cases ballast water is discharged while a ship is at port, or discharged near harbour entrances while the vessel is entering port (Centre for Research on Introduced Marine Pests 2001). Various organisms, particularly those in resting or larval stages, can be transported in ballast water from one region to another by both domestic and international shipping.

Organisms have been directly transported from outside the Region, with secondary translocation to other ports also occurring. The seastar *Asterias amurensis* was initially introduced to the Port of Hobart (Tasmania), and from there was transported by a local ship to the Port of Melbourne (Victoria). Once introduced, species also spread out from the infected area by natural processes.

Not only commercial shipping and cargo vessels exchange ballast water. Tourism ships, defence craft, petroleum, harvesting and recreational vessels also use ballast water for stability and are subject to hull fouling. These vessels may also transport introduced marine species.

POSSIBLE

Aquaculture

Aquaculture contributes to the spread of associated introduced species as a result of translocation of stock, cages, settlement lines and other associated equipment (Centre for Research in Introduced Marine Pests 2001).

The transmission of disease and parasites between regions due to aquaculture operations are areas of concern in finfish and shellfish aquaculture.

Harvesting

Introduction of fish

Brown trout and rainbow trout have been introduced into lakes and streams in the Region to provide recreational fishing stock. Whilst these trout live primarily in freshwater, it is possible that sea-run trout enter estuaries during some times of year, where they may have an impact. This impact has not been assessed.

Introduction of fish bait

By 1998 the use of fish bait had introduced 14 known species elsewhere in the world (Food and Agriculture Organisation website 2001; www.fao.org).

Human changes

Dredging, coastal construction, and changes in waterways all have the potential to transport introduced marine species, particularly as secondary introductions after an initial invasion.

Petroleum

Rig establishment/operation/decomissioning

Constructing a petroleum rig involves delivery and supply ships that may carry hull-fouling organisms and can draw ballast water from shallow seas or harbours and discharge it into the area of the rig, potentially transferring and introducing marine species.

Drilling rigs remain in shelf areas for long periods of time, and their passage between areas takes place at relatively low speed. They may therefore have the potential to accumulate and transport species not normally transported by other ships. Drilling rigs may also act as 'islands' from which exotics may disperse to the adjacent coastal or shallow reef areas (URS Pty Ltd 2000).

Recreational

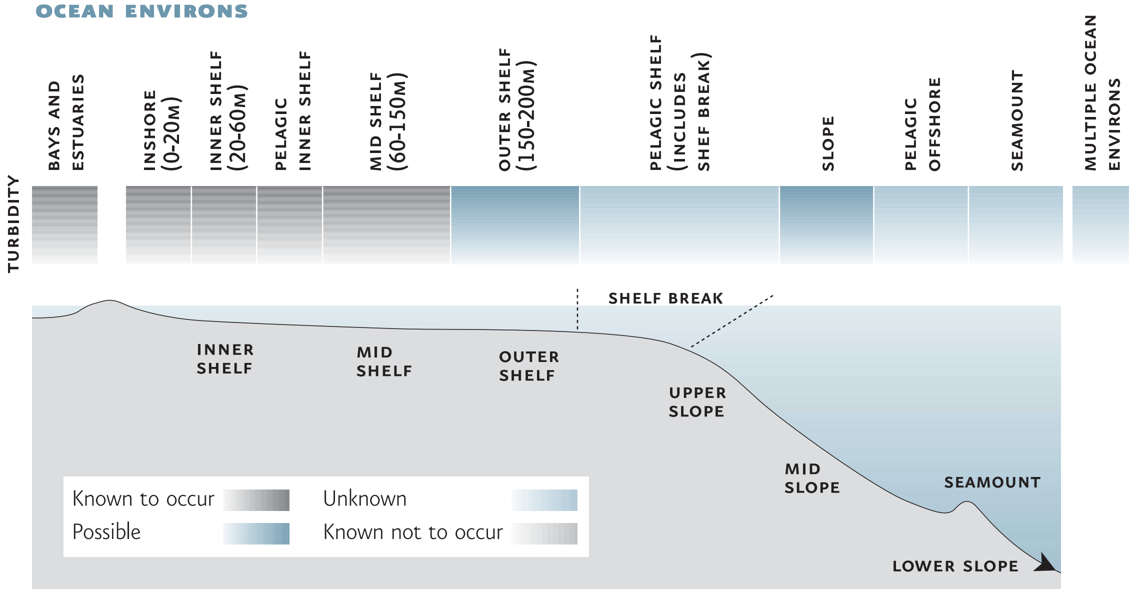
Aquarium collection

The macroalga *Caulerpa taxifolia* has both wild and aquarium clone forms. The clone form, released from an aquarium in Monaco, has spread throughout the Mediterranean, with significant effects. The status of the weed in Australia is unclear, but it is known that the aquarium trade, infected recreational craft and commercial and recreational fishing vessels have all contributed to the spread of the species (Centre for Research in Introduced Marine Pests 2001).

Turbidity/light

Turbidity – changing the extent to which light penetrates the water column.

OCEAN ENVIRONS



Turbidity can reduce the amount of light and oxygen available to the seabed and lower levels of the water column. This can affect light-dependant biota. Human activities that introduce and stir up the bottom sediment can increase the turbidity and so reduce light penetration.

KNOWN TO OCCUR

Bays and estuaries

Increased turbidity decreases the light available to marine plants, which reduces their capacity to photosynthesise. Seagrass beds are highly susceptible to any decrease in water clarity (Edgar 2001). Increased turbidity has led to seagrass loss, mangrove dieback, and reduced diversity among natural algal communities. Increased turbidity and an associated increase in smothering from sedimentation can also cause the loss of local species. In some of the bays and estuaries of the Region, local environments have been modified by turbidity and nutrient flows (Environment Protection Authority 2002). Modifications to the coastal environment can also increase turbidity. For example, in Western Port Bay (Victoria), changes in the catchment upstream have increased sedimentation (Environment Protection Authority 2001).

Inner shelf

Increased turbidity has affected the flora and fauna of the Inner Shelf. Species dieback, diversity loss, and reduced water quality has occurred in some areas in the Region. For example, as a part of the Minerva Gas Field (Bass Strait) studies, it was found that up to 200 m from the well head mortality rates increased due to high rates of sedimentation and burial, as well as residual toxicity (Currie 1995).

Settling sediment can also smother marine flora. Changes in the physical nature of flora can affect the structure of the marine community by making the habitat unsuitable for some species, selectively removing particular food sources, or increasing the chances of predation (Lewis 1996).

Mid shelf

Effects from activities such as dredge trawling and spoil disposal from dredging can occur in the 60–150 m depth profile. These impacts include a modification of the benthic environment and stirring up the bottom sediment (Edgar 2001). This increases sedimentation, which in turn increases turbidity (Environment Australia 2001).

Pelagic shelf

Increased turbidity can occur in deeper water through several mechanisms, including dumping dredged material or spoil, such as that dumped in deep water from Port Philip Bay (Victoria) (Pirzl & Coughanowr 1997).

Sources of disturbance

Activities	Turbidity
Aquaculture	Known to occur
Defence	Known not to occur
Emerging	Unknown
Harvesting	Known to occur
Human changes	Known to occur
Indigenous	Possible
Land-based	Known to occur
Ocean dumping	Known to occur
Petroleum	Known to occur
Recreational	Possible
Shipping	Known to occur
Submarine cables	Known to occur
Tourism	Possible

Key

Known to occur · Possible · Unknown · Known not to occur

Known to occur

Aquaculture

Adding high-nutrient fish feed to the water at salmon aquaculture farms leads to sediment enrichment and an increase in turbidity. This is known to occur in salmon farms in the Region (Tasmanian Department of Primary Industry, Water and Environment 1999).

Harvesting

Dredge trawling, such as for scallops, disturbs the seabed and causes increased turbidity. Trawls and dredges disturb the substratum, re-suspending surface sediment. This can last for a few hours in shallow water or for decades in the deep sea (Jennings & Kaiser 1998).

Human changes

Dredging

Dredging activities affect the marine environment by smothering benthic biota and habitats and degrading water quality, decreasing light and increasing turbidity (Edgar 2001).

Dredging is conducted mainly to construct and maintain port harbours, docks and channels. Dredged material is disposed of on land or in water near or away from the dredge site. It increases the concentration of suspended solids and disturbs sediments around the dredging site and spoil disposal areas (State of the Environment Report 1996). This causes increased turbidity and reduced light in the water column.

Studies have shown that the long-term influences of dredging on benthic infauna occur by permanently modifying sediments (Jones & Candy 1981).

Coastal construction

Coastal alterations such as reclaiming land, or creating marinas or breakwaters can change wave patterns, which can then disturb habitats (Edgar 2001). Altered patterns of sedimentation and erosion as well as deterioration of water quality can also occur.

Land-based

Industrial discharge

There are various industries in the Region that discharge wastes into the sea. These include pulp, paper and woodchip mills, food processing works, salt and chemical plants and oil refineries. An increase in turbidity and a corresponding decrease in light is an associated impact from these discharges (Environment Protection Authority 2001).

Urban run-off

Stormwater discharges and diffuse run-off are significant sources of pollution in estuaries and coastal environments in the Region. Urban run-off contains high sediment loads (Williams 1980, Edgar et al. 1999) and can cause a number of disturbances including turbidity and reduction in light penetration.

Agricultural run-off

Land clearing for agriculture and other rural industries such as forestry, results in significant increases in catchment run-off. This is a source of elevated sediment in estuaries and coastal waters (New South Wales Department of Fisheries 1999, Edgar et al. 1999).

The run-off suspended in the water column changes the turbidity of the water and reduces light penetration.

Sewage discharges

As discussed in the previous Chapter, more than 100 sewage treatment plants discharge wastes into coastal, estuarine and embayment waters in the Region (based on Parks and Wildlife Service 1995, Winstanley 1995, South Australian Environment Protection Authority 1998b, New South Wales Environment Protection Authority 2000).

Sewage effluent is very high in organic matter and nutrients and therefore degrades water quality mainly through eutrophication, oxygen depletion and elevated turbidity (Coughanowr 1995, Zann 1995).

Ocean dumping

Wastes continue to be dumped into the waters of the Region. Suspended wastes in the water column affect turbidity. Dumped material, while introducing other contaminants to the environment, also mixes with sediments (Harris et al. 1999) and increases turbidity at these sites.

Petroleum

Drilling activities and disposing of drill cuttings and fluids produces suspended sediments in the water column, increasing turbidity. Turbidity can reduce the amount of light and oxygen available at the seabed and lower levels of the water column, which may potentially affect light-dependant biota. Natural oceanic factors (water depth, tidal currents and the interplay of surface and oceanic currents) influence the dispersion and dilution rates of discharged wastes from the rig (Black et al. 1994).

Depending on the location of the drill site, turbid waters are not expected to be transported to sensitive eastern mainland coastlines (kelp and seagrass beds, intertidal temperate reefs) and offshore islands (Hogan, Devils, Cutis, Judgement Rocks, Kent Group, the Furneaux Group). Turbidity is associated with discharge from cuttings and drilling muds (Black et al. 1994). Potential impacts to biota are generally restricted to the immediate discharge area (tens of metres within the plume and 50 m around the well). In the Region, two main production areas have caused localised turbidity; the Gippsland Basin and Bass Strait areas (Lavering 1994). Increased turbidity also occurs from the laying of pipelines and dredging operations (Black et al. 1994).

Shipping

Dredging channels

Shipping lanes into ports often need dredging to maintain a suitable depth for ships. This dredging affects the local flora and fauna, both at the site of dredging and where the spoil is disposed (see the dredging section above).

Groundings/sinkings

Grounded or sunken vessels physically damage the environment, including habitat loss at least in the short-term, and habitat disruption. Disruption on the sea floor plus released cargo or wastes increase turbidity in the water column.

Submarine cables

Cable laying

Laying cables has physical impacts on the marine environment by stirring up sediments from activities including:

- direct disturbance of the seabed at the near-shore exit points through drilling
- wet jetting, trenching and cutting activities
- lateral sedimentation adjacent to disturbance by wet jetting, trenching or cutting
- delayed settlement of laterally dispersed turbidity plumes (cascade suspension)
- drilling mud release at the seaward exit points of drilled ducts (NSR Pty Ltd 2001).

POSSIBLE

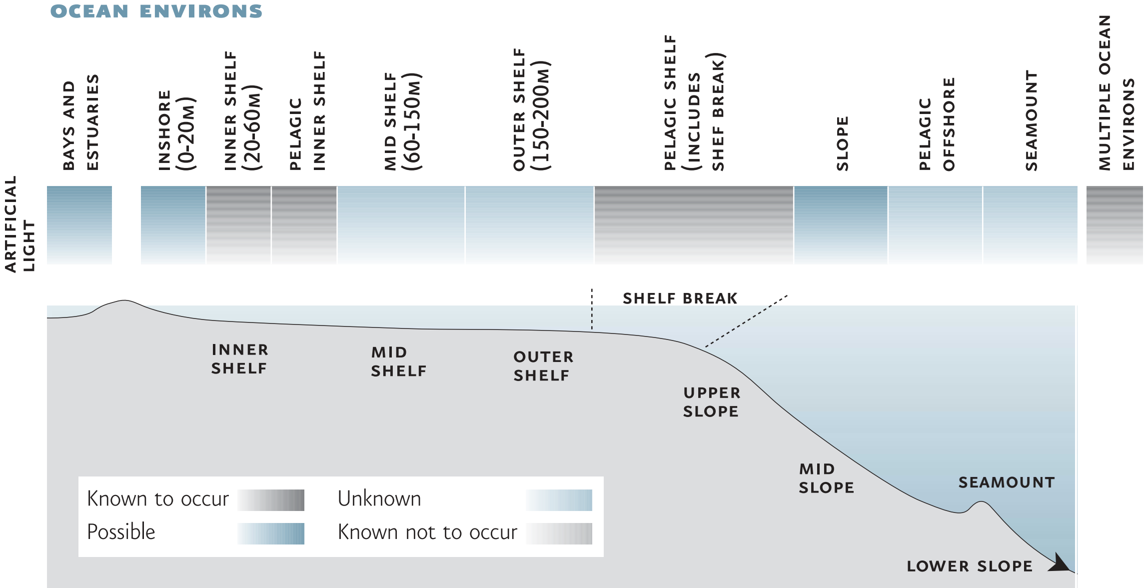
Recreation

Recreational SCUBA diving in areas of soft sediments stirs up the seafloor. This suspension of sediments may cause impacts through increased turbidity.

Artificial light

Artificial light – introducing a source of light that would not naturally occur in the marine environment.

OCEAN ENVIRONS



KNOWN TO OCCUR

Inner shelf/pelagic inner shelf/pelagic shelf (nekton)

Squid are attracted to the strong lights used on squid-fishing vessels. It is possible that other species are attracted to the lights and caught as bycatch (Supongpan et al. 1992).

Multiple ocean environs

Migratory birds become disoriented by bright light, which can alter their migratory patterns (Garnett & Crowley 2000). This may threaten the populations of some species, such as *Neophema chrysogaster* the orange-bellied parrot (Garnett & Crowley 2000).

POSSIBLE

Bays and estuaries/inshore

Lighting from wharf and port facilities and urban development close to shore attracts some marine species, including seabirds, and may cause deaths or disrupt migration patterns.

Short-term artificial light from sources such as cameras or torches used in night diving or research may attract or repel marine fauna.

Shelf/slope/pelagic offshore/seamount (fauna)

Marine species may avoid underwater lighting or be attracted to it.

Deep-sea species are adapted to low or absent light so strong lights in deep water may cause retinal damage (Herring et al. 1998).

Multiple ocean environs

Continuous light from drill rigs and squid-fishing vessels attracts some marine species such as squid, seals and seabirds. Oil rigs may also become stopover points during migrations.

Lighting from other ships and coastal structures affects some marine species. Seabirds become disorientated under certain lighting conditions and can collide with structures. Seals show curiosity around towed lights.

SOURCES OF DISTURBANCE

Activities	Artificial Light
Aquaculture	Known not to occur
Defence	Possible
Emerging	Unknown
Harvesting	Known to occur
Human changes	Possible
Indigenous	Unknown
Land-based	Unknown
Ocean dumping	Known not to occur
Petroleum	Known to occur
Recreational	Unknown
Shipping	Known not to occur
Submarine cables	Known not to occur
Tourism	Possible

Key

Known to occur, Possible, Unknown, Known not to occur

KNOWN TO OCCUR

Harvesting

Disoriented migratory birds (eg the orange-bellied parrot) have been attributed to bright lights from fishing vessels, particularly squid-fishing vessels. Fish species attracted to the light are caught as bycatch.

POSSIBLE

Defence

Within and around the Region naval trials and exercises are generally undertaken in (but not limited to) the East Australian exercise area, off the coast of New South Wales between Tathra and Newcastle, from inshore to the abyssal plain (> 4000 m deep) and the South Australian exercise area directly south of Kangaroo Island, from coastal areas to the abyssal plain (Department of Defence 2001). Ships and submarines during exercises emit light from live firing exercises or laser emitters, which may affect marine life.

Harvesting

The artificial light from squid light fishing may affect marine ecosystems. Dense concentrations of very bright fishing lights probably affect the behaviour of the larvae, juveniles and adults of fish and squid species, zooplankton and perhaps phytoplankton (Rodhouse et al. 2001). The potential effects of light fishing on ecosystems have not been studied.

Other fishing vessels and gear from other fisheries are sources of temporary and variable artificial light that can attract marine species. Lights used in diving may attract or repel some marine species.

Research activities sometimes use lights on fishing nets and towed or stationary cameras. These have been observed to affect the behaviour of fish and seals (S. Davenport pers. comm.).

Human changes

Coastal developments such as wharf and port facilities and lighthouses provide almost continuous lighting that may affect marine species such as seabirds, seals and fish.

Petroleum

Drill rigs provide continuous lighting during the establishment and production phases. The light may attract marine species such as fish, seals and seabirds. Visiting support vessels at times add more light.

Tourism

Artificial lighting during the development and operation of coastal tourism sites and offshore facilities (eg tourist ships) may influence marine life.

Appendix 1 working group members

Title	Name	Position	Organisation
Dr	Roger Bradbury		TJURUNGA Pty Ltd
Dr	Keith Sainsbury	EEZ Program Leader	CSIRO Marine Research
Dr	Frances Michaelis	Assistant Director, Strategic Fisheries Policy	AFFA
Mr	Edward Pinceratto	Manager Environment, Petroleum	BHP Billiton
Mr	Don Hough	Manager, Marine Strategy	Department of Natural Resources and Environment
Mr	Terry Moran	Chair	South East Trawl Fishing Industry Association Limited
Ms	Jane Beck		JM Beck Pty Ltd
Ms	Annaliese Caston	Adviser - Policy and Regulatory, Maritime Safety and Environmental Strategy	Australian Maritime Safety Authority
Ms	Kate Davey	National Co-odinator	Australian Marine Conservation Society

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