Marine Science

For Australian Students

3rd Edition

SAMPLE PAGES

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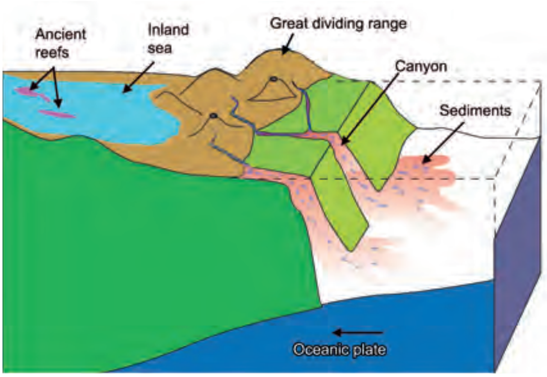
Photo Viewfinder Australia

Sediments

Sediments ran off and covered areas in a deep trench which was later to be uplifted out of the sea to form coastal zones east of what now is the Great Dividing Range. The shallow sea had ancient reefs now found in the Kimberly (Figures 22.1 and 22.5)

This shallow seas also contained paleozoic animal and plant life which can be seen in road cuttings at many places in Eastern Australia (Figure 22.3) and formed the rich coal deposits of eastern Australia Figure 22.6. The old craytons rich in minerals were deformed into the rich mining deposits of Western Australia (Figure 22.2)

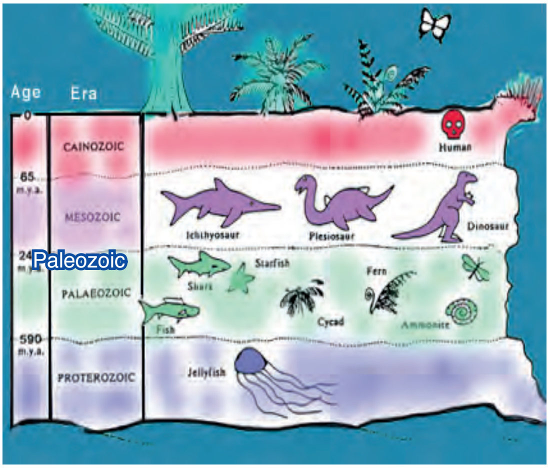


Bob Moffatt

Figure 22.1 Sediment run off

Ian Morris

Figure 22.2 The islands of the Buccaneer Archipelago, located in Western Australia, contain rich silver and iron ore deposits



(Illustration Queensland Museum)

Figure 22.3 Geological time as seen in a road cutting

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Figure 22.4 Cliffs of the Great Australia Bight which were once joined with Antarctica

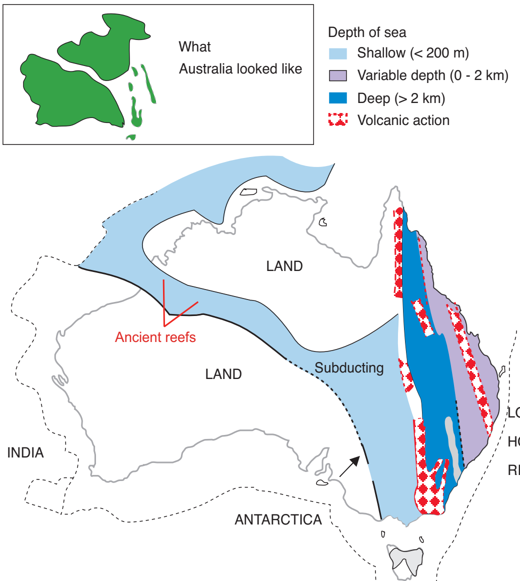


Figure 22.5 Australia 400 mya
(Illustration Bob Moffatt after Perspectives of the Earth Australian Academy of Science)

Mining Australia)

Figure 22.6 Shallow seas contained plant life which decomposed to form coal basins in Eastern Australia .

Exercise 11.2 Using a key

Aim

To use a simple key to identify the major marine phyla.

Method

- Use the key below to identify the creatures to the right.
- Note: This is not intended to be a key to all marine animals, but will enable the identification of most of the more common members of this kingdom. You may be able to find more complete keys and you will need to use these if you are to identify some rarer marine animals.

Materials

- Photographs of marine animals or range of preserved specimens.
- Key to marine life (see below).

Method

1. Use the key to marine life below to classify the animals into Phyla.
2. When classified write down the structural characteristics particular to the animals.

Key to marine life

1a. Body with no organs or mouth. Many small openings, fewer large openings. Spicules.

Sponges (Phylum Porifera)

1b. Not as above ... Go to 2.

2a. Radially symmetrical. Tentacles with nematocysts

Jellyfish, Corals, Anemones (Phylum Cnidaria)

2b. Not as above ... Go to 3.

3a. "Wormlike" shape, body divided into segments, bilaterally symmetrical.

Segmented worms (Phylum Annelida)

3b. Not a "wormlike" shape ... Go to 4.

4a. Hard exoskeleton, jointed legs.

Crabs, Prawns, Barnacles etc (Phylum Arthropoda)

4b. No exoskeleton (May be a shell) ... Go to 5.

5a. Radially symmetrical, tough spiny outer skin may be present.

Sea Stars, Sea Urchins, Sea Cucumbers (Phylum Echinodermata)

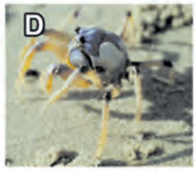
5b. Bilaterally symmetrical ... Go to 6.

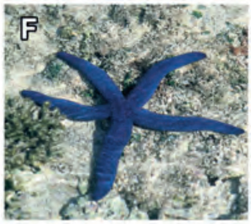
6a. Soft mucus covered body, possibly in a shell.

Shellfish, Snails, Slugs, Squids etc (Phylum Mollusca)

6b. Backbone present, made of bone or cartilage.

Fish, Reptiles, Birds, Mammals (Phylum Chordata)





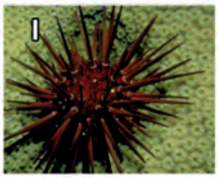


Figure 282.1 Soft coral
(Photo Bob Moffatt)

Figure 282.2 Branching coral
(Photo Bob Moffatt)

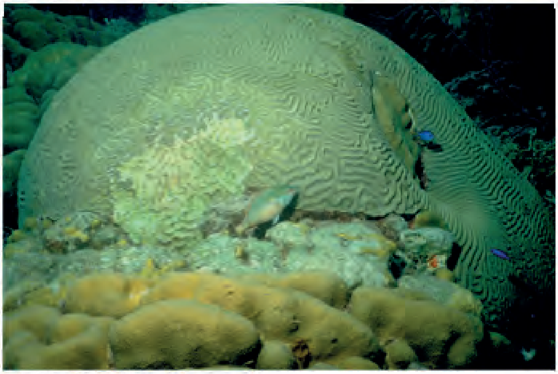


Figure 282.3 Boulder coral
(Photo Underwater Realms)

Figure 282.4 Table coral
(Photo Murray Waite)

Figure 282.5 Solitary coral
(Photo Bob Moffatt)

Figure 282.6 Vase coral
(Photo Murray Waite)

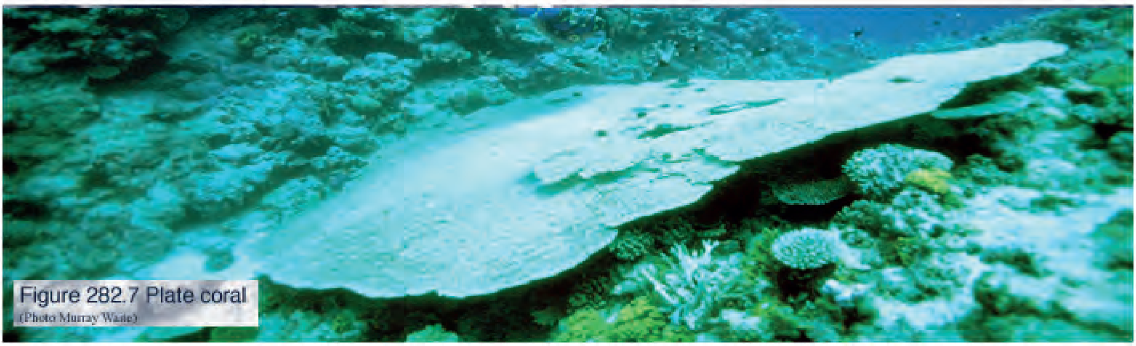


Figure 282.7 Plate coral
(Photo Murray Waite)

Establishing tests for salinity

Using light or electrical conductivity

Salinity is often measured by measuring how well electricity travels through the water.

This property of water is called conductivity. Water that has dissolved salt in it will conduct electricity better than water with no dissolved salt. The more salt that is dissolved in the water, the better the water conducts electricity.

The salt content of the water can be measured very precisely using the conductivity method (Figure 134.1).

A conductivity / TDS / Salinity Tester is used to check salt content and comes in a kit with a probe, battery, electrode soaking solution and conductivity standard solution.

The instrument gives a direct reading.


Image courtesy
Select Scientific
www.selectscientific.com.au

Figure 134.1 A conductivity / TDS / Salinity Tester

Using a refractometer

Salinity can also be measured with a hand held refractometer (Figure 134.2)

A refractometer measures the change of direction or bending of the light as it passes from air to water. Light moves slower in water than air.

The more salt in the water, the slower the light moves

A refractometer is the best choice for measuring salinity when only approximate values are needed.

Refractometers are easy to use in the field and relatively inexpensive. The salinity is read from a scale in the viewfinder (Figure 134.3)

Figure 134.2 A refractometer can also be used to measure salinity
Photo Red Sea

Figure 134.3 Salinity readings
Photo Red Sea

Temperature and sea water

Ocean surface temperatures vary from 28°C in the tropics to below zero at the poles. Figure 154.1A shows the surface temperatures in the Pacific Ocean. Figure 154.1B shows the temperatures of the Pacific depths (photographs courtesy NOAA).

The ocean surface can be heated by radiation from the sun, conduction of heat from the atmosphere or condensation of water vapour. The sea surface can be cooled by radiation back from the sea to the atmosphere, conduction of heat back to the atmosphere or evaporation.

Ocean currents can also transfer heat from one place to another.

Colour references

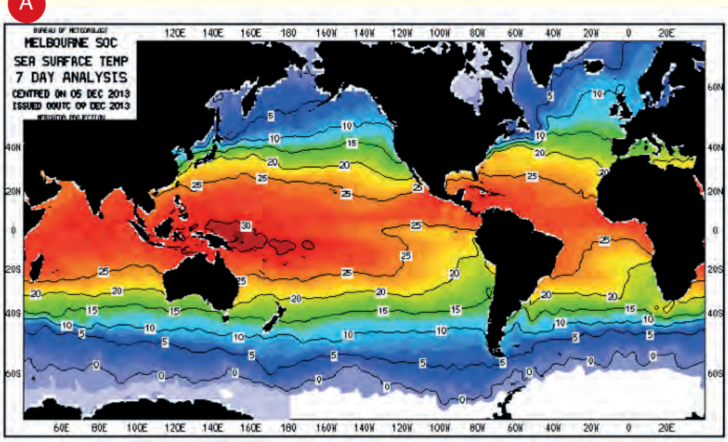
Try the following words in your search engine:
Pacific Ocean surface sea temperature

Biological significance of temperature

Animal migrations occur due to temperature. Whales migrate to warmer waters to calf. Corals spawn at certain temperatures and the composition and texture of marine animals and plants is governed by temperature. Animals that live on the rocky shore also develop protective coverings to compensate for temperature changes.

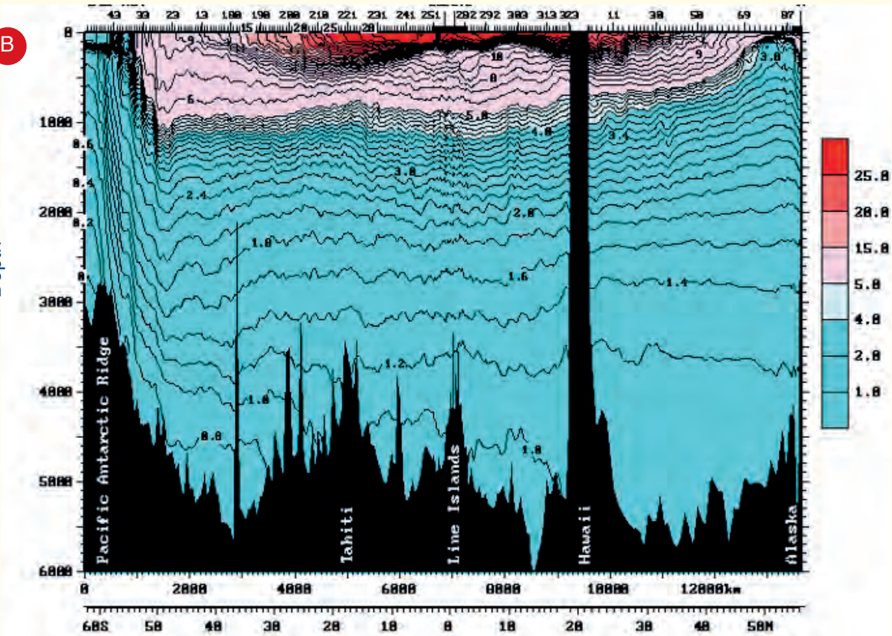
In recent times, coral bleaching (see Chapter 11) has been blamed on increased temperature changes.

A



B

Depth



Can you see the thermocline? See chapter 3 for more information on temperatures and currents.

Figure 154.1 Pacific Ocean potential temperatures. (Illustration A courtesy Commonwealth bureau of meteorology Illustration B courtesy NOAA)

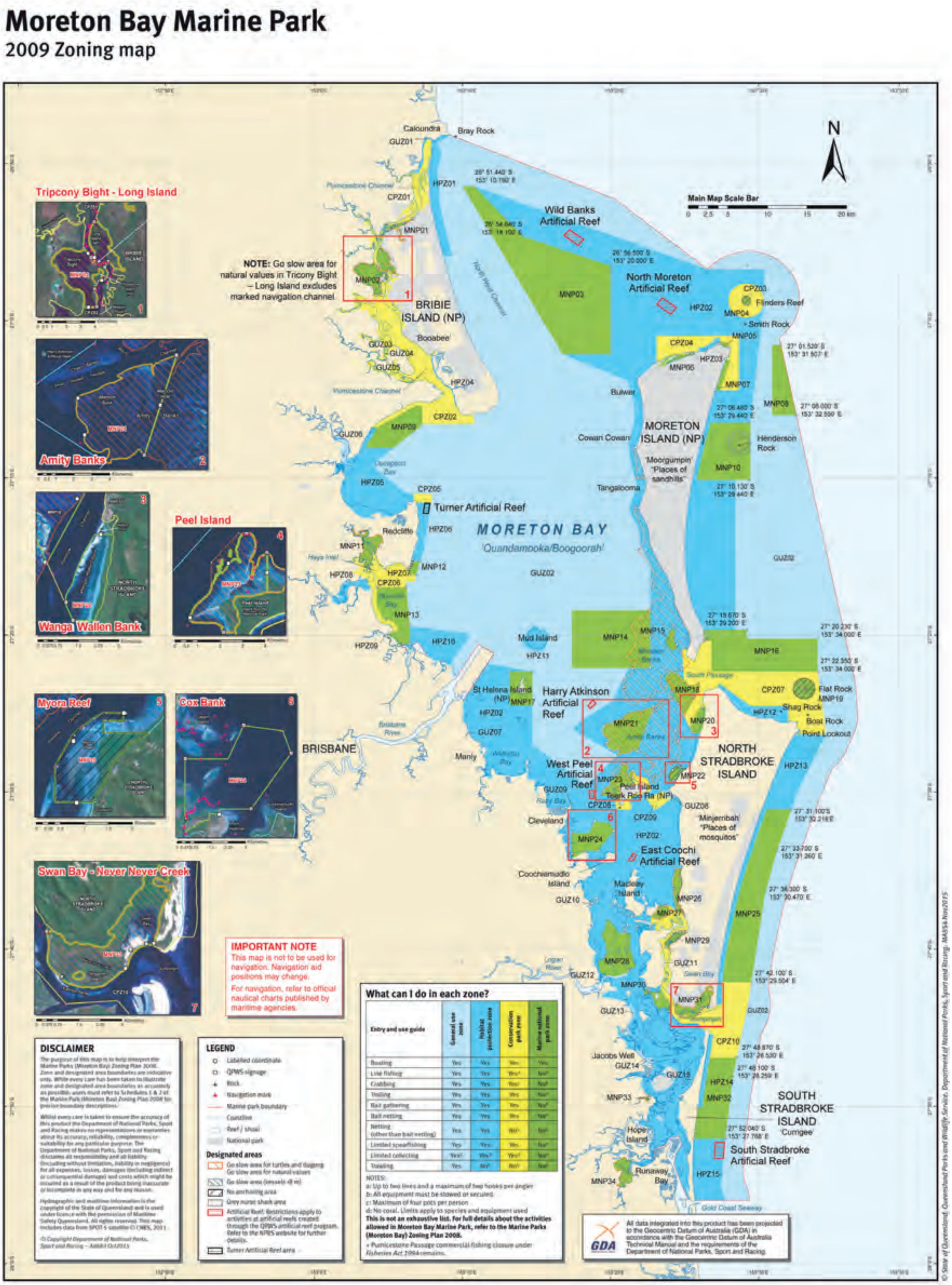


Figure 561.1 Moreton Bay Marine Park
(Courtesy EPA Queensland)

Ningaloo Marine Park Sanctuary Zones and Muiron Islands Marine Management Area

Marine park zoning

Ningaloo Marine Park is managed under a cooperative arrangement between the Australian Government Department of Sustainability, Environment, Water, Population and Communities and the Western Australian departments of Parks and Wildlife, and Fisheries. Please note that some different regulations apply in the Commonwealth waters (located three nautical miles from the shore) to those of the state waters.

Ningaloo Marine Park (state waters)

Sanctuary zones

Sanctuary zones provide total protection for marine life. They allow visitors to observe marine life in its natural state. No extractive activities are permitted in these zones, which means no recreational or commercial fishing are allowed.

Special purpose (benthic protection) zones

These zones allow visitors to observe marine life in its natural state, however recreational 'troll' fishing is allowed. No other extractive activities are permitted.

Special purpose (shore-based activities) zones

These zones are established alongside some sanctuary zones to allow shore-based recreational fishing for finfish only (no other extractive activities are allowed).

Recreation zones

These zones make up large areas of the marine park. Recreation zones are managed for nature conservation and recreation, including recreational fishing.

General use zones

These zones are managed for nature conservation while allowing for sustainable commercial and recreational activities.

Zone markers

Some sanctuary zones may be marked by yellow in-water buoys or land-based reference posts with directional triangles onshore pointing into the no-take zone. These markers should only be used as a reference guide to line up the zone boundary and the use of global positioning systems (GPS) is recommended at all times (see maps overleaf for sanctuary zone coordinates).

Spear guns and gidgies

These are not to be used in Ningaloo Marine Park between Winderabandi Point and Tantabiddi Boat Ramp and in the Ningaloo Commonwealth Marine Reserve. Species restrictions also apply. Please contact the Department of Parks and Wildlife or the Department of Fisheries in Exmouth for more information.

Marine Management Area zoning

Marine Management Areas provide an integrated management structure over areas that have both high conservation value and intensive multiple use. The Muiron Islands Marine Management Area is one of only two marine management areas in WA.

Conservation areas

Conservation areas within the Muiron Islands Marine Management Area are essentially the same as sanctuary zones. They allow visitors to observe marine life in its natural state. No extractive activities are permitted in these zones, which means no recreational or commercial fishing are allowed.

Fishing rules

Fishing rules apply throughout the marine park. Refer to the *Recreational fishing guide* for details. Available from the Department of Fisheries offices or online at www.fish.wa.gov.au.

Ningaloo Commonwealth Marine Reserve

Recreational fishing must be undertaken in accordance with the current authorisation and conditions for recreational fishing available at:
www.environment.gov.au/marinereserves/north-west/ningaloo/

Figure 567.1 Ningaloo marine park map
(Illustration courtesy Department of Environment and Conservation, reproduced with permission)

- data storage and analysis of information (using computer databases such as *Geographic Information Systems* GIS).

Australia's EEZ is vast and largely unexplored, marine ecology is a very complex subject, and marine research is time-consuming and very expensive. Quite often we don't know enough to answer the planners' questions. In these cases the ***precautionary principle*** dictates that they should err on the side of caution.

Environmental education: Important for community support

It is important that Australians know about the marine environment, and the threats to it. Care comes from understanding. Once we understand the consequences of our actions, we will accept the reasons for controls, and can even develop ourselves better ways of doing things. ESD requires the support of the wider community and possible sacrifices in life-style. Public environmental education, particularly in subjects such as the one you are currently studying now, is essential so that future generations are better informed.

Figure 468.1 Snorkelling and diving are a great way to learn about the sea.
(Photo Len Zell)

We live in the information revolution where we are bombarded with information by radio, newspaper and TV. The Internet is already a major source of information. The environment is frequently in the news. The sea is a popular subject on TV adventure stories and documentaries. Australians are becoming more environmentally aware. Public perceptions are being changed through education. Only a decade ago the shark was a feared man-eating monster. Now it is a graceful predator which should be preserved.

Stakeholder involvement

Environmental management generally involves regulating the behaviour of particular industry or community groups involved. These are sometimes termed ***stakeholders***. It is now widely recognised that if stakeholders are to support a plan, they need to be well informed and actively involved. (In the past, governments generally passed laws, and then told people they must obey, or else! It was an unpopular approach, and not very successful.)

Figure 468.2 Environmental organisations try to educate the public.
(Photo Bob Moffatt)

Figure 468.3 Student excursion to offshore island
(Photo Len Zell)

Water quality issues

Declining water quality is a significant issue. The catchments are heavily used and runoff of sediments and nutrients into the Bay is high. There are problems in the inner bay where the circulation is limited. Seasonal outbreaks of a toxic algae *Lyngbya*, which kills fish and causes skin irritations in bathers, are blamed on elevated nutrients. To improve water quality in the Bay, the Local Councils which control the catchments collaborated in a detailed study of the environment. This found that water quality near Brisbane was not good, but that in the eastern ocean side is excellent. The Councils combined to established *Healthy Waterways*, a body to better manage catchments, and there are already some improvements in water quality.

Conclusions

Moreton Bay is a unique area with high biodiversity value, but is subject to intense human uses. The Moreton Bay Marine Park demonstrates the potential of multiple-use protected areas in areas of high usage. *Healthy Waterways* also demonstrates how a cooperative approach to catchment management is possible.

Solitary Islands Marine Park (SIMP)

New South Wales has recently established three large, multiple-use marine protected areas: the Solitary Islands region near Coffs Harbour on the North Coast, Lord Howe island in the offshore Tasman Sea, and Jervis Bay on the South Coast. Another is planned for the Byron Bay area on the far North Coast.

The NSW Solitary Islands Marine Park (SIMP) extends 75 km north from Coffs Harbour to the 3 mile limit, and is over 70,000 ha in area. Commonwealth waters beyond 3 miles increase its size to almost 100,000 ha.

Biodiversity values

The SIMP region includes many different habitats: estuaries, beaches, rocky shores, shallow and deep continental shelf sediments and rocky reefs, supporting salt marsh, seagrasses, mangroves, and intertidal, algal, coral and sea floor communities. The Solitary Islands lie in a tropical/temperate overlap zone, or ‘ecotone’. They are bathed by the strong East Australian Current (Figure 563.3) which brings warm tropical water and tropical larvae from the south Pacific and Great Barrier Reef region. This current meets the cold southern water around the Port Stephens area, and is diverted into the Tasman Sea, bringing warm water and larvae to Lord Howe Island, the southern-most coral reef in the world.

The subtropical coral reefs are unique. They are dependent on the warm east Australian Current, and are few in number, small in size and are very widely separated (many by hundreds of kilometres). They occur at the lower temperature limit of coral growth and do not grow fast enough to form reef structures. They are made up of a mix of tropical and cold water species but are dominated by a few specialist subtropical corals.

Bob Moffatt

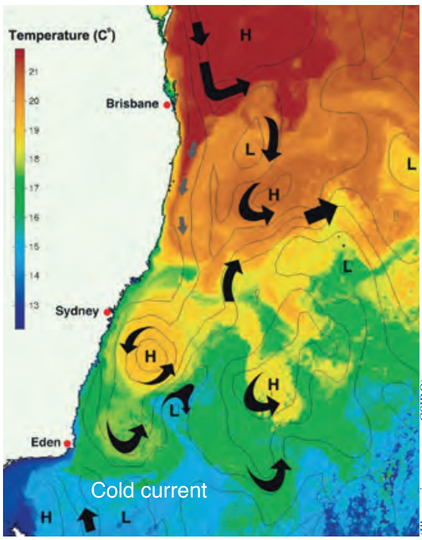
Bob Moffatt

Bob Moffatt

Figure 563.1 Shipping is a major activity in Moreton Bay Marine Park.

Lord Howe Tourism

Figure 563.2 Ball's Pyramid & Lord Howe Island



(Illustration courtesy CSIRO)

Figure 563.3 Currents off Coffs Harbour

Exercise 8.4 Simpson's Biodiversity Index

Based on original ideas by Nancy Tsernjavski and Angela Colliver

A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance.

Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so diversity increases.

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

n = the total number of organisms of a particular species
N = the total number of organisms of all species

The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity.

- To calculate Simpson's Index for Hypothetical Bay, two areas (natural vegetation and disturbed vegetation) were sampled using quadrats placed randomly or systematically. The number of plant species within each quadrat, as well as the number of individuals of each species should be noted. There is no necessity to be able to identify all the species, provided they can be distinguished from each other.
- As an example, let us work out the value of D for a single quadrat sample of ground vegetation in the Hypothetical Bay dunes. Of course, sampling only one quadrat would not give you a reliable estimate of the diversity of the dune flora. Several samples would have to be taken and the data pooled to give a better estimate of overall diversity.

  The method used to optimise the sampling is the Optimum Quadrat Size technique.

Species	Number (n)	n(n-1)
Spinifex	2	2
Goats foot	8	8
Sea oak	1	0
Banksia	1	0
Wattle	3	6
	N=15	$\sum$ n(n-1) = 64

- Now put the figures into the formula for Simpson's Index above

Answer

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

$$D = 1 - \left(\frac{64}{15(14)}\right)$$

Simpson's Index of Diversity = 0.7

Group discussion

Form groups of about 5-6 and use the poster on Page 213 as a discussion starter to answer the questions below.

Questions

1. The poster depicts a range of marine organisms in various habitats spanning coastal dune to intertidal zone, rock pool, reef and open ocean, through the zone of light and into the zone of perpetual darkness.

   What does your group think of the graphic, its characteristics and setting in attempting to explain species diversity?
   a. Make a list of the types of animals and plants you can identify.
   b. Classify them as best you can using the tree of marine life (Page 207).
   c. Make a list of the external features for each organism.
2. What is the difference between genetic, species and ecosystem diversity? Use the illustrations in the graphic to give an example of each.
3. Use the key on page 202 to devise a new key for the vertebrates shown in the graphic.
4. Draw up a two column table with temperate and tropical as headings. Now list under each heading where you think the animals and plants in the graphic would be found.
5. Study the images on pages 214 - 215 .
   a. Make a copy of each illustration and draw food webs for each.
   b. Using the tree of marine life, classify into animal and plant groups each of the marine organisms shown.
   c. Draw up a table to distinguish between the four different ecosystems shown.
   d. For each ecosystem, make a list of at least 4 individuals not shown.
6. Explain this statement:

   Food webs are one important type of interaction, but species can provide an attachment base for other species, can alter current or light patterns, provide camouflage or other forms of shelter or compete for space. (See page 210, para 5, for context).
7. What are the five kingdoms of marine life depicted and what characteristic/s separates them from each other?
8. Name one or more animals from the following groups in the illustration; Mammalia; Reptilia; Osteichthyes; Chondrichthyes; Amphibia; Mollusca; Cnidaria; Arthropoda; Mollusca; Echinodermata; Plantae.

brought far more money into the area than commercial landings ever did. In 2002 in NSW, money from recreational fishing licences was used to buy out the professionals from 29 estuaries. Some 400 professional fishers were paid to leave the industry. This has caused loss of jobs and considerable personal hardship. Professional fishers warn that the general public will suffer as fish prices double.

Commercial fisheries — fishing for profit

Australia's commercial fishing industry ranks fourth amongst the nation's rural food-based industries. Total landings are about 220,000 tonnes, worth \$2 billion, a year. Some 200 marine species are caught, of which prawns, lobster, abalone, scallops, oysters and tuna are most important. Finfish (sharks and bony fish) make up more than 60% of landings by weight, but the high value invertebrates like abalone, prawns and crayfish provide 75% of the earnings.

Australian fishing industry

About 27,000 people are employed in the commercial fishing industry, and there are more than 9,000 commercial fishing boats. Most are small, under 10 m in length, and owner-operated. Deepwater trawlers and long-liners are much larger, over 15 m in length. The latter are generally owned by larger companies, and are termed *industrial* fisheries. A number of large foreign fishing vessels, from Japan, New Zealand and other countries, are also licensed to fish in Australian waters. Some others fish illegally.

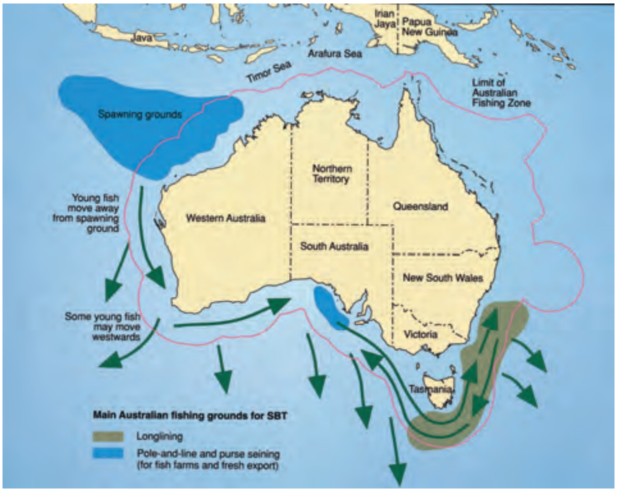


Figure 517.1 Australian tuna fishing grounds
(Illustration from SOMER 1996, reproduced with permission)

Exercise 20.2 Survey of your class fishing practices

Do you ever go fishing? Share some of your tales about the 'ones that got away'. Set up a table to show the following information for your class using fishing frequency as the main identifier. Use at least 4 groupings based on how often class members fish.

Write a two page essay on recreational fishing in your area. Use the following questions as a guide.

a. How many of the class go fishing each year?
b. About how many times?
c. How does this compare with the average local fishing family?
d. What fishing gear do they use?
e. Where do they fish?
f. What do they fish for?
g. On average, how many fish do they catch?
h. What is the most common catch?
i. Would they be willingly to pay \$25 a year for a fishing licence if the money went in to managing the fishery?

Figure 517.2 School fishing class
(Photo Geoff Jensen)