

# An Introduction to **MARINE STUDIES**



**2nd Edition  
Revised  
2012**



*Wet Paper*

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Bob Moffatt

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**Web references**  
[www.reefed.edu.au/home/glossary](http://www.reefed.edu.au/home/glossary)  
[www.environment.gov.au/education](http://www.environment.gov.au/education)

## What is Marine Studies?

The focus of marine studies is the cultural, commercial, environmental and recreational aspects of the sea and how it is managed. In this book 'the sea' includes all oceans, estuaries and river catchments that lead to the sea.



Figure 4.1 A surfers memorial service

### Cultural

The history of Torres Strait Island, Aboriginal, Asian, Maori and European cultures and their links with the sea helps us understand ourselves and our own culture. For example, Chapter 15 shows how different cultures have brought many new seafoods and cooking methods to our country but Chapter 28 shows how culture has contributed to mistaken attitudes that are trashing the seas of the world.



Figure 4.2 Commercial aspects

### Commercial

Shipping and water transport, fishing, boat building and diving are long-established marine industries. Now they are being joined by offshore exploration, aquaculture and ecotourism. Other marine-related commercial activities are surf and boat equipment supplies, and beach and sports gear manufacturing. Commercial aspects of the sea also present many new job opportunities for young people because in some states, there has been a boom in coastal development.

### Environment



Figure 4.3 Environmental concerns

Marine environmental studies play a big part in the success of commercial ventures, some of which are not obviously linked with the sea. For example, marine science will open new doors to our understanding of life in and out of the sea. Studies by marine oceanographers on the effect of the El Niño current off Peru on the climate of all Australia and New Zealand may lead us to better manage the impact of our weather. Marine communications, using satellite technology, help us track fish movements, locate pollution sources and find lost sailors. Marine geology will help us extract valuable resources from the seabed.

## Recreation

Marine recreation has many opportunities for fun and relaxation: walking on the beach, sailing, fishing, diving, surfing, swimming, boating and climbing over rocks. Enjoying the sea and its surroundings releases us from the stress of everyday life.

## Management

The sea is so different from the land. We must understand and appreciate these differences if we are to manage it successfully. The sea is not our natural environment and we will always be intruders in its alien world. We cannot easily modify the sea to suit our purposes. Unlike on land, we cannot build roads, houses or fences, although we can damage it by overfishing, pollution and bad practices.

Damaged land can be rehabilitated but once the sea is damaged, we must rely on its own natural systems to repair itself. We must do what we can to properly manage how we relate to the marine environment or our seas will become polluted and unproductive.

## Ecological sustainable development – the new goal

Ecological Sustainable Development (ESD) is defined as *development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depend.*



Figure 5.1 Recreational use of the sea



Figure 5.2 Management and environment

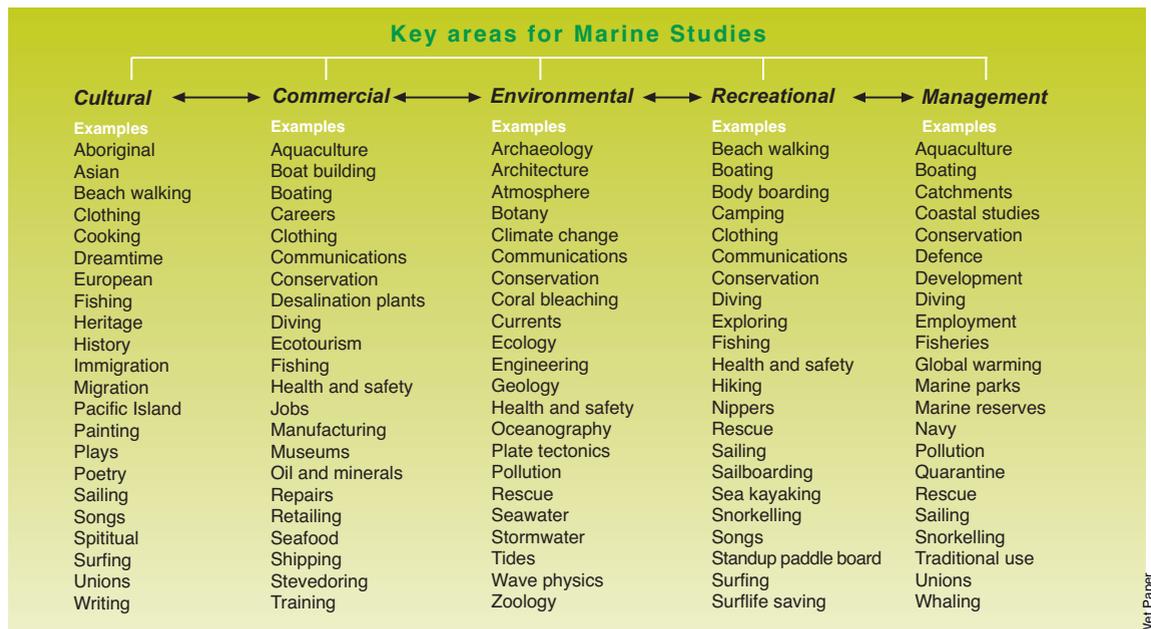


Figure 5.3 Key areas for marine studies

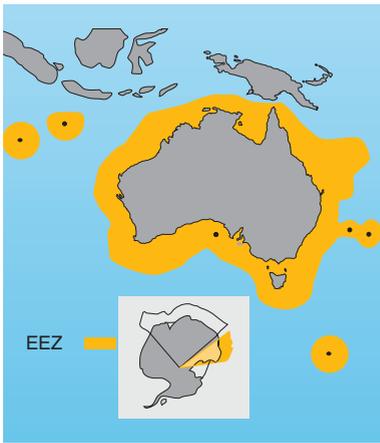


Figure 6.1 Australia's new coastal zone



Figure 6.2 Deep sea crab

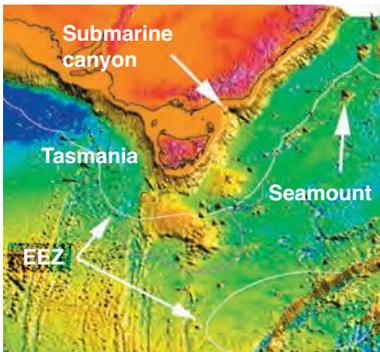


Figure 6.3 New coastal features



Figure 6.4 Southern Surveyor

## Importance

The sea is largely an undiscovered wilderness and as the Earth's atmosphere continues to warm our seas, an understanding of the dynamics of this wilderness is of paramount importance.

Scientists estimate over 50% of Earth's oxygen is produced by the ocean's floating microscopic plants — **phytoplankton**. These phytoplankton (see Chapter 25) also absorb 40% of the carbon dioxide greenhouse gases believed to contribute to global warming.

Australia's waters are home to more than 4000 species of fish including 166 species of shark and more than 110 species of seahorse. We also have the largest area and highest diversity of temperate seagrass and one of the largest areas of tropical seagrass in the world, and new creatures such as the deep sea crab Figure 6.2 have only just been discovered.

### Economic importance

In an agreement signed with the United Nations secured the opportunity to claim, for its own exclusive use, the economic resources within 200 nautical miles of the coastline.

This area known as the 200 mile Exclusive Economic Zone (Figure 6.1 - EEZ) effectively doubled Australia's size. Australia's EEZ is around 15 million square kilometres, and is amongst the largest EEZs in the world.

Research ships such as the *Southern Surveyor* (Figure 6.4) have been mapping this new border zone and discovered many new undersea features such as seamounts and submarine canyons (Figure 6.3).

New maps also need to be drawn around Australia's offshore territories (Norfolk Island, Cocos-Keeling and Christmas Island, the sub-Antarctic islands of Macquarie and Herd, and the Australian Antarctic Territory).

Australia also found itself with new sea borders with Indonesia, East Timor, France, Solomon Islands and New Zealand. Australia has a very complicated border arrangement with Papua New Guinea.

There is an urgent need to lift the level of awareness of the marine environment with the general public in the areas of fishing, tourism as well as development and conservation of the coastal zone.

With over half of the world's population living within 100 kilometres of a coastline – more than 2 700 000 000 people – it is little wonder that the marine environment will come under increasing pressure.

# Problems

## Lack of protection

Less than 8% of Australia's marine territory is protected in Marine Protected Areas and nearly three quarters of this area is within the Great Barrier Reef Marine Park. There is an urgent need for more marine parks in Australia and enforcement of international conservation laws, eg whaling and Australian coastal wilderness areas (Figure 7.1).

## Human impacts

Over a third of the oil found in the sea comes from the land. At any one time around 500 seals in Tasmanian water have 'collars' of plastic litter around their necks which suggests we should do something about the amount of plastic we use. More than 30% of surfing beaches have one or more stormwater outlets on them.

These facts suggests we should do something about planning our cities. The amount of fish harvested in the world is more than that of cattle, sheep, poultry or eggs however fifteen of the world's seventeen largest fisheries are either over-fished or in trouble.

## Catchment pollution and habitat destruction

All catchments in Australia, with the exception of the Lake Eyre Basin, ultimately discharge to estuarine or marine ecosystems. The health of marine and estuarine ecosystems is closely linked to the catchments with which they interact. Consequently, many land-based activities can have a significant effect on our coastal environments as habitats are destroyed for land based housing and commerce (Figure 7.2).

## Decreasing biodiversity

The number of marine animals and plants in our seas is decreasing, (eg Figure 7.3). The reason is that human activities affect all of the levels of biodiversity. Fish and other marine organisms are harvested from the ocean in very large quantities, immediately lowering biodiversity drastically.

Marine organisms are being removed too often to allow for the replenishing of population levels. To further complicate the problem, the habitats where marine organisms live are being destroyed as well.

## Other problems

Other major problems affecting our coast include water quality, sewage outfall, sedimentation, coastal wetland degradation, agricultural practices, depletion of estuaries, over-exploitation of resources and introduction of exotic species.

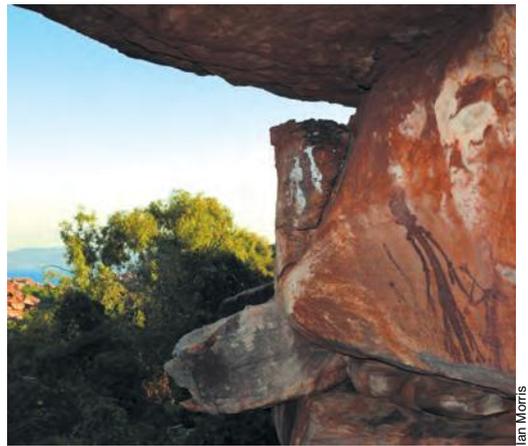


Figure 7.1 Our wilderness in Northern Australia is in urgent need of management or we could lose it forever



Figure 7.2 Loss of habitat

Whale type	No in 1900	No in 2000
Blue	228,000	11,700
Humpback	115,000	10,000
Minke	490,000	880,000
Sei	256,000	54,000
Sperm	2,400,000	1,950,000
Southern Right	1100,000	3,200



Japanese fishermen were still whaling in 2013.

Figure 7.3 Whale population sizes in 2000. How many are there today?



Figure 8.1 Management agency sign



Figure 8.2 National rescue agency ACT



Figure 8.3 Fishing agency QLD



Figure 8.4 Local authority controls VIC

# Management agencies

At some time you will come across a management agency if you use the marine environment. The purpose of agencies is to either protect lives or marine creatures. Each will have its own set of rules and regulations and can either be policed or regulated by volunteers. Rules and regulations are often changed as a result of public consultation.

## Recreation and leisure

If you drive a boat or go fishing a licence will be needed in most states. Fines will apply if you fail to obtain either. However if you swim in the sea, volunteers encourage you to swim between the flags. If you go snorkelling or surfing voluntary organisations encourage you to obtain some type of safety training.

If you go walking on the seashore many aquatic habitats are controlled by statutory bodies such as marine parks (Figure 8.1) or local councils (Figure 8.4). Sometimes you can't fish at certain times of the year or can only take a certain type of fish length.

## Voluntary organisations

There are hundreds of groups who seek to manage or educate us about the marine environment. Some examples of these include the Surf Lifesaving Association, Australian Sports Fishing Association, fishing, surfing, diving and boating clubs, Voluntary Marine Rescue (VMR's), Surfing Australia, Australian Underwater Federation as well as a host of windsurfing, beach walking, birdwatching and sea kyaking groups.

## Industry Agencies

If you were to start an aquaculture farm, you would need a permit and a business licence in many Australian states. You would be encouraged to obtain some qualifications in farming and have to follow the industry regulations. There are also voluntary industry associations for commercial fishing and diving as well as aquaculture.

## Conservation agencies

In some Australian states there are agencies that regulate and manage marine plants, fish stocks, aquatic habitats, marine mammals and reptiles.

## Marine disaster management agencies

Natural disasters affecting the marine environment are usually monitored by the state emergency services. Human-influenced disasters affecting the marine environment are usually

controlled by environmental protection agencies. Predicting and preventing coastal and marine disasters is very complicated and is attempted by the Australian Bureau of Meteorology and Local Authority by-laws.

## Why study marine studies?

Here are some reasons why coast and marine education is important. You may wish to add to this list in class discussions.

### Recreation and safety

- 90% of new housing development in the last ten years has been in the coastal zone (Figure 9.1) and more people are living and working near the sea creating enormous impacts on the coastal zone for water and recreation space.
- Each year events such as floods, fires, rips, cyclones or storms claim lives. Cuts, bites and puncture wounds from marine animals can also seriously affect our health.

### Industry

- Oil and gas, marine clothing, building materials, fishing, aquaculture, tourism and shipping are worth over 500 billion dollars and create millions of jobs. To access these jobs or start a business of your own, a knowledge of the marine industry is essential.

### Oceanography

- A knowledge of how the oceans of the world affect our climate, inshore fishing industries, coastal landforms and sea water quality is vital if we are to develop management plans.

### Ecology

- Of the 33 animal phyla in the world today, 28 are found in coast and marine environments. More than ever we need marine scientists to unlock the marine ecology secrets.

### Conservation

- Major problems affecting our coast such as pollution, sewage outfall, sedimentation, coastal wetland degradation, agricultural practices, depletion of estuaries, over-exploitation of resources, introduction of exotic species, reclamation of swamps and mangroves need management.

All of society needs to understand these issues and embrace management initiatives designed to solve these problems.

It is important for you to develop an understanding of how science, ethics and business practice is applied to industry, research, management and conservation. Finally there are many opportunities for creative thinking and involvement in projects and tasks as you explore the chapters that follow, and in the future you may choose marine related employment.



Figure 9.1 Coastal development WA

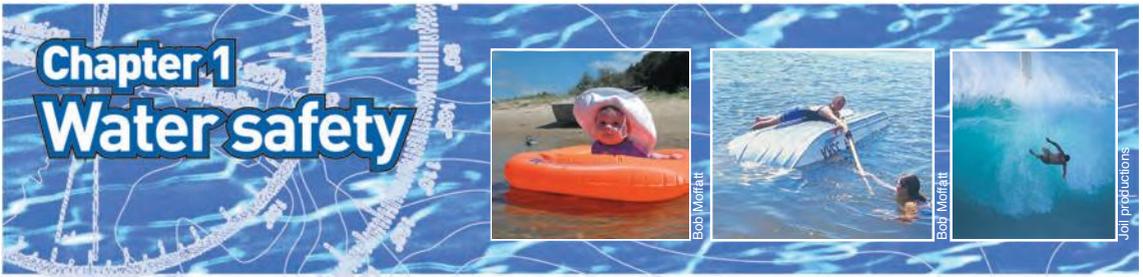


Figure 9.2 Coastal bushfires NSW

## Diving deeper



1. Find out where you would get a fishing or boating licence in your state.
2. Where would you get a snorkelling qualification?
3. Who determines when a *fish closed season* would occur in your state?
4. Visit a local voluntary marine rescue association (VMR).
5. Who is the Australian Maritime Safety Authority and what do they do?
6. What is the National Ocean Office and what does it do? Visit their web site - [www.noo.gov.au](http://www.noo.gov.au).
7. Make a wall chart entitled *why study marine studies*.
8. Study Figure 5.3 and redesign the table as it applies to your local area.



**Web references**

- [www.watersafety.vic.gov.au](http://www.watersafety.vic.gov.au)
- [www.healthinsite.gov.au](http://www.healthinsite.gov.au)
- [www.royallifesaving.com.au](http://www.royallifesaving.com.au)



Figure 10.1 The sea has become part of our culture.



Figure 10.2 Operate equipment at a safe speed and dress safely.



Figure 10.3 Use the correct gear for night sailing.

Television commercials constantly remind motorists to obey road safety laws and more recently we are starting to see commercials that talk about water safety.

In recent years, drownings accounted for 465 deaths in Australia alone, the second biggest killer of this country’s population. Over half these drownings were related to swimming, surfing or falling into the ocean.

We use the sea for **commerce** and **recreation**; sports such as sailing, surfing, swimming or boating irresistibly attract many of us to the water.

**Water safety** is an important part of marine studies because we all need to be aware of the dangers associated with water and its environment. We need to learn how to avoid drowning.

Simple skills such as how to tow someone out of danger using an everyday object, how to operate a powerboat at a safe speed while wearing clothes to suit the situation (Figure 10.2), or more advanced skills how to avoid falling off a yacht at night (Figure 10.3) are essential.

## Our water culture

Our rivers, lakes, dams, oceans and seashore have become part of our way of life; the focus of multi-million dollar industries for commercial harvest or tourism and enjoyment. An overwhelming proportion of our population live within 2 hours drive of the coast.

Our internationally renowned fishermen, rowers, water-skiers, sailors, powerboat drivers, surfers, swimmers, sailboarders and scuba divers highlight the widespread use we make of our beautiful water environment.

The rapid explosion in reef tourism, advances in fisheries research and the expansion of our territorial waters by the declaration of the **International Law of the Sea** show the economic importance of the sea to the Australian and New Zealand economies.

More than any other nation, our love of water has become part of our culture. As part of that culture, we must also learn water safety.

## Some causes of drowning

The table in Figure 11.1 breaks down into percentages where drownings occurred in recent years. The following sections look more closely at the actual causes of these tragic accidents.

### Poor supervision

Inadequate supervision of young children around water is the cause of most child drownings. Figure 11.1 shows that falls into swimming pools are the greatest cause of drownings and the lack of barriers around water sources must contribute to these figures. This table also shows that people can even drown in baths which underlines the importance of water safety at home.

### Surrounding environmental conditions

A lack of understanding of the dangers associated with water and its environment often leads to accidents. For example, the best of swimmers can fall off a rocky headland, be knocked unconscious and drown. People who can swim quite well in the backyard pool often panic when caught in a **surf rip**, become exhausted, black out and drown.

Chapter 18 describes how weather can contribute to dangerous water situations, for example, sailors can drown at sea when strong gusts of wind overturn their dinghies. Surfing or swimming in rough wave conditions like those in Figure 11.3 often leads to the swimmer exceeding the level of their abilities, becoming exhausted, and drowning after being battered on the rocks. Environmental factors such as tides, currents, waves and coastlines are discussed in Chapters 23 and 24.

### Failure to observe signs

Ignoring warning signs, such as those shown in Figure 11.2, can lead to people being stung by dangerous marine creatures, suffering a heart attack or shock and drowning. In many swimming places, signs warn people about swimming dangers, the most obvious of these are flags put up on surf beaches to indicate safe swimming areas. Yet, to the amazement of the lifeguards, people still swim outside these managed situations.

Drowning statistics	Percentage
Swimming, paddling or wading	22.0
Surfing, surfboard riding	4.0
Swimming in ocean, river, estuary, bay, lake, lagoon, dam, water hole, irrigation canal, drain or trench	3.0
Water-skiing, surfboard riding	2.5
Swept off rocks, breakwater while fishing	5.0
Skindiving, spear fishing	2.0
Attempting a rescue	1.3
Fall into swimming pool	28.0
Fall into ocean, harbour, estuary bay, lake, lagoon, dam, water hole, irrigation canal, drain or trench	16.0
Drowned in bathtub	2.0
Accident to watercraft causing submersion of motorised craft	9.0
Accident to watercraft causing submersion of non-motorised craft	3.0
Drowning caused by cataclysm or other environmental factors	2.0
Other	0.2
<b>Total</b>	<b>100.0</b>

Figure 11.1 Drowning deaths in recent years



Figure 11.2 Warning sign - Dangerous sea creatures



Figure 11.3 Beach rip



Figure 12.1 Don't get sucked into stormwater drains  
download the video [www.sucked-in.tv](http://www.sucked-in.tv)



Figure 12.3 Not checking for submerged objects



Figure 12.4 Lack of concentration while operating a boat



Figure 12.5 Sand down sharp fin edges before use.



Figure 12.2 Rough sea conditions

## Lack of safety and first aid skills

Bystanders' lack of knowledge of resuscitation and rescue techniques often leads to needless death. Chapter 2 will show you some of the simple steps that can keep a person alive when they have stopped breathing or their heart has stopped.

Many people cannot swim or don't know simple techniques to survive in water. Would-be rescuers risk drowning because of their poor swimming skills. People who use equipment such as boats, jet skis or surf craft may lack the safety skills required for their use. A simple lack of concentration while operating a boat can lead to fatal accidents.

Other factors that cause accidents include failing to think ahead, such as not checking water depth before diving, as shown in Figure 12.3, which can lead to severe spinal injuries and/or drowning.

## Faulty equipment

All equipment is important at sea, from the smallest of ropes to secure a torch, to the **life jackets** (personal flotation devices or PFDs) that keep mariners afloat. Always maintain equipment in good working order as your life may depend on it. That worn securing strap on your life jacket may cause the device to come off, leaving you with no flotation, or that too-sharp fin on your surfboard may cut you or others and lead to severe cuts and bleeding (Figure 12.5).

## Alcohol

Alcohol and water just don't mix. Alcohol slows reaction time and the ability to think clearly which leads to accidents which increase the chance of drowning. Remember, the 0.05 alcohol limit applies to boating activities as well as to driving a motor vehicle.

# Water safety issues

## Dangerous situations

Homes should be made safe for young inquisitive children. They are at the age of exploration – of finding out what things are and what they do. Many people lock up poisons, keep medicines and sharp objects out of reach, but forget about water. We all take responsibility for supervising children in or near the water (Figure 13.1). In rivers, lakes and at the beach there are additional dangers. Watch for snakes, sharks and stinging creatures. Currents, submerged objects, weed and unstable overhanging banks are all potential dangers.

Uneven riverbanks and seabeds with deep holes are dangerous for non-swimmers who wade in shallow water to cool down. Large lakes become very choppy with wind. During storms, roads and stormwater drains contain fast flowing water. **Never ride surfboards or body boards in these water conditions as you may be sucked into stormwater drains (Figure 12.1).**

Walking along cliff faces (Figure 13.3) with their rocky outcrops, slippery rocks and waves can be dangerous as is driving into flooded streams. At sea, where conditions can get extremely dangerous, it is important to be familiar with emergency drills and safety equipment (Figure 13.4).

## Water safety practices

### At home

Don't cross flooded creeks in 4 wheel drives

Here are some simple hints for supervising children at home:

- always stay with children at bath time;
- never let children out of your sight around water;
- never leave toddlers alone in a paddling pool;
- empty paddling pools when children get out;
- cover and fence swimming pools and cover inground fish ponds with heavy steel mesh; don't leave buckets, tubs or large bowls around the house with water in them;
- teach young children to swim; and
- display safety guidelines, rules and **cardiopulmonary resuscitation (CPR)** charts wherever there is water danger and encourage all swimmers to note the rules and obey them.

Some water safety procedures for all ages are listed below:

- check the depth markers, exit points (usually steps) and the people in the pool before getting in;
- stay in a depth zone that is comfortable; and
- avoid running, bomb-diving or dunking.



Figure 13.1 Supervision near water is essential.



Figure 13.2 Safety at home



Figure 13.3 Be careful when walking near cliff faces.



Figure 13.4 Life jacket drill



Figure 14.1 Three types of PFD

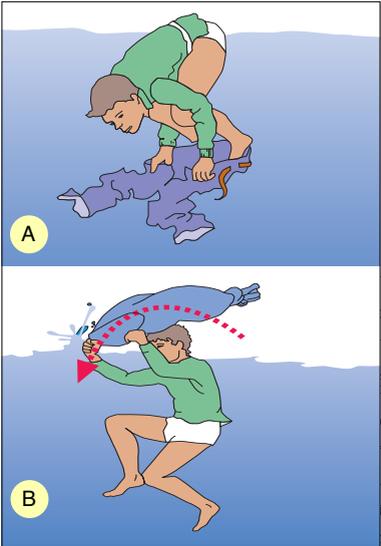


Figure 14.2 How to remove clothing that can be used as a flotation device.



Figure 14.3 You can use everyday objects as floats.



Figure 14.4 Don't exceed the level of your confidence or skill.

## At rivers, lakes and at sea

Suggested safety practices are listed below.

- If you are boating, canoeing or water skiing, use the correct PFD (life jacket) and wear it all the time. Figure 14.1 shows three types of PFD listed below:
  - PFD 1 has a neck support to keep your head out of the water if you are exhausted;
  - PFD 2 is often used by people who do water sports where they only need to float for a short time;
  - PFD 3 is often used by water skiers who need a large range arm movement and only need to stay afloat long enough for help to arrive quickly.
- Keep an eye on the weather. Check radio forecasts before setting out. If you are canoeing or sailing in a large lake and the weather looks like changing pack up and go home.
- Never get too close to overhanging cliffs or large breaking waves on a rocky platform and never swim alone.
- Watch out for slippery rocks when walking on a rocky shore.
- In flood situations:
  - avoid crossing flooded creek crossings by yourself and seek local advice; and
  - avoid playing on body boards in flooded parks as you may end up going down a stormwater drain and drown.

## General water skills

### Learning to float



The shock of falling into water fully clothed can make you panic. Floating can also be a problem if you are being washed downstream. Figure 14.2 shows how to take off your clothes while in the water and use them as a flotation device. Buckets, esky lids, plastic drink bottles or pieces of foam can also be used as flotation devices, as shown in Figure 14.3.

### Watch out for slippery surfaces

Water creates a slippery surface on boat ramps, rocks, decks, handrails, stairs or anything that is flat and hard. The right footwear will reduce the chance of slipping.

### Know the level of your abilities

Overconfidence and showing off can be deadly at waterfalls, underwater hockey, big surf or snorkelling in caves. Never be afraid to chicken out as it may prevent serious injury or save your life one day (Figure 14.4).

### Learn first aid

Training in first aid is essential if you use the sea (Chapter 2).

## Learn basic rescue methods

One award you can qualify for in your local swimming pool is the bronze star available from the Royal Lifesaving Society of Australia (Figure 15.1).

Some of the things you will need to do for this award include:

- swim 200 metres in still water and 25 metres fully clothed
- swim 10 metres underwater and tread water for 3 minutes
- identify dangerous local swimming spots and list the conditions that would make them dangerous
- demonstrate some rescue methods as shown in Figure 15.3.

The web pages shown in Figure 15.2 give information about this award. The Surf Life Saving Association, Kids Alive do the Five and Surfing Australia are other associations that have training for school students.

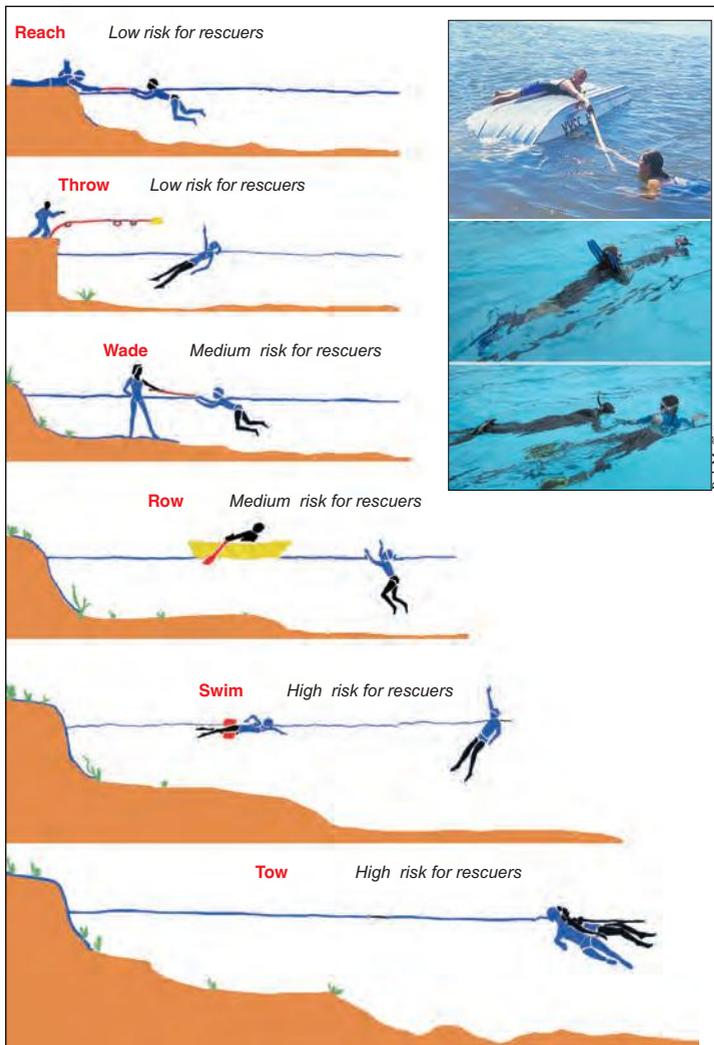


Figure 15.3 Rescue techniques  
Illustration after Royal Life Saving Association

## Diving deeper



1. Learn to tie some knots used by mariners, such as the bowline.
2. Visit a shop that sells sailboards. What safety equipment is necessary for this sport?
3. What is a *dan buoy* and how is it used in sailing?
4. What is a *heliograph* and how is it used as a safety device?
5. What types of fire extinguishers are used to fight different types of fires?

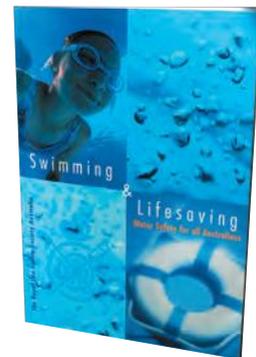


Figure 15.1 Life saving manual  
Royal lifesaving society of Australia



Figure 15.2 Life saving web sites

# Regulations in specific sports

## Boating and sailing



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Figure 16.1 Sailing requires training, safety equipment and skills.



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Figure 16.2 Boating requires a licence, safety equipment and skills.

Sailing and driving a powerboat are two common types of boating. By joining a sailing club you can learn to sail through the Australian Yachting Federation (AYF) training logbook (TL) scheme. Beginners obtain a TL1 **logbook** which enables them to sail a dinghy safely inshore.

Schools, parents and friends, sea cadets, air-sea rescue and coastguard or private providers run excellent programs if you want to learn how to drive a powerboat.

In most states, you need a licence to drive a power-driven vessel and you have to be a certain age to obtain that licence. A government department administers the licence scheme and you will have to sit for an exam, undergo a test or present some type of certification from a training authority to get that licence.

### Australian government marine safety agencies

#### New South Wales

[www.maritime.nsw.gov.au](http://www.maritime.nsw.gov.au)

#### Victoria

[www.marinesafety.vic.gov.au](http://www.marinesafety.vic.gov.au)

#### Northern Territory

[www.ipe.nt.gov.au](http://www.ipe.nt.gov.au)

#### Tasmania

[www.mast.tas.gov.au](http://www.mast.tas.gov.au)

#### Western Australia

[www.dpi.wa.gov.au/imarine](http://www.dpi.wa.gov.au/imarine)

#### Queensland

[www.msq.qld.gov.au](http://www.msq.qld.gov.au)

#### South Australia

[www.transport.sa.gov.au/safety/marine](http://www.transport.sa.gov.au/safety/marine)



Wet Paper

Figure 16.3 Attend flare demonstration days.



Lloyd Jones

Figure 16.4 Learn how to get into life rafts.

Because so many people use the water and there are no places for stop signs or traffic lights, everyone must learn a set of common international rules to prevent collisions at sea. People who use the sea are required to know many of these rules before they are issued with a boat licence and the further you go out to sea, the more rules you will need to know.

Boating and sailing have their own safety principles and equipment. You can learn how to use this equipment if you are involved in activities such as:

- water safety days run by marine teachers associations to learn how to set off flares or to use life rafts (Figures 16.3 and 16.4);
- rescuing others as part of your marine studies class
- using life jackets and survival techniques in courses run by volunteer associations; and
- enrolling in marine safety courses run by professional associations such as your state Surf Life Saving Association, the Australian Underwater Federation, the Australian Yachting Federation, your local maritime college, TAFEs or private providers.



Figure 17.1 Some safety equipment

## Boating safety equipment

Safety equipment designed for a specific purpose are listed 1-10 below and shown in Figures 17.1 and 17.2:

1. A **fire extinguisher** can put out a fire on a small vessel.
2. The **emergency position indicating radio beacon (EPIRB)** is used to locate mariners at sea.
3. **Flares** attract attention if a boat is in difficulties.
4. A **marine radio** sends and receives safety messages as well as weather forecasts.
5. An **anchor** keeps a boat in position when water is moving due to tides.
6. A **first aid kit** must be able to fix cuts and bruises, and relieve sea sickness, headache or sunburn.
7. A **chart** enables sailors to locate their position at sea.
8. The **signalling light** and V sheet attracts attention if the vessel gets into trouble.
9. **The oars** are used to row the boat if the motor breaks down.
10. **PFD or life jacket** (see your state marine safety agency for up to date regulations)

## Snorkelling

Buoyancy vests, wet and stinger suits are just some of the specific safety equipment used by snorkellers and divers. In Chapter 8 you will learn a lot more about the skills necessary for snorkelling and the types of qualifications you need.



1. What is the second greatest killer in our country?
2. Draw a pie chart showing the percentage of people drowned while swimming, paddling or wading in 2004.
3. Why should rules such as no running, no bombs and no dunking be part of swimming pool rules?
4. Analyse the differences between the three types of PFD.
5. How are marine radios used in safety situations?
6. Predict three events when flares could be used.
7. Why do sailors use special lines at night?
8. Propose two reasons why you should not ride your body board or surfboard in flooded drains.
9. Recommend 5 water safety principles.



Figure 17.2 Look for the Australian Standards AS 1512 label.



Figure 18.2 Lycra shirts and arm leashes are used by body boarders.



Figure 18.3 Hooks, knives, fish with spines all create safety issues for fishers.



Figure 18.4 Canoeing and safety gear



Figure 18.1 Surfing requires a high degree of skill.

## Surfing

[See page 262 for the surfing code of ethics](#)

Surfing is one of the few sports that has no government regulations. Surfers have to learn how to paddle out to avoid being run over; how to ride a wave towards the shore without colliding with other surfers; and catch a wave without wiping out, as shown in Figure 18.1. Surfers practise these skills each day, gradually mastering the basics before venturing out into the bigger swells.

Most surfers use a leg rope or leash, so their boards don't get lost, and wear protective clothing to prevent skin cancer (Figure 18.2). Surfing requires a high degree of physical fitness and most surfers maintain this by eating healthy foods and exercising regularly. Some surfers wear helmets and wet suits in colder weather to prevent hypothermia (see Chapter 2).

## Fishing

Commercial fishing operators need a licence and are controlled by many safety rules. Recreational fishers who use a boat, follow the boating safety guidelines but recreational shore anglers may use common sense safety rules, such as making sure hooks are not going to harm other people when casting, using gloves when handling fish with sharp spines and not fishing off rocks where waves can wash them out to sea.

## Canoeing

A basic canoeing certificate, life jacket and sun protection are requirements for canoeing. Dangers can include submerged rocks, overflows and broken glass on the river bank. If you want to learn advanced skills you should join a canoe club or association.



Wet Paper

Figure 19.1 The Australian Maritime College (AMC) in Tasmania

### Commercial use of the sea

Training is an essential part of any commercial operation at sea and organisations such as the Australian Maritime College specialise in training seafarers.

Basic training occurs on land where the trainees learn how to launch and retrieve a lifeboat from a vessel. In special pitch-black rooms (Figure 19.2) filled with jets of water and the sounds of howling winds, students learn to jump into the sea and experience the fear of abandoning a ship at sea, at night and in rough conditions in a marine safety course for mariners. Other courses include the elements of ship board safety, fire fighting, first aid and life raft drill.

### Building a raft

A common introductory exercise in marine studies classes is to build a raft as shown in Figure 19.3. Learning to tie common knots, working as a group, working with safety gear on are very important skills.

Some common knots used in marine situations are shown below. See if you can decide which ones would be most useful in the raft building exercise.

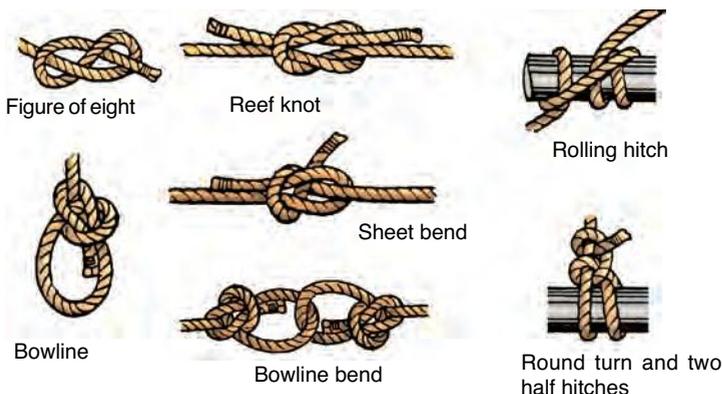


Figure of eight

Reef knot

Rolling hitch

Sheet bend

Bowline

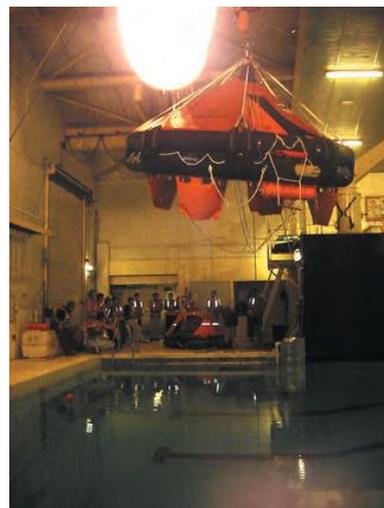
Bowline bend

Round turn and two half hitches

## Diving deeper



6. Explain the procedure for enrolling in a boating or sailing course.
7. Design a water safety brochure for a swimming pool body corporate meeting. Prepare a budget for its production.
8. Make up a list of safety rules for a home pool.
9. Visit Surfing Australia's web site and find out how to do a learn to surf class.  
[www.surfingaustralia.com](http://www.surfingaustralia.com)



Ruth Farley

Figure 19.2 Life raft drill AMC



Simone Baker

Figure 19.3 Raft building

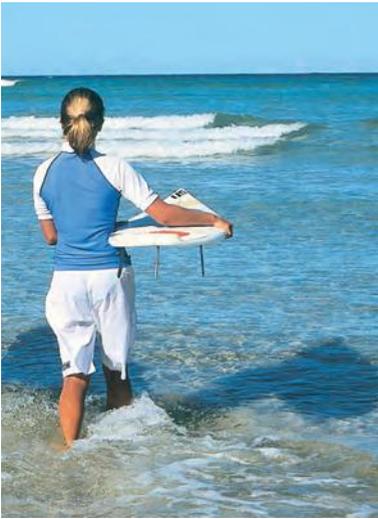


Figure 20.1 Assess the situation carefully.

## Water and weather conditions

See also Chapter 18 Weather

The ocean can be a potentially dangerous and inhospitable place for the unwary person. Always take the time to assess the conditions and make a realistic decision in relation to your ability level. There are certain times when the ocean is not suitable for any level of activity. Severe rips, rough conditions, boat ramps and entry points are just a few things to consider before entering the water.

## Key words

Alcohol, arm leashes, buoyancy vests, cardiopulmonary resuscitation, chart, commerce, drowning, emergency position indicating radio beacon, fire extinguisher, fishing, flares, flotation device, international law of the sea, life jacket, life raft, lycra shirt, marine radio, PFD, raft building, recreation, resuscitation, rough sea conditions, safety devices and equipment, safety line, signalling light, simple rescue skills, surf rip, surfing, TL1 logbook, warning signs, water safety.

## Diving deeper



10. Research different types of flares used by mariners at sea. Describe each one and how they work.
11. Research what an RFD is, what it contains and how it is used .
12. Outline the main reasons for the international regulations for prevention of collisions at sea.
13. What types of signals are used by a water skier?
14. Make a collection of boating safety pamphlets and report on how they are used to improve water safety.
15. Research how to get out of a car accidentally driven into deep water.
16. Design a safety sign for a marine sport eg: surfing, boating, sailing, canoeing, snorkelling.

Caution  
Strong rips here



## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. We use the sea for [1] \_\_\_\_\_ and [2] \_\_\_\_\_ ; sports such as sailing, surfing, swimming or boating irresistibly attract many of us to the sea.
- b. A lack of [3] \_\_\_\_\_ of the dangers associated with water and its environment often leads to accidents. For example, the best of swimmers can fall off a [4] \_\_\_\_\_ \_\_\_\_\_ , be knocked unconscious and [5] \_\_\_\_\_ .
- c. Remember, the 0.05 [6] \_\_\_\_\_ \_\_\_\_\_ applies to boating activities as well as to driving a motor vehicle.
- d. One [7] \_\_\_\_\_ you can qualify for in your local swimming pool is the bronze star available from the Royal Lifesaving Society of Australia.
- e. Most surfers use a leg rope or [8] \_\_\_\_\_ , so their boards don't get lost, and wear protective clothing to prevent skin [9] \_\_\_\_\_ .
- f. [10] \_\_\_\_\_ is an essential part of any commercial operation at sea and organisations such as the [11] \_\_\_\_\_ \_\_\_\_\_ specialise in training [12] \_\_\_\_\_ .
- g. Severe [13] \_\_\_\_\_ , rough conditions, boat [14] \_\_\_\_\_ and entry points are just a few things to [15] \_\_\_\_\_ before entering the water.



**First aid procedures change constantly**

If you have an earlier edition of this book, then you need to keep up to date EACH year. So check one of the following [www.stjohn.org.au](http://www.stjohn.org.au), [www.resus.org.au](http://www.resus.org.au), [slsa.com.au](http://slsa.com.au)

These pages also do not replace a practical course in resuscitation run by either St. John Ambulance Association, Red Cross, Surf Life Saving Association, The Royal Lifesaving Council, your local ambulance service or any accredited rescue service provider.

The sea can be a dangerous place. However careful you are, accidents will happen (see Figure 21.1). The way you respond could be vital to your own survival or the people involved.

The information in this chapter can never replace a first aid course such as those run by St. John Ambulance Association, Red Cross or your local ambulance service. However, it covers the basics of **resuscitation** and how to deal with injuries. First aid relevant to dangerous marine creatures is covered from page 34.



Figure 21.1 Bristle worm spines can be painful.

## The DRSABCD action plan

**First aid** is the treatment given to an injured person while waiting for qualified treatment from professionals. There is an important priority to be established in any emergency. We can remember this if we remember the **DRSABCD** action plan. The illustrations on page 23 summarise the sequence given below.

- **D**anger
- **R**esponse
- **S**end for help
- **A**irway
- **B**reathing
- **C**ompression
- **D**efibrillation (if available)

### Danger

As a first aider, your first priority must be yourself. You are no use to anyone if you are hurt trying to help an accident victim. Other rescuers would then have two patients to deal with. Consider the risks involved in helping another person. Some examples are listed below.

- trying to rescue a snorkeller in distress if you are a poor swimmer;
- trying to rescue a surfer in a rough sea with a surf rescue board if you have never used a surfboard before;
- assisting a person on a beach with broken glass in bare feet or who was being attacked by a crocodile;
- trying to remove stinger **tentacles** from a patient using bare hands.

### Check for signs of life

CPR should only be performed when a person shows no signs of life; that is, when they are:

- Unconscious
- Unresponsive
- Not breathing normally
- Not moving.





Figure 22.1 Response check



Figure 22.2 Clear the airways.



Figure 22.3 Check for signs of life.

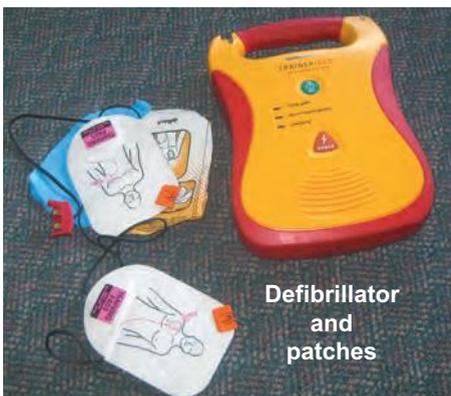


Figure 22.4 Defibrillator

## Response check *See Figure 23.1 (2)*

The most common method used to get a response is to touch and talk to them. (Remember **COWS**)

**C**an you hear me? **O**pen your eyes.

**W**hat's your name? **S**queeze my hand.

## Send for help NOW *See Figure 23.1 (3)*

Call 000 for an ambulance or find someone with a mobile and ask them to dial 112. Remain calm while answering questions, state the exact location of the incident, the phone number you are calling from and what has happened as described in Figure 23.1 (3).

## Airways *See Figure 23.1 (4) and (7)*

Depending on what happened to them, the patient's breathing may be obstructed. Lay the patient on their side, kneel near their shoulders and remove any obstacles or vomit. It is very important to make sure the airway is open as shown in Figure 23.1 (4).

## Breathing *See Figure 23.1 (5), (8) and (9)*

Check for breathing by looking for chest expansion, listening for the sound of breathing and feeling for breathing movement on your cheek.

Position the airway as shown in Figure 23.1 (7) **Adults and children** – tilt head backward. Place one hand on the forehead and use the other hand to lift the chin. (Note - for infants <1 year – do not tilt head).

## Compression *See Figure 23.1 (6) and (9)*

**Adults** – place heel of hand in centre of chest. Place other hand on top of first.

**Children 1 – 8 years** – place heel of hand in centre of chest.

**Infants <1 year** – place 2 fingers in centre of chest. Compress 1/3 depth of chest. Compress 30 times and follow with 2 breaths.

Continue until ambulance arrives or person regains consciousness or it becomes impossible for you to continue.

## Defibrillation *See Figures 23.1 (10) and 22.4*

Follow the voice prompts on the machine if one is available. If injured person shows signs of recovery, roll onto side and check if they are breathing. Reassure the person and bystanders.

# Call triple zero (000) in an emergency

ask for ambulance, stay with the person and resuscitate



## 1 Check for Danger

Ensure safety for yourself, bystanders and casualty.  
If safe, remove casualty from water as soon as possible.



## 2 Check Response

Can you hear me?  
Open your eyes.  
What's your name?  
Squeeze my hand.



## 3 Send for help NOW call triple zero (000)

Phone for an ambulance.  
Remain calm while answering the questions:  
- exact location of the incident  
- phone number you are calling from  
- what has occurred.  
Follow the instructions from the ambulance service.



## 4 Clear Airway

If water or vomit is present in mouth, roll casualty on side, tilt face downwards and clear mouth with your fingers.



## 5 Check for normal Breathing

Look and feel for rising and falling chest.  
Listen and feel for breath sounds.  
If the patient is not breathing normally, commence resuscitation.

## 6 Start Compressions

Adults – place heel of hand in centre of chest. Place other hand on top of first.  
Children 1 – 8 years – place heel of hand in centre of chest.  
Infants <1 year – place 2 fingers in centre of chest.  
Compress 1/3 depth of chest.  
Compress 30 times.



## 7 Position the airway

Adults and children – tilt head backward. Place one hand on the forehead and use the other hand to lift the chin.  
Infants <1 year – do not tilt head. Place one hand on the forehead and use the other hand to support the chin.



## 8 Start breaths

Adults and children – seal nose and give 2 breaths into mouth.  
Infants <1 year – give 2 breaths into mouth and nose.  
Watch for chest to rise.



## 9 Repeat breaths & compressions

Repeat 30 chest compressions and 2 breaths.  
Continue until ambulance arrives or person regains consciousness or it becomes impossible for you to continue.



## 10 Attach a Defibrillator as soon as available. Follow the prompts

If injured person shows signs of recovery, roll onto side and check if they are breathing.  
Reassure the person and bystanders.



Learn first aid. Contact [www.ambulance.qld.gov.au](http://www.ambulance.qld.gov.au) or 13 QGOV (13 74 68).

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Queensland  
Government

# Cardiopulmonary resuscitation

Cardiopulmonary resuscitation (CPR) is a combination of rescue breathing and chest compressions that delivers oxygen and artificial blood circulation to a person who is in cardiac arrest. It can be life-saving first aid and can be done by one or more people (Figure 24.2).

A ‘heart attack’ occurs when the heart is starved of oxygen. A heart attack can ‘stun’ the heart and interrupt its rhythm and ability to pump. If the heart stops pumping, it is known as a cardiac arrest.

This is because the heart does not receive enough oxygen and cannot pump blood around the body (Figure 24.1). There is no heartbeat because the heart is not working.

When the blood stops circulating, the brain is starved of oxygen and the person quickly becomes unconscious and stops breathing. Without treatment the person will die.

## CPR can be life-saving first aid

Cardiopulmonary resuscitation (CPR) can be life-saving first aid and increases the person’s chances of survival if started soon after the heart has stopped beating. If no CPR is performed, it only takes 3–4 minutes for the person to become brain dead, due to lack of oxygen.

By performing CPR, you provide the needed oxygen and circulate the blood, so that the brain and other organs can stay alive while you wait for the ambulance.

CPR does not guarantee that the person will survive but it does give that person a chance when otherwise there would have been none.

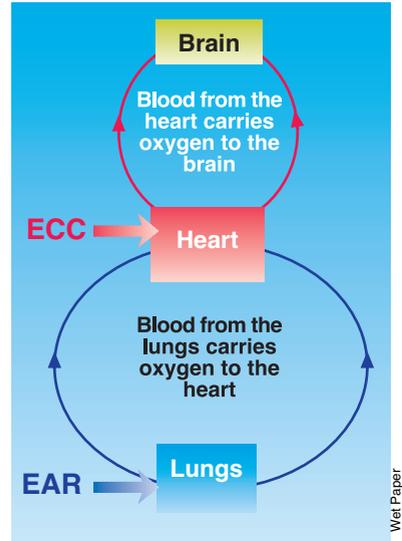


Figure 24.1 Heart-lung schematic diagram

## Causes of cardiac arrest

A cardiac arrest can be caused by:

- Heart disease – this is the most common cause of cardiac arrest and is the leading cause of death in Australia
- Drowning
- Suffocation
- Poisonous gases
- Head injury
- Drug overdose
- Electric shock.



Figure 24.2 CPR with one or two rescuers

# CPR – the basic steps

These are the basic steps for performing CPR; they can be used for adults, children and infants. They are based on guidelines updated in 2006 are easier to follow. (Note: some parts are a repeat of page 23).

However, they are only a guide and not a substitute for attending a CPR course. CPR is most successful when administered as quickly as possible.

1. Check for danger – approach with care and do not put yourself in danger.
2. Look for a response – is the victim conscious? Gently touch and talk to them – if there is no response, get help.
3. Dial triple zero (000) – ask for an ambulance.
4. Check the airway – don't move the person.
  - Tilt their head back, open their mouth and look inside. If fluid and foreign matter is present, gently roll them onto their side.
  - Tilt their head back, open their mouth and remove any foreign matter (for example, chewing gum, false teeth, vomit).
5. Check signs of life – look, listen and feel for breathing.
  - If the person is breathing leave them lying on their side.
  - If they are not breathing, go to step 6.
6. Use mouth-to-mouth (rescue breathing) – if the person is not breathing normally, make sure they are lying on their back and:
  - Open the airway by tilting the head back and lifting their chin.
  - Close their nostrils with your finger and thumb.
  - Put your mouth over the person's and blow into their mouth.
  - Give 2 full breaths to the person (this is called 'rescue breathing').
  - Make sure there is no air leak and the chest is rising and falling. If their chest does not rise and fall, check that you're pinching their nostrils tightly and sealing your mouth to theirs.
  - If still no luck, check their airway again for any obstruction.
7. Provision of an oxygen resuscitation kit, as shown in Figure 25.4, allows for the administration of oxygen to the patient.



Figure 25.1 Tilt head back.



Figure 25.2 Place wide open mouth over patient's mouth and blow air into patient.



Figure 25.3 If the chest rises, turn your head so you can hear and see chest fall.



Figure 25.4  
Oxygen kit

7. Cardiac compressions – start chest compressions:
  - Place the heel of one hand on the lower half of the person’s breastbone.
  - Place the other hand on top of the first hand and interlock your fingers.
  - Press down firmly and smoothly (compressing to 1/3 of chest depth) 30 times.
  - Administer 2 breaths.
  - The ratio of 30 chest compressions followed by 2 breaths is the same, whether CPR is being performed alone or with the assistance of a second person.
  - Aim for a compression rate of **100 per minute**.
8. Maintain CPR – continue, repeating the cycle of 30 compressions then 2 breaths. Continue until ambulance arrives or person regains consciousness or it becomes impossible for you to continue.
9. Don't check the pulse. Regular recovery (pulse) checks are not recommended as they may interrupt chest compressions and delay resuscitation.



Figure 26.1 Locate the compression point.



Figure 26.2 Position the heel of the other hand in the middle of the sternum.

## CPR techniques for young children and infants

### Children aged 1–8 years

CPR steps for children aged eight years or younger are the same as for adults and older children, but the technique is slightly different.

- Use the heel of one hand only for compressions, compressing to 1/3 of chest depth.
- Follow the basic steps for performing CPR described above.



Figure 26.3 Place one hand over the other.

### Infants (up to 12 months of age)

- Place infant on their back. Do not tilt their head back or lift their chin (this is not necessary as their heads are still large in comparison to their bodies).
- Perform mouth-to-mouth by covering the infant’s nose and mouth with your mouth – remember to use only a small breath.
- Do chest compressions, using two fingers of one hand, to about 1/3 of chest depth.
- Follow the basic steps for performing CPR described above.

### What to do if the person recovers during CPR

CPR may revive the person before the ambulance arrives.

- Review the person’s condition if signs of life return (coughing, movement or normal breathing). If the person is breathing on their own, stop CPR and place them on their side with their head tilted back.
- If the person is not breathing, continue full CPR until the ambulance arrives.
- Be ready to recommence CPR if the person stops breathing or becomes unresponsive or unconscious again. Stay by their side until medical help arrives. Talk reassuringly to them if they are conscious.



Figure 27.1 Grasp the patient's leg, hips and head.



Figure 27.2 Lift the leg.



Figure 27.3 Gently roll the patient over and observe them until the patient recovers or expert help arrives.

## Stopping CPR

Generally, CPR is stopped for one of the following reasons:

- The person revives and starts breathing again on their own.
- Medical help, such as ambulance paramedics, arrive to take over.
- The person performing the CPR is forced to stop from physical exhaustion.

## Recovery position

If pulse and breathing are present or once they return, lie the patient in the recovery position as shown in Figures 27.1–27.3, being careful to avoid spinal injuries.

Regularly check their airway, breathing and circulation (all other considerations are of minor importance), so do not leave the patient unless absolutely necessary. If you didn't do it before, now is the time to get help.

## Continuing care

While you are waiting for expert help to arrive, you must still care for the patient. Keep the patient under constant observation and record everything that has occurred (if possible).

## Control shock

Shock occurs when blood pressure drops for a prolonged time. Shock can damage vital organs such as the heart or brain, or cause death if there is a lack of oxygen to these areas. Manage the situation by trying to remove the cause of the shock, then lie the patient down, with their feet higher than the head. Give some reassurance to calm the patient.

## Changes to procedures

If you have an earlier edition of this book, then you need to know the Resuscitation Council of Australia issued new resuscitation guidelines.

Pages 23-27 have summarised the major changes but for the latest information on resuscitation please check.

<http://www.resus.org.au>

These pages however do not replace a practical course in resuscitation run by either St. John Ambulance Association, Red Cross, Surf Life Saving Association, The Royal Lifesaving Council, your local ambulance service or any accredited rescue service provider.



1. What do the letters DRSABCD, CPR stand for?
2. How do you get a response from a patient?
3. Why must you check the airway for obstacles before beginning rescue breathing?

# When do you call an ambulance?

Source: [www.betterhealth.vic.gov.au](http://www.betterhealth.vic.gov.au)

In a medical emergency, calling for an ambulance could mean the difference between life and death. The people who take your call are trained to help you and will direct you to the appropriate resources.

It is a good idea to take a first aid course so that you can recognise a medical emergency and administer effective first aid until medical help arrives.

## What is a medical emergency?

Always call triple zero (000) for an ambulance in the following circumstances:

- Unconscious person – who doesn't wake or respond when shaken.
- Heart attack (suspected) – crushing chest pain that lasts more than five minutes. The pain may spread to arms and jaw.
- Breathing difficulty – especially if the person is unable to speak more than a few words or has blue lips or mouth.
- Abdominal pain – that is severe and undiagnosed.
- Haemorrhages – major uncontrolled bleeding.
- Bleeding – that does not stop after at least 10 minutes of continuous pressure.
- Burns – which are bigger than the size of a hand and/or cause severe pain that is not relieved with simple painkillers, or if the person has difficulty breathing.
- Choking – especially if the person is unable to talk, cry or breathe.
- Convulsions or fitting – if the person is still fitting as you phone triple zero (000) or if they have no history of convulsions (for example epilepsy or brain injury).
- Drowning, near drowning, diving or scuba accident.
- Stroke (possible) – especially if the person experiences numbness, loss of function of hand, arm or leg, slurred speech, facial droop or severe abrupt headache.
- Headache (severe) – not the usual kind, with or without loss of function of arm or leg.
- Pain (severe) after a fall or injury – when the person is unable to sit up, stand or walk.
- Allergic reaction – especially with difficulty breathing or loss of consciousness.
- Electrical shock – of any kind.
- Trauma (injury) – which is severe, especially to the head, neck, chest or abdomen – for example if the person was stabbed, shot or impaled, or hit by or ran into an object.
- \* Hypothermia or heat stress – which is severe.



SA Ambulance Service

## If you're not sure, call anyway

Remember, if you are unsure that what is happening is a real emergency, you can always phone for an ambulance and they will come and assess the situation. Ambulance paramedics can always attend, assess and then leave the person at home if they do not require further emergency treatment.

## How to call triple zero (000)

Once you have decided that the situation is a medical emergency, you will need to call triple zero (000) and ask for an ambulance. You should:

- Get to a telephone – if you are providing first aid to the injured person, ask someone else to make the call.
- Call out for help if you are by yourself – if no one responds, you may have to leave the injured person briefly to call for an ambulance. It is important to phone for an ambulance as quickly as possible to get the ambulance on the way.
- Dial triple zero (000) – you can use a fixed, mobile or pay telephone. Triple zero (000) is a free call (even from a pay phone).

## Things to remember

- Some people hesitate to call for an ambulance because they are not sure if the situation is a medical emergency – if in doubt, call triple zero (000).
- Give an accurate location so the ambulance gets to the injured or ill person as soon as possible.
- Do not hang up the phone until the ambulance call taker tells you to.
- It's a good idea to do a first aid course so you can recognise a medical emergency and administer first aid until the ambulance paramedics arrive.

*In an emergency  
call triple zero 000*



# Burns

## Treatment for burns

When treating burns, first remove the heat from the affected area. Remove any burning material (unless stuck to the skin) and cool the burnt area by pouring cold water over it. Watch the casualty for shock and remember DRSABCD.

Any large burns, (burns on hands, face, airway or genitalia) or deep burns (where the skin may be burnt black or white) must be examined by a doctor.

The best way to relieve pain is to cool the burned area with cold running water (Figure 29.1). Do not break blisters or apply lotions, ointments or creams.

**Sunburn** is a special case of burning. In our climate we need to be aware of the danger of over-exposure to the sun. The 'Slip, Slop, Slap' message is worth keeping in mind. Sunburn which causes blisters, or on very young or old people, should be seen by a doctor.

Treat sunburn with cool showers, cool wet towels and by moving the casualty into a cool place. Later the pain and itching may be relieved with calamine lotion.

Keep sunburnt people out of the sun.

### Action for severe burns

- DRSABCD
- cool the burned area under cold running water
- cover the burn with a sterile non stick dressing
- transport the patient to a doctor or hospital.

### Action for scalds

- cool the burned area with cold water for 10 minutes
- If no water is available, remove thick clothing unless stuck to the skin.

### Action for flames

- smother the flames with a blanket or piece of clothing
- lie the patient on the ground
- douse the burned area with cold water for several minutes
- remove clothing not sticking to the skin and cover the burned area with a nonstick dressing.

### Action for electric burns

- switch off the power
- commence CPR if necessary
- douse the burned area with cold water for several minutes.



4. Why should you tilt the patient's head right back while performing rescue breathing?
5. What information should you give when sending for help?
6. What is the principle behind the cycles in CPR?
7. You and your friends find an adult with no signs of life. Describe what you should do.
8. You find a baby floating in a pool. After you drag the baby out of the pool, you discover the baby shows no signs of life. What do you do?
9. Make a resuscitation flow chart of a person who is not breathing from an electrical shock.



Figure 29.1 Flood burn with water for 20 minutes.

### Action for chemical burns

- flood the burnt area with water for 10 - 15 minutes
- remove contaminated clothing and footwear making sure you are not contaminated yourself
- try to identify the chemical
- if the burn is to the eye, flush the eye for 20 minutes and cover both eyes
- seek urgent medical advice



Figure 30.1 Sharp animals such as coral can cause cuts.



Figure 30.2 A clot that has stopped bleeding



Figure 30.3 Control of bleeding

## Cuts and bleeding

*Nothing can replace a first aid certificate. The notes given here are designed to highlight first aid you may need while on a snorkelling adventure. It is recommended you do a first aid course from an accredited provider such as the Australian Red Cross, TAFE, St John Ambulance, a surf lifesaving association or local ambulance service.*

### Blood and bleeding

Blood is the only fluid tissue in the body and comprises about 8% of a person's body weight. In a normal-sized adult, there are about 5 litres of blood which normally flows smoothly through the blood vessels.

If a blood vessel wall is damaged bleeding occurs. When this occurs, a series of chemical reactions come into play to stop the bleeding and prevent further damage. The blood cells around the damaged area cause a mesh-like protein called fibrin to form, causing other cells to become caught and form a clot which finally stops the bleeding (Figure 30.2). The damaged area must be covered for long enough for this process to form.

If blood is lost from the body, the supply of oxygen to cells is reduced resulting in shock and finally death. Cuts are common in snorkelling from coral or sharp rocks. Severe cuts can result from bites from dangerous animals or knives.

Severe bleeding can cause death.

### Controlling bleeding

Bleeding can usually be stopped by applying pressure to the wound. Put a sterile pad over the wound and bandage firmly (but not too tightly) over the pad. If necessary, apply extra pressure by hand.

Foreign material in the wound may be lightly brushed out. Do not try to remove an object like a knife or stingray barb. Place packing around the foreign object to immobilise it, and bandage around the object and over the wound. Even minor cuts can become seriously infected and must be treated carefully.

Excessive bleeding can be dangerous and needs to be controlled. Monitor the casualty for shock.

### Action to control bleeding

Try at all times to wear gloves or avoid contact with blood.

#### Severe bleeding

- apply pressure - use a towel or anything to stop bleeding;
- elevate the bleeding area; and
- rest the patient - treat for shock if necessary.

## Bleeding from the ear

- Position the patient on the side with the affected ear down and seek urgent medical advice. Do not plug the ear.

## Bleeding from the nose

- Ask the patient to sit up, lean slightly forwards and pinch the nostrils for 10 minutes while breathing through the mouth.
- Advise the patient not to sniff or blow the nose.
- If bleeding persists seek medical advice.

## Bleeding from lacerations

- Control the bleeding by pressure, elevation and rest.
- Clear the area of skin around the laceration and apply a sterile dressing.
- Those with broken skin should check their tetanus injection records.

## Cuts

### Treatment for cuts

1. Wash the cut thoroughly and inspect if any foreign materials are still in the wound.

A painful but practical way to remove small pieces of coral or grit is with a toothbrush.

2. Apply a drying antiseptic and cover the wound with a sterile dressing. Note that some people are allergic to betadine so if you can, check first.

If necessary, apply a dressing and keep the affected area dry. Many marine bacteria are resistant to some antibiotic creams. If the wound becomes infected, seek medical advice so that the marine bacteria can be identified by a pathology test and the correct antibiotic prescribed.



Figure 31.3 Web site — [www.healthinsite.gov.au](http://www.healthinsite.gov.au)

## Coral cuts

Coral cuts need special attention because they are most likely to become infected.



If cleaned and treated with a drying agent (hydrogen peroxide or *betadine*), the wound will dry up and deprive the bacteria of a moist place to grow.

*Check the patient is not allergic to betadine*

Thoroughly clean the wound as soon as possible after the injury.

Remove all foreign material with lint free material, tweezers or tooth brush, apply an antiseptic lotion or a local antiseptic powder or ointment.

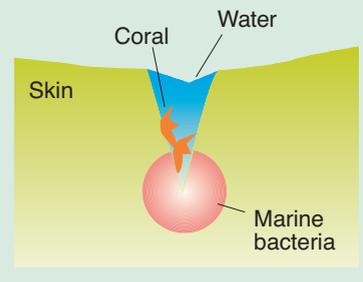


Figure 31.1 Marine bacteria multiply rapidly in a cut that is moist.



Figure 31.2 Coral cut



10. What is the recovery position? Describe how it is performed.
11. A person is burnt on the hands by a hot saucepan during a school camp. Draw up a flow chart explaining what should you do.
12. Propose three methods to avoid sunburn.
13. What are the symptoms of overheating and how should they be controlled?
14. Why should you not move a person with a suspected broken bone or spinal injury?
15. Define *hypothermia*.

## Shock

Shock is a term used to indicate that something is wrong with blood circulation. Initial signs and symptoms of shock may include:

- pale appearance and cold clammy skin
- altered breathing - rapid and shallow
- rapid, weak pulse
- faintness
- nausea/vomiting/shaking and or trembling.

The signs and symptoms of **severe** shock include:

- deterioration of the level of consciousness
- thirst
- blue lips and fingertips (cyanosis).

### Treatment

Monitor the casualty's breathing and pulse regularly. If the casualty becomes unconscious, place them in a lateral position. Carry out **DRSABCD** and control **severe** bleeding if necessary and seek medical advice as soon as possible.

#### Reassure the casualty

- Raise the casualty's legs above the level of the heart (unless they are fractured).
- Apply splints for fractures.
- Dress wounds or burns.
- Keep the casualty warm.
- Give nothing by mouth. You can moisten the lips but do not give any food or drink to the casualty.

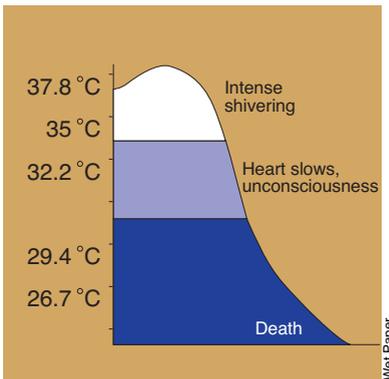


Figure 32.1 Hypothermia graph and body condition

## Marine medical emergencies

### Over-cooling

See page 83 for sea survival times

The sea can be a cold and unforgiving place. An unprotected person in the water in the colder oceans may only survive for a few minutes before dying of **hypothermia** as shown in Figure 32.1. Exposure in tropical seas may produce hypothermia, but it will take longer.

Hypothermia occurs when the body is cooled to the point where it can no longer warm itself. Wetsuits and dry suits can prevent over-cooling (see Figure 33.1.). Wetsuits trap a layer of water next to the skin which is heated by the body and in turn keeps the body warm. Dry suits trap a layer of air next to the skin.



## Overheating

The human body only functions in a small temperature range. Just as over-cooling is potentially fatal, so overheating can kill. There are three levels of this condition.

The first type of overheating is often heat cramps. The patient suffers painful muscle cramps, nausea, tiredness and weakness, but their skin will still be moist and cool. Give the patient cool drinks to replace lost fluid, move them to a cooler place, stretch their cramped muscles and make them rest.

Heat exhaustion is more severe. The patient will have heat cramps but will also be thirsty, with a headache. They may be uncoordinated and sweating heavily. Their skin will be pale, cool and clammy. As for heat cramps, lie the person down in a cool, quiet place with tight clothing loosened or removed. Give them drinks and sponge their body with cool water. If there is no sign of a quick recovery, consult a doctor.

Heat stroke, the third level of overheating, can kill. The symptoms are similar to other forms of overheating but the patient has a rapid, powerful pulse and their skin is flushed and dry. This person needs to see a doctor urgently. In the meantime remember DRSABCD, give drinks (if conscious) and cool them with fans, wet sheets, sponges or ice packs.

## Fractures

If you suspect an accident victim has broken bones, do not move them. If you have to move them, splint the limb first in the position it was in when you found it. At all costs, avoid moving the limb if you can. If you suspect spinal injuries, the casualty should never be moved by an untrained person.

## Seasickness

One of the very worst sensations anyone can experience is seasickness. Most people suffer from this at some time. When seasickness does strike, try to get into the fresh air, keep busy and focus on the horizon. Distracting people who are seasick will often make them feel better. Taking a motion sickness tablet before you go out or at the very first hint of illness may be effective.

## Drowning

Water in the lungs is not the main reason for drowning; it is caused by suffocation where not enough oxygen reaches the tissues. However a patient who has been revived from drowning should be observed for up to 72 hours to avoid secondary drowning caused by water in the lungs blocking the small lung air sacs called **alveoli**.

## Diving deeper



1. Devise a number of ways to improve a wet suit design.
2. Research three things you could do to prevent seasickness.
3. Investigate the survival times for a person falling into the sea off your local coastline.
4. Design a questionnaire to survey attitudes to sunbaking.
5. Prepare a first aid booklet for a school excursion to the beach.

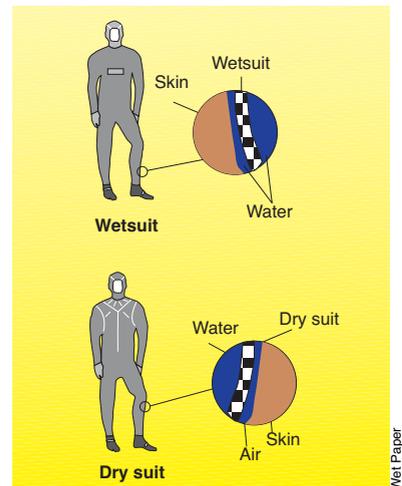


Figure 33.1 Wet and dry suits can prevent over cooling.



Figure 33.2 A SCUBA diver needs to wear a wet suit to avoid over cooling.



Figure 34.1 Moray eel

\* All measurements in this book are approximate.

# Accidents with marine organisms

**Treatment**  
Control bleeding  
DRSABCD

## Bites

Bites can be caused by many marine animals including sharks, moray eels, and crabs. Usually the bite is done in retaliation for being attacked or accidentally disturbed. The moray eel (Figure 34.1) is usually quiet.

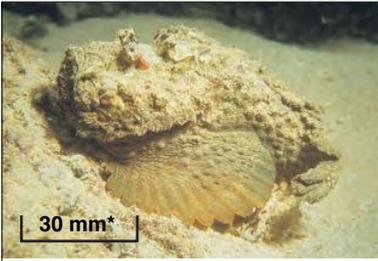


Figure 34.2 Stonefish and spines

## Envenomation

Envenomation is the embedding of poison in the blood system from a marine animal. Common causes are standing on an animal eg stonefish or stingray; making contact with an animal eg fireweed or sea jelly; being bitten eg snake bite, being stung eg cone shell. Wounds caused by spines are called puncture wounds and need to be treated very carefully.

## Stonefish

See also pages 47 and 306

**Treatment**  
Hot water ~ 45°C  
Call 000 DRSABCD

The stonefish is not known for its attractive appearance. It is, in fact, very hard to see at all, because its camouflage blends in perfectly with its surroundings, as shown in Figure 34.2. Stonefish, found on reefs in tropical and subtropical waters, contain a deadly venom which can kill humans. This venom is contained at the base of 13 sharp dorsal spines. The spines are contained in sheaths which remain folded and hidden if undisturbed. They become erect upon the slightest contact and will immediately puncture the unfortunate victim, releasing the deadly venom. To avoid stonefish, be very observant when diving on reefs.



## Scorpionfish

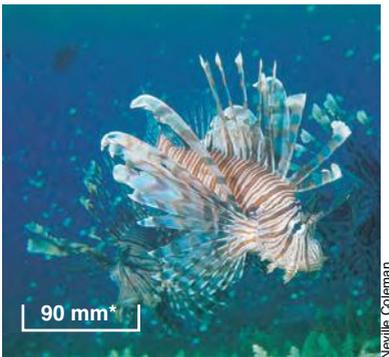


Figure 34.3 Scorpionfish (Lionfish)

Scorpionfish (Figure 34.3) are boldly coloured in red, white and black. This colouring however fades in low-light conditions such as dusk and then the stripes serve as disruptive camouflage. With their long fin spines they resemble feather stars which helps them to masquerade, when selecting an ambush site.

**Treatment**  
Hot water ~ 45°C  
Call 000 DRSABCD

When they approach their prey, they spread their fins to the side and slightly forward. The fins act as a barrier to cut off the escape of the prey.

## Blue-ringed octopus

See also page 48

These small, beautiful creatures as shown in Figure 35.1, are highly venomous and have been responsible for many human deaths throughout the world.

They are usually found in shallow rock pools at low tides, or in reef pools and areas with high concentrations of shellfish, such as mussels.

When they bite, they release highly toxic venom through a parrot-like beak in the centre of their eight tentacles.

Victims often do not realise they have been bitten because anaesthetic saliva is released with the venom. This often proves fatal because the venom affects the nervous system with paralysis occurring within 30 minutes.

When these octopuses are disturbed, brilliant, almost fluorescent, blue rings appear on their arms and bodies, giving plenty of warning to potential predators.

## Cone shells

See also pages 46 and 300

Cone shells are beautiful, yet potentially lethal, cone-shaped molluscs that carry a highly developed venom apparatus, consisting of a rapid-acting poison that is injected by means of a dartlike, barbed tooth.

The venom causes a mild sting (puncture wound) that initially is characterized by bee-sting-like pain or, rarely, numbness and blanching.

This is rapidly followed by numbness and tingling at the wound site, around the mouth and lips, and then all over the body.

If the envenomation is severe, the victim is afflicted with muscle paralysis, blurred vision, and breathing failure. A sting can be fatal.

## Treatment for stonefish, blue-ringed octopus and cone shells

- For suspected stonefish, blue-ringed octopus and cone shell bites, call 000 for an ambulance, use the pressure-immobilisation technique, and have the patient taken immediately to the emergency department of the nearest hospital.
- A full description for stings is given over on page 36.

**Treatment**  
**Pressure - immobilization**  
**Call 000 DRSABCD**

**Treatment**  
**Pressure - immobilization**  
**Call 000 DRSABCD**

## Hot water immersion technique

Source [www.emedicine.com/EMERG/topic300](http://www.emedicine.com/EMERG/topic300)

Heat treatment is widely recommended as effective initial treatment for envenomations by Scorpaenidae, as well as echinoderms, stingrays, and other venomous spine injuries.

The affected limb should be immersed in water no warmer than 114 degrees Fahrenheit, or 45 degrees Celsius.

Be careful not to inflict thermal burns by placing an insensate limb (as a result of local anesthesia or decreased sensitivity as a result of pain) into scalding water.



Figure 35.1 Blue-ringed octopus



Figure 35.2 Cone shell

## For the latest information

Treatments are constantly changing so for the latest information consult your state health web site, eg: [www.health.qld.gov.au/poisonsinformationcentre](http://www.health.qld.gov.au/poisonsinformationcentre)

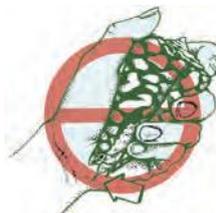


Figure 35.3 Don't pick up cone shells  
Rose Bedford

# Treatment of stings

## General action

Smaller people eg children and those with little body hair are more susceptible to the effects of envenomation. Extra care should be taken when envenomation occurs with these people.

## Action

The following is general action recommended by the Royal Life Saving Society.

- DRSABCD
- pressure immobilise the affected area
- commence resuscitation immediately if necessary — the casualty may appear dead when, in reality, this is not so
- seek medical assistance
- move casualty as little as possible
- stay with the casualty
- monitor pulse and breathing
- *check on casualty's allergies*

## Pressure immobilisation bandage

- use for bites of snakes, Blue-ringed octopus, Cone shells, funnel web spiders and in case of allergic reaction to other bites and stings.
- use a wide bandage, pantihose or other suitable material
- apply bandage over the area
- bandage from the toes/fingers back up over the envenomated area and over the joint
- immobilise the limb by using a splint or a sling; use another bandage to secure the splint.
- do not wash the area - any residue venom may be used for identification purposes.

## After care

- Reassure the casualty and maintain a calm and purposeful manner.
- When time permits write down all relevant information such as the cause of the envenomation, what the affected area looks like, the time of treatment, the extent of the injury.

### \*Advice – Northern Australia

For suspected Irukandji and Box Jellyfish call Cairns or Darwin base hospitals accident and emergency for advice.

#### Reference web sites

[www.health.qld.gov.au/PoisonsInformationCentre](http://www.health.qld.gov.au/PoisonsInformationCentre)

[www.pharmacology.unimelb.edu.au](http://www.pharmacology.unimelb.edu.au)

(Search for cone shell)

<http://cnsfse01.jcu.edu.au/schools/tropbio/cubozoan.html>

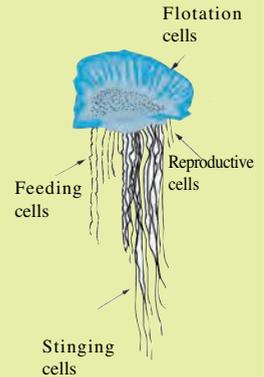
<http://slsa.asn.au>

(Search for envenomation)

## Treatment of Blue bottle

If stung by a Bluebottle you should:

1. Remove the tentacles using the tips of your fingers (your finger tips have tough calloused skin and shouldn't be stung) being careful not to touch any more exposed skin with the tentacles.
2. Rinse the area with fresh water.
3. Apply ice to reduce pain and swelling and to stop more stinging cells from firing.
4. Reassure the patient and monitor them for allergic reactions. If breathing becomes difficult seek medical help.



## Treatment of Box jellyfish\*

If stung by a Box jellyfish you should apply vinegar and seek medical assistance immediately.\*

## Treatment of Irukandji \*

If stung by a Irukandji you should seek medical assistance immediately.\*

## Treatment of Scorpionfish

If stung by a Scorpionfish spine you should seek medical assistance immediately and immerse the affected area in hot water.

## Protection

In Northern Australia, stinger suits like the one shown below, cover the entire body.

These can be purchased from dive shops or on line.

This type of suit protects you from being stung.



## Bluebottle

Bluebottles, also called the Portuguese Man o'War, are found in all oceans except the colder regions near the poles. Although more widespread, they are not as deadly as Box jelly and have only caused death when the victim was particularly allergic to its toxin. The Bluebottle, as shown in Figure 37.1, gets its name from the colour and shape of its body which looks like a blue, sail-shaped balloon up to 25 centimetres long. The trailing tentacles are up to 10 metres long, which makes them hard to avoid especially in strong currents or large waves. Although not fatal in most cases, the sting causes severe pain and welts on the skin. Treatment is with cold water and removing the tentacles.

**Treatment -**  
**Cold water\***  
\* Check for latest info



Neville Coleman

Figure 37.1 Bluebottle

## Box jelly

Box jelly (Figure 37.2), also known as sea wasps, are the deadliest stinging jelly in the world and have killed swimmers, particularly children, off northern Australian beaches. They have large, transparent, bell-shaped bodies up to 30 centimetres across, each with a large, trailing clump of tentacles up to 4 metres long, containing millions of nematocysts (stinging cells). Preferring warmer waters, they are found only in the tropical waters of Australia's far northern beaches between December and March. Beaches from Cairns around to Broome are closed for swimming during this period.

**Treatment - Vinegar**  
**Urgent medical advice**



Sydney Aquarium

Figure 37.2 Box jelly and antivenom

Victims, especially children, can die within minutes of being stung after suffering intense pain followed by paralysis (caused by the poison shocking the heart) and then breathing failure. The poison also attacks the red blood cells in the victim's skin upon contact and produces large, purple, whip-like marks. **Never rub sand into a jellyfish sting.**

## Irukandji

These are small members of the Box jellyfish family with a bell size of about 2 centimetres (Figure 37.3).

**Treatment -**  
**Urgent medical advice**  
**DRSABCD**

This means they can pass through stinger nets. Although the sting is very minor the pain which develops later can be excruciating. If stung in Northern Australia, flood the area with vinegar and get to hospital within 20 minutes for pain killers.



Jamie Seymour

Figure 37.3 Irukandji

## Stinging hydroid

Stinging hydroids (Figure 37.4) can cause painful stings to the skin. The best way to avoid this is learn to identify it and look but don't touch.

**Treatment -**  
**Cold water\***  
\* Check for latest info



Neville Coleman

Figure 37.4 Stinging hydroid

## Diving deeper



6. Compose a skin cancer protection jingle for a radio commercial
7. Find out how to remove a fish hook from a person's finger.
8. How do you control a nose bleed?
9. A person has a tooth broken off. Could that tooth be glued back on? Ask your dentist.
10. What are the symptoms of a heart attack?
11. A person's clothing catches fire. What should you do?
12. What is the treatment for snake bite?
13. What is the treatment for an Irukandji sting?

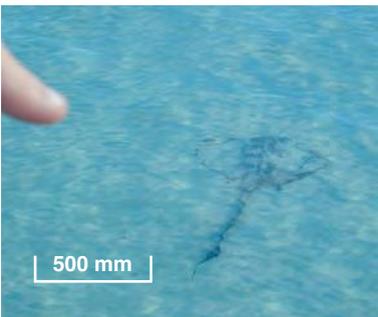


Figure 38.2 Stingrays may not be visible when entering the water

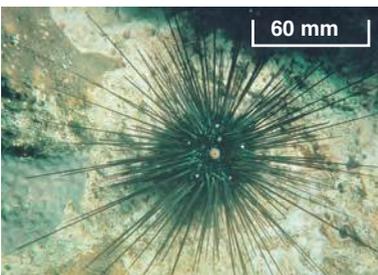


Figure 38.3 Sea urchin

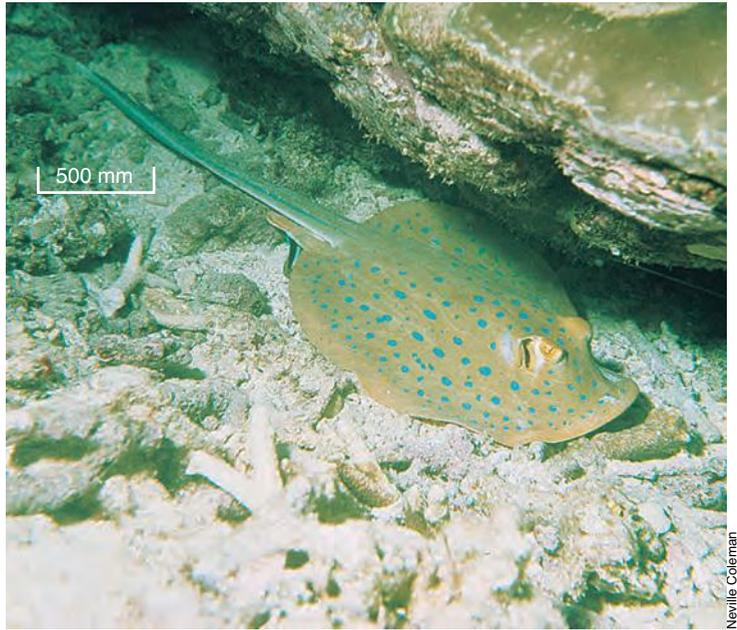


Figure 38.1 Common stingray

## Stingrays

People have been stung after accidentally treading on, or swimming too close to rays as they lie hidden in the sand on the seabed. Figure 38.1 shows a common stingray.

**Treatment**  
Hot water ~ 45°C

When such a threat occurs, stingrays respond with a rapid vertical thrust of their tails or slicing motion which drives the barbs deep into the victim's skin and releases toxic venom. It's best to shuffle your feet as you enter the water and they will move on.

## Sea urchins

Sea urchins or sea eggs as shown in Figure 38.3, have many long spines that can penetrate a snorkeller's foot.

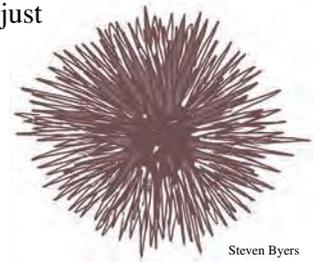
**Treatment**  
Surgical removal

*Further reference*  
[www.emedicine.com/wild/topic47.htm#section-treatment](http://www.emedicine.com/wild/topic47.htm#section-treatment)

Most injuries occur when snorkelling rocky headlands, as the sea urchin likes to live in rock crevices just under the water.

The best way to avoid sea urchin spikes, is to wear booties.

The spikes are very painful and are hard to remove so medical assistance is usually required.



Steven Byers

## Starfish

Some sea stars such as the Crown of Thorns starfish have poisonous spines. These should be handled only with well protected gloves as the animal can cause extremely painful wounds. Treatment is by hot water to alleviate the pain taking care not to scald the patient.

## Fish poisoning

Some fish such as Red bass (Figure 39.1) can be poisonous if you eat them. Toadfish are also extremely toxic and have caused deaths in Australia.

**Treatment**  
Seek urgent medical advice

In tropical Australia some fish carry a toxin called ciguatera. Symptoms include tingling in the toes and fingers, reverse hot and cold sensations, nausea and aching muscles. In all cases of fish poisoning seek medical advice immediately and initiate DRSABCD.

## Bristle worms

The first aid for itching caused by the bristles of a Bristle Worm is to remove them by applying adhesive tape over the affected area.

**Treatment**  
Remove with forceps and sticky tape

As the adhesive tape is peeled off, the bristles pull out of the tissues. Apply an anaesthetic ointment to the affected area and seek medical advice if pain persists.

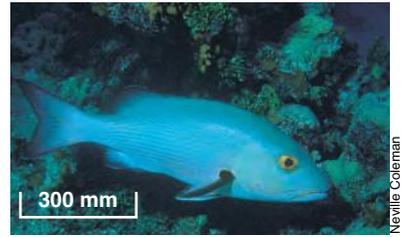


Figure 39.1 Red bass

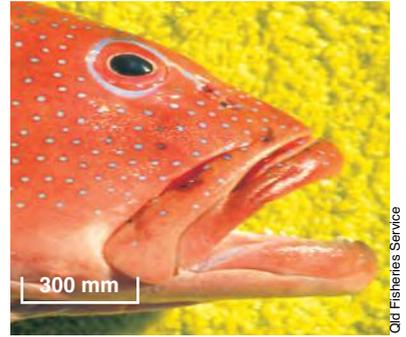


Figure 39.2 Large reef fish can contain *Ciguatera* toxin.

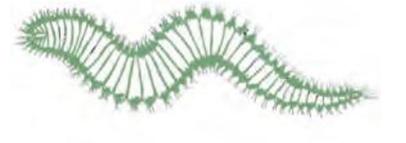


Figure 39.3 Bristle worm  
Steven Byers



16. What is fish poisoning and how can it be prevented?
17. What is the first aid for a fish spine poisoning?
18. How does a Stingray inflict venom on a victim and what is the treatment?
19. What is the first aid for removing the bristles from a Bristle Worm puncture wound?
20. A person treads on a sea urchin and gets a number of spines in the foot. What is the treatment?
21. What is the best way to avoid a puncture wound?
22. What is the difference between the treatment of Box jellyfish and Bluebottle stings?
23. What is the treatment for a bite by a small shark?
24. What types of injuries can scuba divers suffer from?



## Diving deeper



14. Consider doing a first aid course. It will be useful!  
You could contact your local branch of Red Cross or St John Ambulance. You may even be able to do a first aid certificate course through your school, TAFE or local ambulance centre.
15. Imagine you are putting together a marine first aid kit.
  - Suggest some items which may be needed in your area.
16. Some sharks behave in different ways when they are aggressive. Find out more details.
17. What is the freecall number for diving emergencies in your phone book?
18. How much does it cost to join the ambulance? What is the cost to transport you to your local hospital if you are not in the ambulance?
19. What is your local doctor's name and phone number?
20. Prepare a wall chart that shows how to treat the stings, bites and puncture wounds mentioned in this chapter.
21. Make a phone chart showing emergency numbers for police, ambulance, neighbours, family doctor.

## Key words

Accidents, airway, anaesthetic, antivenene, barotrauma, breathing, circulation, compress, CPR, DRSABCD, EAR, first aid, hypothermia, immobilization, nitrogen, obstructions, oxygen, poisoning, pulse, resuscitation, sternum, sunburn, tentacles.



## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. [1] \_\_\_ \_\_\_ is the treatment given to an injured person while waiting for qualified treatment from professionals.
- b. As a first aider, your first priority must be [2] \_\_\_ \_\_\_ . You are no use to anyone if you are hurt trying to help an accident victim.
- c. The most common method used to get a response is to [3] \_\_\_ and [4] \_\_\_ to them.
- d. Check for breathing by looking for chest [5] \_\_\_ , listening for the sound of breathing and feeling for breathing [6] \_\_\_ on your cheek.
- e. [7] \_\_\_ \_\_\_ \_\_\_ is a technique for maintaining blood circulation to the heart.
- f. While you are waiting for expert help to arrive, you must still [8] \_\_\_ for the patient.
- g. When treating burns, first remove the [9] \_\_\_ from the affected area. Remove any burning material and cool the burnt area by pouring cold [10] \_\_\_ over it.
- h. Bleeding can usually be stopped by applying [11] \_\_\_ \_\_\_ to the wound.
- i. [12] \_\_\_ cuts need special attention because they are most likely to become [13] \_\_\_ .
- j. The first type of overheating is often heat [14] \_\_\_ . The patient suffers painful muscle cramps, nausea, tiredness and weakness, but their [15] \_\_\_ will still be moist and cool.
- k. In tropical Australia, some fish carry the Ciguatera [16] \_\_\_ . Even some fish that are normally regarded as good eating can carry ciguatera toxin because of their [17] \_\_\_ .
- l. The first aid for [18] \_\_\_ caused by the bristles of a Bristle Worm is to remove them by applying adhesive tape over the affected area.

# Chapter 3 Dangerous creatures



## Web references

<http://public.lifesaving.com.au>, [www.aims.gov.au](http://www.aims.gov.au)

## Psychology behind our fear

The saying, ‘what we don’t understand we fear and what we fear we fight’ can best describe the purpose of this chapter.

Over the years many marine creatures have gained a dangerous reputation. Until recently, Moray eels were thought to lurk in crevices in order to dart out and attack passing snorkellers.

However, by understanding the marine world better, we are slowly coming to accept that many of these so-called monsters of the deep are, in most situations, quite harmless. If we learn to treat all marine life with respect and learn the behaviours of potentially dangerous marine creatures, we will be able to enjoy our marine world.

Although people have few problems with marine life overall, Australian waters contain a large share of marine animals with the potential to cause us discomfort, serious injury and, in some cases, death and there are a few of these **predators** in New Zealand.

There are two main types of potentially dangerous marine creatures: **active ones** which will attack us to defend their territory or simply consider us as part of their diet; and **passive ones** that would much prefer to ignore us and only cause harm when deliberately or accidentally provoked, disturbed, stepped on or brushed against.

We will look at some of the animals in each category to learn about their lives and how to reduce the risk of being hurt.

## Active sea creatures

Fortunately, few marine animals take the first aggressive step when attacking people. Generally, only Saltwater crocodiles and a few shark species attack people without being provoked. They have been responsible for about 50 fatal attacks in Australia in the last 25 years. Statistics show that you have a much greater chance of dying in a car accident than dying from a shark attack.



Figure 41.1 A shark continually loses its teeth.



Figure 41.2 Shark in non-aggressive mood

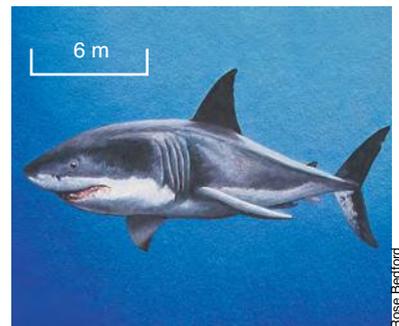


Figure 41.3 Great white – a potentially dangerous marine creature

\* All measurements in this book are approximate.

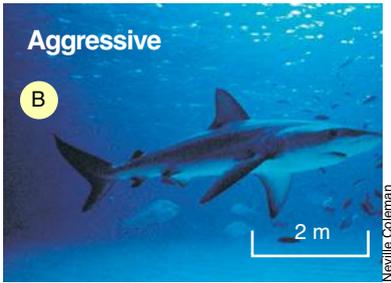
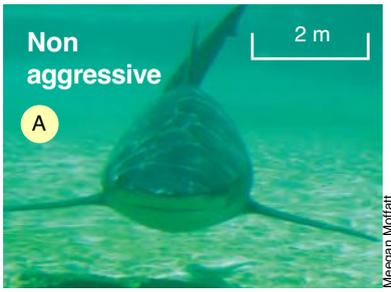


Figure 42.1 When a shark drops its pectoral fins, it's time to become concerned.

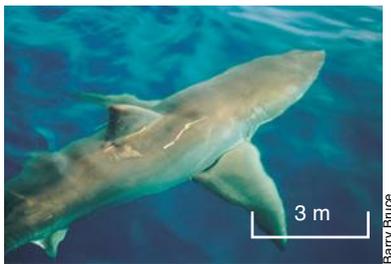


Figure 42.2 Great White shark

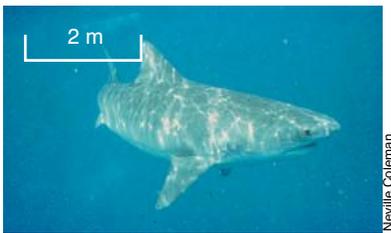


Figure 42.3 Tiger shark

*Educators have recently begun to persuade people that sharks have important roles at the top of many food chains in marine ecosystems.*

*Visit the mesa web site and look at the resources in the 2005 save our sharks seaweek archive*

[www.mesa.edu.au](http://www.mesa.edu.au)



## Sharks

There are about 350 different species of sharks, ranging in size from less than a metre to the giant Whale sharks with average length of over 12 metres – longer than two school buses. The Whale shark, despite its large size, is non-aggressive and feeds only on plankton.

The Great White and, to a lesser extent, Tiger and Bull sharks are responsible for many attacks on humans resulting in death or serious injury. However, take care whenever any species of shark is close by.

### Aggressive moods

It is not easy to determine the mood of any animal, however with sharks there are some warning signs. Figure 42.1A shows a shark in a non-aggressive mood. The pectoral (side) fins are raised and the shark is cruising along. Figure 42.1B shows a shark with the pectoral fins down and in an **aggressive** mood.

Sharks have a keen sense of smell for blood, feed at dawn and dusk and can chase schools of fish. So one way to avoid a shark attack would be not to surf at dusk or when fishermen are cleaning their fish from boats anchored nearby.

### Great White sharks

These large, efficient predators are responsible for most fatal attacks on humans throughout the world. Also called White pointers due to their cone-shaped heads and pointed snouts, as shown in Figure 42.2, these creatures fully deserve our utmost respect.

Most adult Great White sharks are about 5 metres long, the same length as the average family car. There have been recorded sightings of these sharks up to 10 metres long.

They have a large girth up to 1.3 metres and are capable of very fast speeds. A diver in waters off South Australia who saw his buddy taken by a great white said that the attack resembled being hit by a train in both speed and intensity.

Great Whites live worldwide from the warm waters of the tropics to the almost-frozen ocean near the poles.

Great Whites, like most sharks, have excellent eyesight and can see much better in water than humans can. They spend considerable time circling and studying prey before attacking. The Great White is the only shark that can hold its head vertically out of the water. This enables them to observe prey on the surface or on shore, such as seals on rocks.

These creatures are not mindless eating machines. Their mouths and teeth are perfectly adapted for their role as predator.

## Saltwater crocodiles

Saltwater crocodiles, which can grow to 8 metres, live in the tropical waters of northern Australia and Papua New Guinea. They can live for 100 years. They are highly dangerous and will attack without provocation. In fact, they have a greater strike rate for killing humans than do sharks. Saltwater crocodiles have features which earn them our utmost respect and their reputation as a top predator.

They are very fast for their large size, especially in the water, and surprisingly fast for short bursts on land, travelling at speeds up to 40 kilometres per hour. Most attacks have occurred at or near the water's edge.

Crocodiles are highly intelligent, often observing the habits of their prey from a safe distance for days before attacking. For example a camper, near Gove, NT, was collecting fresh water from his usual spot on a river bank when he was attacked by a crocodile that had been waiting for him. Fortunately, the crocodile accidentally grabbed his bucket and the man escaped. Experienced campers in these regions collect water by attaching a rope to the bucket and suspending it from a steep bank, a safe distance from the water's edge.

Saltwater crocodiles can open their top and bottom jaws equally (humans can only move their bottom jaws). Each jaw contains 40 to 60 teeth specially adapted for grasping (Figure 43.1).

*Diving deeper*



1. If a Stonefish only uses its venom for defence, how does it catch prey?
2. Design and make a dangerous marine creature. Make a display chart to accompany the creature indicating its dangerous features. Run a class competition to select the most and least dangerous creature.
3. Research how different cultures view dangerous marine creatures. Find out about totems. Research the role sharks and crocodiles play in different cultural beliefs.



Figure 43.1 Saltwater crocodile

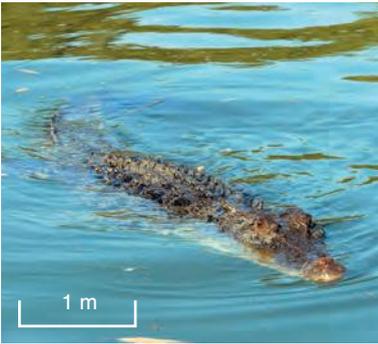


Figure 44.1 Saltwater crocodile  
Kimberley region WA

Ian Morris

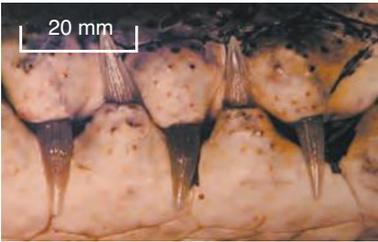


Figure 44.2 Saltwater crocodile teeth

Wet Paper



Figure 44.3 Freshwater crocodile  
Kimberley region WA

Bob McIlrath

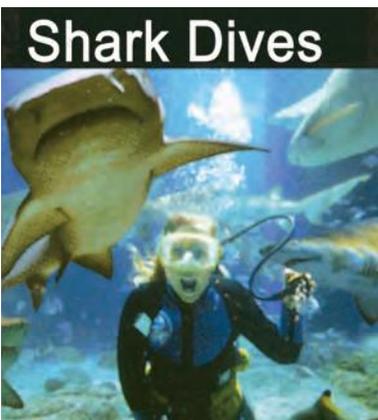


Figure 44.4 Dives for adventure tourists

Underwater world

Crocodiles usually drag their prey underwater with a powerful rolling action (the ‘death roll’), trying to drown their victims and eat them later. Uniquely, Saltwater crocodiles can swim well underwater with their jaws wide open. A flap of tissue closes their gullet to stop water going down their throats.

They are very **territorial** and will attack any animal, or even boat, that enters their stretch of water. They also make very bad pets because they can never be trusted. For example, reptile park operators who raise them from eggs are in greater danger because the longer they care for them the more the crocodiles regard them as a threat to their territory.

### The future for sharks and saltwater crocodiles

Sharks and Saltwater crocodiles have survived virtually unchanged at the top of their food chains for up to 200 million years. Recently though, their numbers have been reduced by human hunting. Crocodiles were shot throughout the 1960s until they became a protected species in 1972. Now their role as a major tourist attraction in northern Australia will increase their future chances of survival.

Sharks, on the other hand, are still netted and killed in great numbers to protect our swimming beaches. This netting also kills many harmless shark species, dolphins, turtles and rays. Although not protected at the moment, sharks may owe their future survival to tourism, for example, as attractions in caged dives for adventure tourists (Figure 44.4). Through education, people have come to recognise that these creatures have important roles at the top of many food chains in marine ecosystems.

### What do you do to avoid shark attacks?

- Avoid places that have a history of attacks.
- Swim or surf on patrolled beaches.
- Surf or snorkel with a group and all agree to keep a lookout for sharks.
- Avoid swimming or surfing near fishers or spear fishers.

Although the risk of shark attack is very remote, you may reduce the risk even further by following this advice. Try to remain calm and get out of the water if possible. If you see the shark before it attacks, be aggressive and attempt to beat it off. Many sharks, even large great whites, have been discouraged and driven off by beating fists in the water or on their snouts.

Once a victim is rescued, wrap them in a blanket, apply a pressure bandage to any wounds and get them to a medical practitioner or hospital as fast as possible (refer to section on shock and bleeding on pages 30 -32).

# Passive sea creatures

The passive ones are a large group containing particular species of Crown of Thorns starfish (Figure 45.3), crabs, stingrays, jellyfish, cone shells, stonefish, sea-snakes and the Blue-ringed octopus.

All these creatures have killed people but they will only attack if accidentally or deliberately disturbed.

They also include oysters (Figure 45.1) and barnacles (Figure 45.2) which are found on rocks, jetties and boat ramps. These can cause more accidents annually than most of the animals described in this chapter.

## Stingrays

See also page 38

Most species of these timid, bottom-dwelling animals contain two barbs in their tails which they use for self defence. People have been stung after accidentally treading on or swimming too close to rays as they lie hidden in the sand on the seabed.

Although their sting is very painful, most people recover after treatment. There was one recorded death in Australian waters when the victim was stung in the chest and the toxin paralysed their heart muscle.

The Electric ray does not have a tail but is capable of producing an electric shock of nearly 200 volts. This is enough to severely cramp the muscles of an adult human which is potentially hazardous to divers.

Rays will quickly flee if you splash heavily when wading into the water. Swim at least a metre off the bottom if snorkelling or diving. A common stingray is shown in Figure 45.4.



Figure 45.4 Common stingray

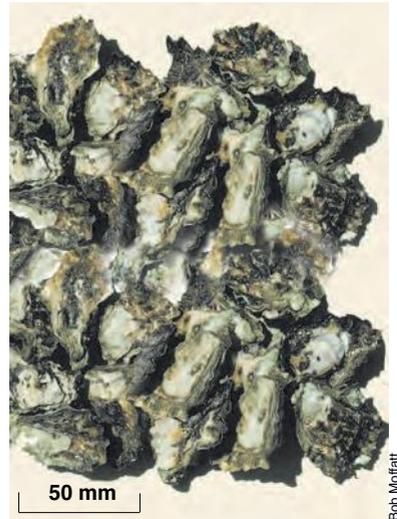


Figure 45.1 Oysters on a boat ramp

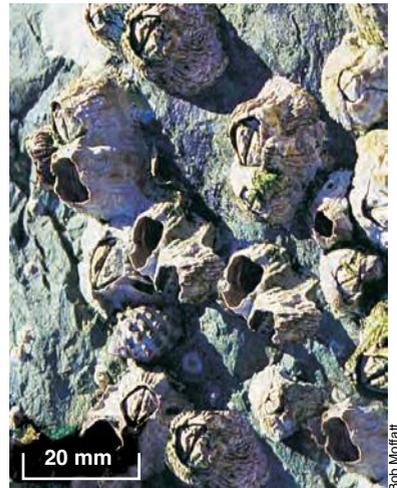


Figure 45.2 Barnacles on a rock

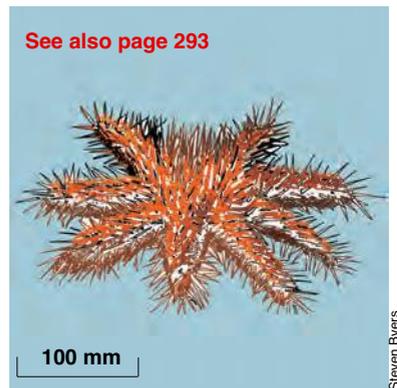


Figure 45.3 Crown of Thorns starfish



Figure 46.1 Cone shell



Figure 46.2 Crayfish



Figure 46.3 Turtle

## Cone shells

See also page 35

These cone-shaped shellfish, often attractively coloured (shown in Figure 46.1) can be dangerous to the unwary. Many species of cone shells are found on reefs in tropical and subtropical waters throughout the world. They are usually nocturnal and obtain prey or ward off attackers by releasing a **venomous** harpoon. The venom paralyses the muscles which creates breathing and circulatory problems for divers if stung.

The venom from some species is highly toxic to humans and the deadly Geographer cone has caused at least one fatality in Australia. Simply do not pick these creatures up, especially without wearing gloves.

## Lobsters and turtles

These are examples of animals which have spines and strong flippers which if handled incorrectly can cause nasty injuries.

## Crabs

Spanner and mudcrabs (Figure 46.4) have a pairs of claws which can easily crush a finger. Their bodies also have spines which can be jabbed into a victim as the crab thrashes around.

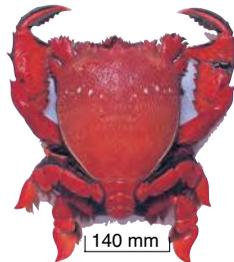


Figure 46.4 Spanner crab



Mudcrab



1. Why are sharks and Saltwater crocodiles called aggressors?
2. Make a list of passive dangerous marine creatures describing one danger from each.
3. What features of the Great White shark make it an efficient predator?
4. Why are oysters and barnacles a danger?
5. Describe how you can reduce the risk of shark attack.
6. Explain, in step form, what you would do if your nearby diving or surfing buddy was attacked by a shark.
7. What is the size and lifespan of a Saltwater crocodile?
8. How is a crocodile able to open its mouth underwater?

## Stonefish and bullrouths

See also page 34

Stonefish live in murky water so they can blend in with the surroundings, as shown in Figure 47.1. They contain a deadly venom in spines in their dorsal fins.

The spines become erect upon the slightest contact and immediately puncture the unfortunate victim, releasing the deadly venom.

Bullrouths have a large head with seven spines on the operculum. These fish should only be handled with extreme care. The dorsal, anal and pelvic spines all have venom glands. A puncture wound from one of these spines can be excruciatingly painful.

## Jellyfish

See also pages 295 - 296

Jellyfish (or sea jellies) belong to a group called the Cnidarians which catch their prey by using long tentacles containing large numbers of barbed stinging cells called **nematocysts** (Figure 47.4). On contact, the nematocysts either release a paralysing toxin into the victim or ensnare it with complex, sticky threads. Cold water or ice stops the nematocysts from firing in jellyfish.

Most species of jellyfish are only a nuisance to humans, producing only mild stings. Two notable exceptions are the box jellyfish and the irukandji (Figures 47.2 and 47.3).

## Box jellyfish and irukandji

See also page 37

Box jellyfish are pale blue and transparent with four distinct sides. The jellyfish has up to as many as 15 tentacles on each corner which can be 3 metres in length and feed on small fish and crustaceans. Irukandji (Figure 47.3) are smaller and have been described earlier on page 37.

They are more numerous after local rain, especially near river and creek outlets and are usually absent when seas are rough. Marine stingers are not usually found over coral, in deep water, nor around extensive seagrass or weed beds.

Box jellies seem to move towards the shore in calm waters when the tide is rising and gather near the mouths of rivers, estuaries and creeks following the rain.

The season for the Box jellyfish starts with the onset of the wet across the top of northern Australia, usually around October and lasts until April.

Further south along the northern Queensland or northern Western Australia coast the season is usually from November to March. You have virtually no chance of surviving the venomous sting, unless treated immediately.

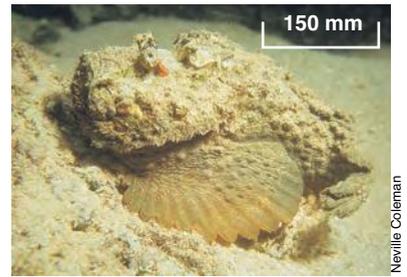


Figure 47.1 Stonefish

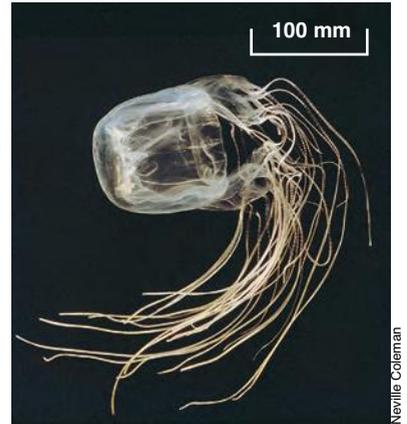


Figure 47.2 Box jellyfish

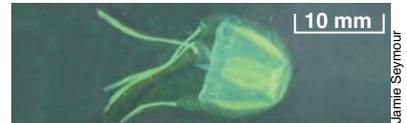


Figure 47.3 An irukandji

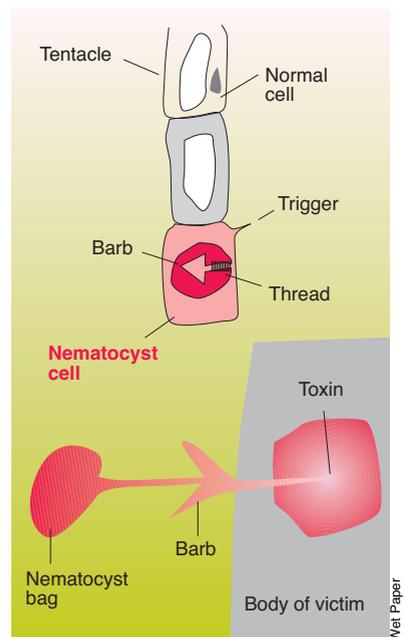


Figure 47.4 A nematocyst



Figure 48.1 Bluebottle or sea jelly



Figure 48.2 The banded coral sea-snake

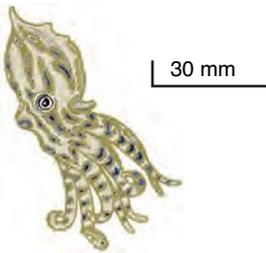


Figure 48.3 Blue-ringed octopus  
Rose Bedford

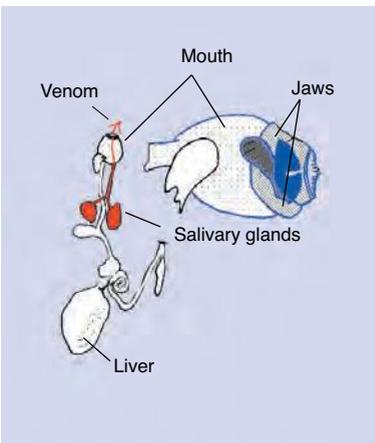


Figure 48.4 Venom apparatus  
(After Halstead)

## Bluebottle

See also page 37

The sea jelly (Figure 48.1) is Australia's most common species. It has a blue float usually 20-80 millimetres long (but can be up to 150 millimetres long) which is wrinkled on the top. The bluebottle has a single main retractile tentacle hanging from the float that can be contracted to a few centimetres or extended to several metres long. Many shorter smaller tentacles may also hang from the float. The bluebottle is found in vast numbers on the eastern Australian coast every year. They also occur in South and Western Australia. The sting causes immediate pain which can last more than an hour.

## Sea-snakes

Sea-snakes are found in coral reefs in warm tropical and subtropical waters. There are about 30 species, all highly venomous, that use their venom to kill prey and for defence. Figure 48.2 shows a Banded coral sea-snake.

Although their venom is toxic enough to kill humans, they are not generally aggressive. Many of the smaller sea-snake species have very small mouths and short fangs and do not release venom with every bite. However, the larger species (over 2.5 metres long) have long fangs and mouths large enough to go round a human bicep. Most sea-snakes will not try to bite unless deliberately squeezed.

Sea-snakes are very curious and have worried snorkellers and divers by winding themselves around air hoses and flippers. In the mating season, they often mistake their mirror image in a diver's mask for a potential mate and attempt to court the nearest air and pressure hose or snorkel. To avoid contact with sea-snakes, gently repel them with flippers or a gloved hand.

## Blue-ringed octopuses

See also page 35

The Blue-ringed octopus is the size of a golf ball but its poison is powerful enough to kill an adult human in minutes. There is no known antidote. The only treatment is hours of heart massage and artificial respiration until the poison has worked its way out of your system.

Poison is not injected but is contained in saliva, which comes from two salivary glands (Figure 48.4). Poison from one is used on its main prey, crabs, and is relatively harmless to humans. Poison from the other gland serves as defence against predators. The Blue-ringed octopus either secretes the poison near its prey, waits until it stops moving and then devours it, or it jumps out, envelops the prey in its tentacles and bites it.

The Blue-ringed octopus hatches from eggs and is about the size of a pea at the start of its life. The baby octopi will quickly grow and mature until they reach the average adult size. The life expectancy of a Blue-ringed octopus is about 2 years.

The octopus lives in crevices or holes, and burrows as a way of gaining protection. It advertises its toxicity by changing to iridescent colours when aggravated and can commonly be found in shallow tide pools after storms, searching for crabs and bivalves.

## Key words

Active, nematocysts, passive, predators, retaliators, scavenger, territorial, venomous.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Over the years many marine [1] \_\_\_\_\_ have gained a dangerous [2] \_\_\_\_\_. Until recently, Moray eels were thought to [3] \_\_\_\_\_ in crevices in order to dart out and attack passing snorkellers.
- b. The Great White is the only [4] \_\_\_\_\_ that can hold its head [5] \_\_\_\_\_ out of the water. This [6] \_\_\_\_\_ them to [7] \_\_\_\_\_ prey on the surface or on shore, such as [8] \_\_\_\_\_ on rocks.
- c. [9] \_\_\_\_\_ are highly intelligent, often observing the habits of their [10] \_\_\_\_\_ from a safe distance for days before attacking.
- d. The [11] \_\_\_\_\_ ray does not have a tail but is capable of producing an electric shock of nearly 200 [12] \_\_\_\_\_.
- e. Many species of cone shells are found on reefs in tropical and subtropical waters throughout the world. They are usually nocturnal and obtain prey or ward off attackers by releasing a [13] \_\_\_\_\_ harpoon.
- f. Jellyfish (or sea jellies) belong to a group called the [14] \_\_\_\_\_ which catch their prey by using long tentacles containing large numbers of barbed stinging cells called [15] \_\_\_\_\_.
- g. Sea-snakes are very [16] \_\_\_\_\_ and have worried snorkellers and divers by winding themselves around air hoses and [17] \_\_\_\_\_.
- h. The [18] \_\_\_\_\_ for the Box jellyfish starts with the onset of the [19] \_\_\_\_\_ across the top of northern Australia, usually around October and lasts until April.



9. Describe the features that make a crocodile such an efficient predator.
10. How can you tell the difference between a shark in an aggressive mood compared to a non-aggressive mood?
12. Describe ways to avoid crocodile attack.
13. What are the disadvantages of laying shark nets off popular beaches?
14. Why don't we destroy all Great White sharks and Saltwater crocodiles to avoid fatal attacks on humans?
15. Describe how a stingray defends itself.
16. How can you avoid being stung by a Box jellyfish?
17. Why is it often necessary to perform CPR on a victim of a jellyfish or Blue-ringed octopus sting?
18. Give two reasons why the Stonefish is potentially dangerous to humans.
19. Explain why sea-snakes are not regarded as a serious threat to humans.
20. Describe how a Cone shell catches its prey or defends itself from attack.
21. Why don't victims of the Blue-ringed octopus realise they have been bitten?
22. Give two reasons why it is difficult to avoid being stung by Bluebottle jellyfish.
23. How can you tell if a blue-ringed octopus is upset?



# Chapter 4 Maintaining equipment



Bob Moffatt



Bob Moffatt



Wet Paper

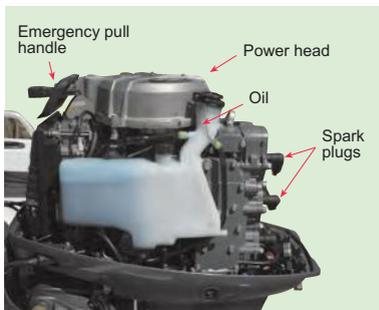
## Web reference

[www.safeboating.org.au](http://www.safeboating.org.au)



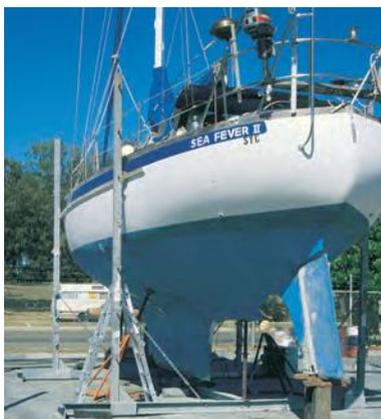
Jan Taylor

Figure 50.1 Sailing fittings



Lisa Taylor

Figure 50.2 Outboard motor



Wet Paper

Figure 50.3 Sailing vessel under repair

Water, wind and heat are a combination of forces that cause materials to break down and decay. Add salt and the process speeds up. Corrosion, rust, waves and winds are just some of the destructive forces that act on the fittings of the sailing boat in Figures 50.1 and 50.3.

Equipment that is used in the marine environment also needs to be **serviced** and checked to see if it works safely and efficiently. For example the outboard motor in Figure 50.2 needs to be checked for corrosion; the spark plugs need to be cleaned; and the oil levels maintained according to the manufacturers specifications.

A study of how marine equipment is maintained is important. By describing the elements of the marine environment that affect the equipment we use, and the steps that can be taken to minimise these effects, the life of what is often a costly investment can be prolonged.

## Environmental protection laws

**Anti-fouling** chemicals, paints and sprays that, if not properly contained, will harm local marine life. Marine environmental protection laws are enforced by local management authorities to prevent local water pollution caused by chemicals and equipment used in marine maintenance. For example it is illegal to wash **bilge water** from a boat containing oil and fuel into stormwater drains.

## Destructive forces

Marine equipment is usually well made, often precision built, constructed of the latest materials and very expensive compared to equipment used on land. Special techniques are required to maintain this equipment to ensure we get the best use and the longest possible life from it.

People living on the coast are aware of the destructive effects the marine environment has on modern materials, yet few understand how the breakdown occurs, and how to prevent that damage.

Water, air, salt, living things and sunlight are five forces that cause marine equipment to break down. So how do each of these affect the materials we use in salt water?

## Water and air

Water is often described as the ‘universal **solvent**’. If marine equipment is made from materials containing water-soluble compounds, that equipment will fall apart as the water removes these chemicals.

For example, wood is partly made of water. If it gets wet, it will swell or change its shape or size. Water can also cause many other materials to change size, swell or shrink and so warp and crack. The chipboard in Figure 51.1 has swollen with the addition of water.

Air contains oxygen, which reacts with many materials used to make marine equipment, particularly metals (Figure 51.2). Metals react with oxygen to produce a coat of metal oxide, a completely different compound that lacks the strength of the original metal and, when removed, reveals pits, or holes. An example of this would be the metal hull of a shipwreck. **Oxidation** of metals costs mariners millions of dollars each year and is responsible for a multi-million dollar industry based around the protection of metals from **corrosion**.

Other materials, such as plastics, also oxidise and so lose colour, strength or flexibility.

## Salt

Sodium chloride, the main salt in sea water, has disastrous effects on most materials, particularly metals. As discussed above, when metals react with oxygen, an oxide coat forms on the metal. While this oxide coat covers the metal, no more oxygen can react and the oxidation stops. The oxide coats of some metals (for example, aluminium) are stable and stay on the metal. Others, such as iron, tend to blister and peel off, exposing the metals to further oxidation.

Salt lifts all oxide coats and so accelerates the oxidation process by allowing further attack by oxygen (Figure 51.3). Steel will rust faster in salt water, aluminium boats will pit badly. Salt crystallises to an abrasive solid as it dries out. Valve seats, O-ring seals and even fabrics can be damaged by salt crystals.

## Living things

Your marine equipment can be damaged by animals and plants in and out of the water. Plankton is microscopic life found in the same part of the ocean that we use so it will be present in your equipment after use.

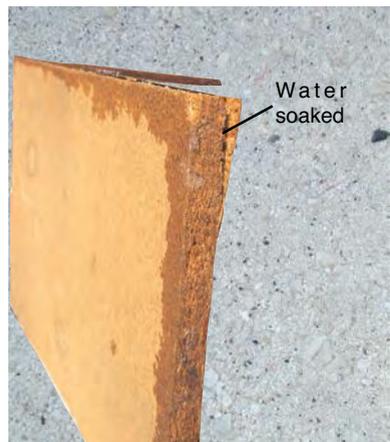


Figure 51.1 Chipboard is affected by water.



Figure 51.2 A metal ladder that has been affected by air and salt water



Figure 51.3 A corroded motor and propeller



1. Explain why it is important to study how to maintain marine equipment.
2. List the effects of water on materials used in the sea.
3. What effect does oxygen have on materials used in the sea?
4. What effect does salt have on materials used in the sea?
5. Explain why metals corrode faster in sea water.
6. Identify the types of living things likely to attach themselves to boats while at sea.
7. Discuss the reasons why equipment should be stored away from sunlight.
8. State a procedure for storing wet suits after use.
9. Explain why it isn't a good idea to put your swimmers or lycra shirt in the clothes dryer or iron them.
10. Discuss the effects of petrol and oil on wet suits and silicone rubber.
11. Why is it necessary to check inside your snorkel immediately before using it?
12. Why hang up your wetsuit rather than putting it away folded?



It will be in your mask, snorkel, wetsuit, outboard motor, plankton net, seabed sampler, jet ski, or whatever else you are using in sea water.

During storage, a variety of animals, as well as **bacteria** and **fungi**, will find your equipment an attractive home or a source of food if you do not stop them.

Wasps, hairy grubs and cockroaches, among other insects, have been known to inhabit masks, snorkels, regulators and fins with sometimes dangerous consequences. Hornet nests will clog water intakes on outboard motors, rats and mice like to nibble on fabric, while a host of moulds will slowly digest equipment as they grow on it.



## Sunlight

Many materials now used in the marine environment are **synthetic**. Previously, most materials were natural. Boats, water skis and surfboards were made from wood; sails from cotton or linen tarpaulins; and heavy sails were made of canvas. Unfortunately these fibres rotted quickly and required constant care and protection. While many synthetic materials resist rotting, they are damaged by sunlight because it contains high levels of ultraviolet radiation. This **radiation** can cause reactions inside plastics and will cause them to break down over time. Many of these fabrics contain chemicals called ultraviolet inhibitors that act like a sunscreen to protect the item from the damaging radiation and so prolong their life.

## Caring for equipment

For all marine activities, we need equipment made from materials that have long, usable lives. Firstly, select materials that resist the effects of the marine environment. Secondly, use very good preventative maintenance measures that will minimise these effects. Good equipment that has been well looked after will last three to five times longer than good equipment that has not been cared for properly.

## Personal gear

Personal gear such as swimsuits, wetsuits, sun- and stinger suits are all made from synthetic fibres, mostly nylon or **lycra** or a combination of both. The fibres are made from **petrochemicals** and, as such, may be attacked by sun tan oils, creams, dry cleaning fluids and other solvents, for example, nail polish remover.

If you buy good quality, locally made equipment, you should find that it has been designed and made for local conditions.

However, after using it in water, it must be protected if you want it to last. Throwing a wet swimsuit under your bed along with your towel is an example of how not to look after your gear.

Below is a short discussion of ways to look after your gear. As you progress through your marine studies course, you will undoubtedly learn more.

## Snorkelling gear

Water, air and salt do not greatly affect modern masks, fins and wetsuits. But sunlight and living things do. Most synthetic fibres and rubber are broken down by sunlight and are affected by strong heat. Living things can find a comfortable home inside snorkels and masks and particularly like the bubbles of neoprene wetsuits.

### Maintaining personal gear

- Use fresh water to wash or flush your gear to remove all salt and microscopic sea life.
- Allow items to dry in the shade because living things are limited in their breakdown activity if no water is present. Store them in a dry place, out of the light. Your bedroom cupboard, protected by a pest strip or mothballs is ideal.
- Never iron lycra fabrics —they melt and burn. Avoid putting them in a tumble drier and never use bleach to remove stains. The tags on most swimsuits indicate the care they require (Figure 53.1).
- Protect your stored gear, maybe with a cover, or talcum powder to discourage insects, or use mothballs in your cupboard to stop silverfish eating your favourite brand name shirt.
- Avoid pulling the loose threads out of garment seams. Use a pair of scissors to cut off about 10 centimetre from the last intact stitch, then use a needle to sew the thread end back in. This will prevent the stitching from coming undone further and your suit is less likely to fall apart.

### Maintaining snorkelling gear

- When you are finished with your snorkelling gear, wash it in clean, fresh water, dry it and store it away from light (Figure 53.2). Talcum powder on your gear reduces corrosion and stops insects like cockroaches attacking the rubber. Check all snorkelling gear, particularly snorkels, before use. Little things crawl into them!
- Wash out neoprene wetsuits as soon as you have finished with them and hang them up to dry. They should be hung on a coat hanger, or over a line or chair, while drying to keep their shape (Figure 53.4).



Figure 53.1 Tags off common swimwear indicate the care required for them.



Figure 53.2 Store snorkelling gear in a cool, dry place.



Figure 53.3 Lightweight wet suits



Figure 53.4 Dry your gear in the shade.



Grant Smith

Figure 54.1 Make sure you wash your gear when you get home.



Wet Paper

Figure 54.2 Storing lures



Wet Paper

Figure 54.3 Storing fishing rods



Wet Paper

Figure 54.4 Use oil to lubricate parts.



Wet Paper

Figure 54.5 Cleaning out behind the reel

If left unwashed after being in the sea when the plankton count is high, the plankton that have entered the neoprene as you swim will die and your suit will smell badly.

Many wetsuit manufacturers sell a disinfectant to kill the bacteria that produce the smells. If you are going to use a commercial disinfectant, first check that it will not damage your suit.

## Fishing gear

Most modern fishing gear is reasonably good quality, particularly that made by reputable companies and sold by responsible tackle shops. You can make your gear last much longer by looking after it and storing it in an organised manner (Figure 54.2).

### Maintaining fishing gear

- Wash down rods with warm soapy water and rinse them off. Use an old toothbrush to remove the slime and scales, then allow the gear to dry before putting it away. Store rods in a safe place that is not too hot or too cold.

Ensure that they are stored straight. The best way to store fishing rods is horizontally, as long as they are supported so they do not sag (Figure 54.3). Do not leave reels on the rods or lean them against a wall with a bend in them. The bend might just become permanent.

Applying a protectant such as Armorall™ will help protect fishing rods from the sun and make it easier to clean off the slime and dirt that accumulates on them while fishing. Check the runners on your rods for cracks from time to time.

- Protect a **reel** during use as much as possible, for example, cover it with a plastic shower cap. As soon as possible after each use, remove reels from rods and wash them down with warm, fresh water. Do not blast the water at the reel at high pressure. Tighten reel drags to prevent water intrusion.
- Add a drop of oil to bearing surfaces (Figure 54.4). For spinning (threadline) reels, place a drop of oil on each side of the bail and on the handle knob and handle bearings (both sides for ambidextrous reels). Remove the spool and place a drop of oil on the oscillating shaft.
- Every few months, depending on use, remove the side plate from the reel and put a little grease on the gears and other moving parts (Figure 54.5).
- Wash off hooks, swivels and lures and allow them to dry before you put them back into a tackle box. Wet tackle will cause corrosion in the rest of your gear. A little cooking oil or tuna oil on hooks, lures and other terminal tackle will help stop corrosion.

## Aluminium boats

Most small dinghies are made of aluminium. However when the **dinghy** is placed in salt water, two factors combine to break down the aluminium.

- Firstly, the salt in the sea water removes parts of the aluminium coating in different places, resulting in pitting or small craters in the metal.
- Secondly, aluminium is subject to galvanic, or electrolytic, corrosion. When any two different metals are placed together with a salt bridge between them, electrons will flow from one to the other. In this case, they flow from the aluminium to any other metal: a steel rowlock, a **stainless** steel hook, a brass swivel, a mild steel anchor or a lead sinker. In your science classes you will learn that when the aluminium gives up its electrons, it is no longer aluminium. The end result is that if a sinker remains at the bottom of an aluminium dinghy, it can cause a hole in the hull.

### Maintaining an aluminium dinghy

- Pick up all hooks, swivels and sinkers that you may have dropped in the boat.
- Cut a plastic 20 centimetre container in half lengthways to make a tray for your anchor and chain that prevents them coming in contact with the aluminium of the boat.
- If you store oars in your boat, make sure the rowlocks do not touch the sides.
- During wash-down, check carefully for sinkers and hooks, particularly under the seats.
- Tighten **rivets** by holding a block of steel on the underside of the rivet and tapping firmly on the head with the rounded end of a hammer.
- Remove large dings by holding a substantial block of wood on the indented side of the dent and tapping it out with a rubber mallet, starting on the outside of the dent and gradually working around the edge and inwards.
- Fix holes with a **pop-rivet**. Select a pop-rivet that is bigger than the hole, drill the hole to the size of the rivet from the outside in, then, using a pop-rivet gun, place the rivet in the hole so that the head is on the outside of the boat. Take large holes and cracks to a professional welder. Temporary repairs can be made with a patch as shown in Figure 55.1 where a piece of aluminium has been fixed over the cracked part of the hull with a series of pop-rivets.

Repairs such as these are used in emergency situations and pop-rivets used in this way will only last for a short time.

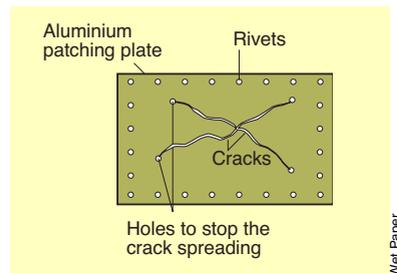


Figure 55.1 Patching a series of cracks in an aluminium boat with a metal patch

## Diving deeper



1. Why did the sailors on wooden ships have to scrub the decks?

How did they stop the water entering between the planks?

2. The majority of metal ships are made of steel.

Use your library and the internet to research the methods used to protect steel ships from corrosion.

3. Try to find out what the *galvanic series* is, and how it is applied to construction and maintenance of metal boats.

4. Use your resources to find out as much as you can about the worm that has plagued wooden boats for centuries. What type of animal is it and can it be controlled?

5. What is *osmosis*? How can it affect fibreglass craft in water?

6. Find out how often spark plugs need to be replaced on a small outboard motor.

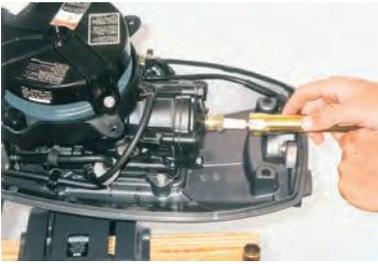


Figure 56.1 Changing a spark plug

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## Outboard motors

The majority of **outboard motors** are water cooled, made of alloy and use a petrol/oil mixture. Maintain outboard motors correctly, not only for enjoyment but for safety reasons as well.

### Maintaining an outboard motor

- Buy fuel tanks made of plastic to prevent corrosion and leakage.
- Tightly seal all fuel-line connections so that they do not leak or suck air. Maintain motor linkages and lubrication points according to the manufacturer's specifications. Use marine-grade **greases**.
- Check and clean **spark plugs** regularly (Figure 56.1).
- In water-cooled outboard motors, water is pumped up inside the engine to cool it down. Make sure this is happening by checking the telltale is working before driving off.
- Flush the motor with fresh water after use to prevent corrosion of the inner cooling system. This is essential to remove weed, microscopic animals and plants, sand and salt. Check around the prop for plastic bags and fishing lines.



Figure 56.2 Materials used to fix dings

Wet Paper

## Surfboards and body boards

Surfboards and body boards are valuable and need to be looked after. The sun, its heat and ultraviolet radiation can severely age and damage surfboards. Sunlight causes resin to become yellow and brittle, the foam to shrink and the shape of the board to deform. It may even cause the fibreglass to **delaminate** from the foam, causing large bubbles.

### Maintaining surfboards and body boards

- Store your board out of sunlight where possible and do not leave it in vehicles. A padded, reflective board cover is a valuable investment.
- Fix dings. A body board can be fixed with Araldite™ or Superglue™. Surfboards require a resin and fibreglass mix which can be bought from surf shops (Figure 56.2).



Figure 56.3 Fibreglass matting

Wet Paper



Figure 56.4 Replacing a surfboard fin

Wet Paper

## Save our seas

When repairing equipment, work out how you are going to clean up before you start. Paints, resins and cleaning solvents are toxic pollutants and must not end up in the storm water system. A mat, paper or grass clippings can be used to absorb materials when working. When finished, wrap or shovel up any mess and put it out with the rubbish. You can also make a bund (embankment) or sand wall at the end of your garden to absorb paint from wash-ups.

## Key words

Aluminium boats, anti-fouling, bacteria, caring, corrosion, delaminate, destructive force, dinghy, grease, lycra, outboard motor, oxidation, petrochemical, pop-rivet, radiation, reel, rivet, solvent, spark plug, stainless, sunlight, synthetic.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- Water, wind and [1] \_\_\_\_\_ are a combination of forces that cause materials to [2] \_\_\_\_\_ and decay.
- [3] \_\_\_\_\_ chemicals, paints and sprays that, if not properly contained, will [4] \_\_\_\_\_ local marine life.
- Marine equipment is usually well made, often precision built, constructed of the latest materials and very [5] \_\_\_\_\_ compared to equipment used on land.
- Air contains [6] \_\_\_\_\_, which reacts with many materials used to make marine equipment, particularly metals. Metals react with oxygen to produce a coat of their [7] \_\_\_\_\_, a completely different compound that lacks the strength of the original metal and, when removed, reveals [8] \_\_\_\_\_, or holes.
- [9] \_\_\_\_\_ of metals costs mariners millions of dollars each year and is responsible for a multi-million dollar industry based around the protection of metals from [10] \_\_\_\_\_.
- During storage, a variety of animals, as well as [11] \_\_\_\_\_ and [12] \_\_\_\_\_, will find your equipment an attractive home or a source of food if you do not stop them.
- When you are finished with your [13] \_\_\_\_\_ gear, wash it in clean, fresh water, dry it and [14] \_\_\_\_\_ it away from light.
- Wash down [15] \_\_\_\_\_ with warm [16] \_\_\_\_\_ water and rinse them off. Use an old [17] \_\_\_\_\_ to remove the slime and [18] \_\_\_\_\_, then allow the gear to dry before putting it away.
- When any two different metals are placed together with a [19] \_\_\_\_\_ between them, [20] \_\_\_\_\_ will flow from one to the other.
- In your [21] \_\_\_\_\_ classes you will learn that when the aluminium gives up its [22] \_\_\_\_\_, it is no longer aluminium. The end result is that if a sinker remains at the bottom of an aluminium dinghy, it can cause a [23] \_\_\_\_\_ in the hull.



- How does salt affect aluminium and how can it be protected?
- Why should sinkers not be left in aluminium boats?
- Why paint boats?
- What repair instructions would you give to your mate who has just put the following in his aluminium dinghy:
  - a large dent
  - a 2 mm hole
  - a 10 cm diameter hole
  - a 2 cm tear
- Why is it necessary to flush an outboard motor with fresh water after use?
- How can you stop the water pump impeller from binding during long storage periods?
- Why is it a bad idea to leave surfboards in a vehicle?
- What are the effects of heat and light on surfboards?
- Why is it a bad idea to plug a ding in a surfboard with wax to stop water getting in?
- How can you look after your storm water system when repairing your marine equipment?



Jim Sheffield



**Web references**  
[www.reefed.edu.au](http://www.reefed.edu.au); [www.mesa.edu.au](http://www.mesa.edu.au)



Figure 58.1 Physical comparison

Few marine animals die of old age because most are victims of predation (that is, they are eaten by predators) and so never reach adult size. Vast numbers of animals and plants are eaten in their immature stages by plankton eaters.

This chapter looks at places animals live in the sea as well as some of the interesting relationships and adaptations developed by them to survive.

### Comparing the land and sea

If you stand on the beach and look out to sea it is impossible to look under the water. However if you stand on a hill and look out over a valley (Figure 58.1) you can feel the wind on your face and see streams and fields, fences and livestock and wilderness areas on the horizon.

If a disease breaks out on land, you can quarantine an area by stopping movement of people and animals. However the ocean knows no boundaries and marine pests spread from country to country as discussed in Chapter 28. You are able to fence land or brand livestock but it is difficult to fence the ocean.

The seabed also contains land features that have been submerged due to sea level rises. Old valleys are called submarine canyons and seamounts were once mountains.

The largest animals in the world are found in the sea. This is because sea water can support a greater weight therefore sea creatures have a completely different skeleton (Figure 58.2).

Terrestrial animals have hollow bones to keep their weight to a minimum whereas aquatic animals mostly have solid bones because the upthrust of the water reduces their weight. Food chains (page 65) and energy pyramids (page 67) are also larger in the sea.

The most obvious difference is the taste of sea water. A litre of sea water contains 35% salt compared to fresh water which contains almost no salt. Chapter 6 discusses many more chemical differences. Other simple comparisons are shown on the next page in Figure 59.1.

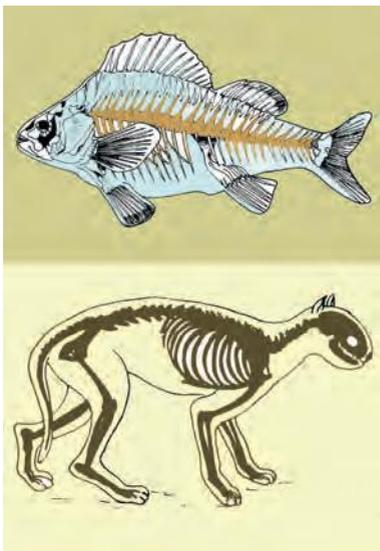


Figure 58.2 Biological comparison

# The biotic environment

The environment in the sea can be divided into two types — biotic and abiotic. The biotic environment consists of living parts. The abiotic environment consists of non-living parts and include such things as salinity, light, pressure, density, temperature, viscosity, dissolved gases and salinity. The abiotic environment is covered in the next chapter.

Scientists often discuss the biotic environment under the following headings:

*Life as an individual*

*Populations and communities*

*Marine ecosystems*

For example, the individual periwinkles in Figure 59.2 live in a population of periwinkles that is part of a rock pool community that makes up a rocky shore ecosystem as shown in Figure 59.3.

## Life as an individual

The sea has many places where animals and plant populations live – they are called **habitats**. Marine scientists name habitats after characteristic features such as rocks, plants or the nature of the beach. The periwinkle lives in a rock pool habitat.

The individuals that live in a habitat interact with one another in a variety of ways. For example the periwinkles graze on the algae on the rocks and compete for food and living space.

Habitats can change over time. As the tide comes in, the rock pool will fill with water. At low tide it will heat up and water may evaporate leaving the periwinkles high and dry.

Feature	Land	Sea
Bones	Light	Solid
Food chains	Short	Long
Food pyramids	Short	Tall
Water	Fresh	Salty
Wind	Yes	No
Currents	Yes	Yes
Fencing	Yes	No
Temp	Varies	Constant
Diversity	Medium	High
Biomass	Medium	High
Plant cells	Tough	Weak
Tree trunks	Yes	No

Figure 59.1 General comparisons of the sea and the land

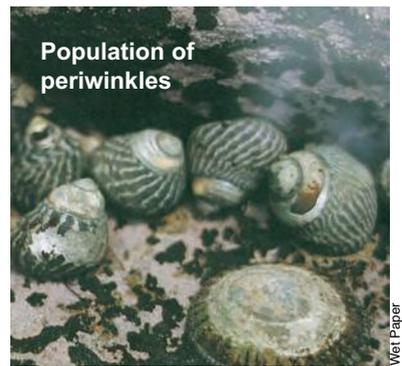


Figure 59.2 Periwinkles in a rock pool



Figure 59.3 The biotic environment of a periwinkle

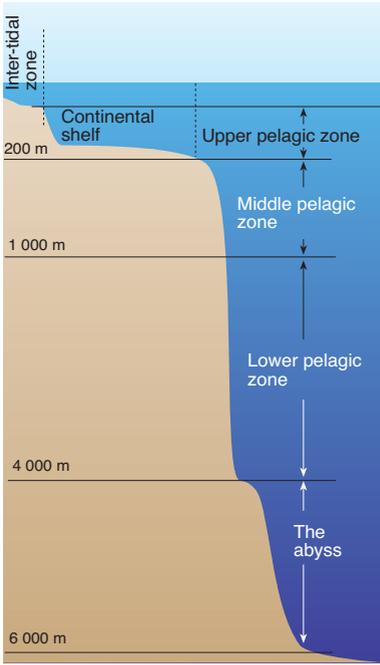


Figure 60.1 Zones of the sea

## Different habitats

The sea is full of different habitats which are divided into zones shown in Figure 60.1.

### Inter-tidal zone

The **inter-tidal zone** is closest to the shore and contains many habitats. Saltmarshes, seagrass beds, reefs, rocky pools, under rocks, mangrove swamps, muddy and sandy shores are just a few of the habitats that support a large amount of life. Living close to the land means that many coastal habitats have a direct influence on the sea. For example, sediment runoff can cover and kill the chiton shown in Figure 60.2.

### Continental shelf

The **continental shelf zone** contains offshore islands, shallow reefs and waters to a depth of about 200 metres. This zone contains the highest number and greatest diversity of marine life and because it is covered by water, it is subjected to great environmental pressures such as over-fishing or pollution.

### Pelagic zone

Beyond the continental shelf is the **pelagic zone** which extends over the ocean depths and on a vertical scale can be divided into three layers. The upper layer, into which light can penetrate, ranges from 0–200 metres. This zone contains the phytoplankton of the sea which make oxygen for our planet. The middle and lower layers extend from twilight to perpetual darkness. These layers range from 200–4000 metres. The amount of light in this zone is too low to support photosynthesis (see page 64). The bottom of the sea is called the **abyss** (4000–6000 metres) where strange animals such as the lantern fish and loosejaw live (Figure 60.3 and Figure 72.1).

### Living in habitats

Each habitat has its own special characteristics. Reef habitats have clear water, lots of light, a large number of organisms and lots of hiding places for them. In this habitat, animals and plants can grow to a variety of shapes and sizes. In contrast, a sand dune habitat is exposed and can look almost lifeless because it contains fewer animals and plants.

The environmental conditions in a habitat determine factors such as the number, type, size, shape and even colour of organisms. For example, rocky shore organisms tend to be small, have a shell and have appendages or holdfasts that enable them to hang onto the rocks as the waves wash to and fro. Wetland organisms often have burrowing appendages and are able to filter out food particles from the mud.



Figure 60.2 A chiton is an inter-tidal animal that lives on a rocky shore habitat.

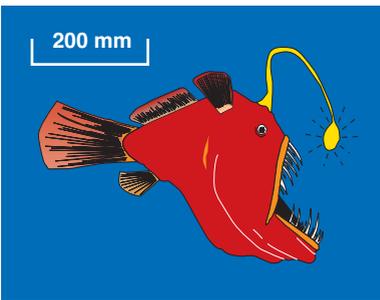


Figure 60.3 A Lantern fish

## Adaptations

Marine organisms continually battle for survival in the harsh world under the sea. These organisms have had to adapt to all the different conditions that can be found in the sea: it is a case of adapt or die.

An **adaptation** is a characteristic that helps an organism survive. This adaptation may be structural, functional or behavioural.

The most obvious of these adaptations have led to a bewildering and bizarre array of shapes. For example, the turtle in Figure 61.1 has a hard shell to protect it from predators. The large mud crab in Figure 61.3 could not live on a rocky shore because its body is too big to fit in the rock crevices so it would get smashed to pieces by the first big wave. So you do not find mud crabs on rocky shores. The mangrove tree in Figure 61.4 has prop roots to stop it falling over in the mud.

The barnacles shown in Figure 61.2 are the dominant life form on a rocky shore where waves crash onto the rocks. They are filter feeders and use their legs to catch microscopic plankton as the waves wash over them.

Adaptations help organisms avoid predators, obtain food, produce more healthy young and withstand different environmental conditions. These special characteristics have allowed different types of organisms to inhabit every possible living space in the seas.

All organisms have become adapted to the different habitats they have grown up in over a long period of time.

For example, the only animals that will survive on a rocky shore are those that can withstand the drying effect of the sun (called **desiccation**), and wind and waves.

*Adaptations can either give marine animals and plants a competitive edge or commit them to extinction.*

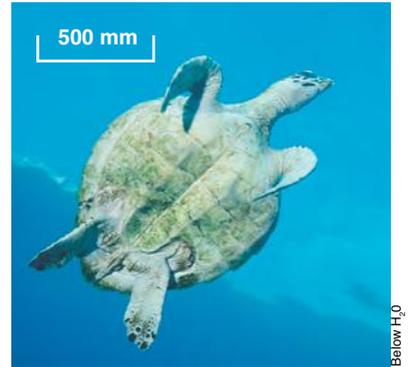


Figure 61.1 Armour in marine reptiles

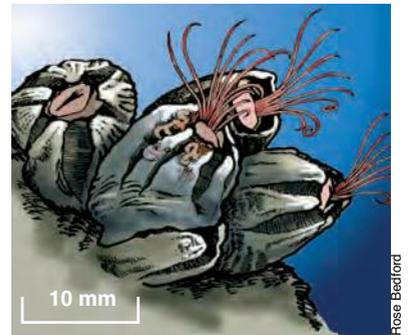


Figure 61.2 A barnacle is a filter feeder and is well adapted to life on a rocky shore.



Figure 61.3 A mud crab is well adapted to a mangrove habitat.

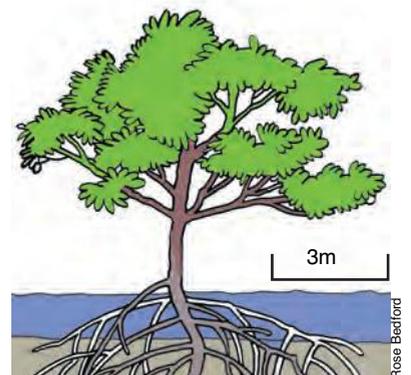


Figure 61.4 A mangrove has prop roots to stop it falling over in the mud.

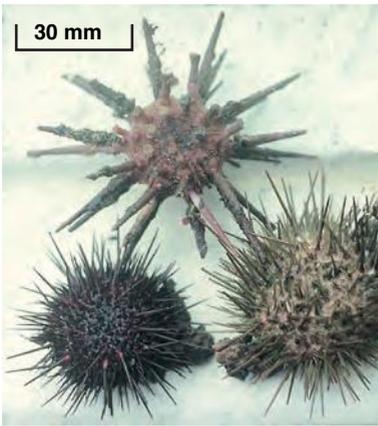


Figure 62.1 Sea urchin spines

Bob Moffatt

## Structural adaptations

**Structural adaptations** are body characteristics which help the organism survive. Many organisms have developed **spines**. These spines make the animal more difficult for predators to swallow or to pull from caves or holes. The spines of sea urchins serve this purpose (Figure 62.1).

Lobsters, crabs, scallops, clams, oysters and turtles are some animals that have **armour** to protect their soft bodies from predators. Most animals that develop heavy armour are slow moving. Fish have scales which act as thin armour.

Fish also have fewer interlocking structures on the vertebrae of their backbones; this lets them swim with the wave-like motion common to most fish (Figure 62.2).

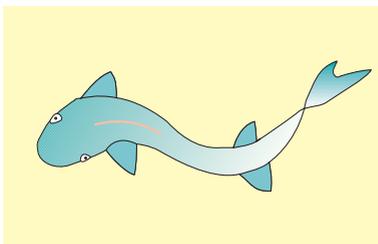


Figure 62.2 Flexible movement of a swimming fish

Wet Paper

## Buoyancy adaptations

Since **density** increases with depth, fish mostly live at a depth where their density equals that of the surrounding water. Some fish have air or **swim bladders** (Figure 62.3) which they use to change the amount of air in their bodies and so change their density. This allows them to live at different depths in the ocean.

Other animal organs which provide **buoyancy** are the large oily livers of some sharks, the light cuttlebones found in cuttlefish, oil globules in fish eggs and large spines and protrusions of animal larvae.

Buoyancy affects the structure of aquatic plants and animals. Because the water supports them, aquatic organisms need fewer supporting structures in their bodies.

An aquatic plant does not need the stem made of tough cells cemented together that a land plant needs to hold it upright. When you take an aquatic plant such as algae (slime) out of the water, it forms a claggy mess. In its natural habitat, supported by water, it is feathery.

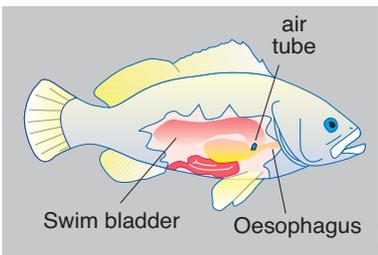


Figure 62.3 How a swim bladder works

Wet Paper

The **gill structures** of fish need little support in water but collapse if brought out into the air (Figure 62.4).

## Pressure adaptations

Creatures such as jellyfish are able to adjust the pressure in their tissues to match the pressure of the water outside their body. Fish that live in the depths of the sea have dense bony bodies without swim bladders. Whale bodies are also adapted to allow them to dive to great depths. Because their lungs collapse in deep water, a special network of blood vessels carry extra oxygen around their bodies. Whales also have fatty emulsions which carry extra oxygen.



Figure 62.4 Gills of a fish

Wet Paper

## Viscosity adaptations

Animals such as sharks that need to move rapidly through the water need to be streamlined. These fish have muscular bodies, a cylindrical shape and use fins to give them added thrust through the water. This adaptation can be shown in a streamlining tank where water is passed over different shapes (Figure 63.1).

## Camouflage

To escape detection by predators, a marine animal may camouflage itself to look like its background. The shrimp in Figure 63.2 has mastered the art of camouflage, matching perfectly the different colours of its background. Some fish have markings which hide the position of their eyes and some have an eye marking on their tail, a body part which has few vital organs. This distinctive marking attracts the predator's attention so when it attacks, the fish has a good chance of survival as it 'ducks for cover'. Some animals mimic objects or other living things. Some seahorses look like a type of weed.

## Functional adaptations

Functional adaptations in marine animals involve changes in the body over time.

These can be instant, short-term changes such as a gland that produces poison when the animal is threatened by predators or detects blood in the water. Others involve long-term changes such as the ability to change sex, secrete salt with urine or change the organism's reproductive cycle (for example, the alternation of generations in plants discussed on page 229).

Examples of functional adaptations are the life cycle of Barramundi, which are born male and change sex at the age of 2–3 years. Some animals such as Stonefish, Box jellyfish, Blue-ringed octopuses, cone shells, sea anemones and sea-snakes are capable of injecting poisonous **venom** into animals which attack them. The venom in the spines of the Butterfly cod is especially dangerous (see Chapter 2).

## Behavioural adaptations

Most animals try to escape their predators. Slower moving animals escape by burrowing underground or hiding in holes. Soldier crabs migrate over mud flats at low tide, but burrow quickly to avoid predators when the tide comes in. Fish can swim together in schools to look like one large fish (Figure 63.3) Some animals hide in existing holes, such as the Rock cod in Figure 63.4 whose large pectoral fins make it capable of short, sharp bursts of speed to escape predators.

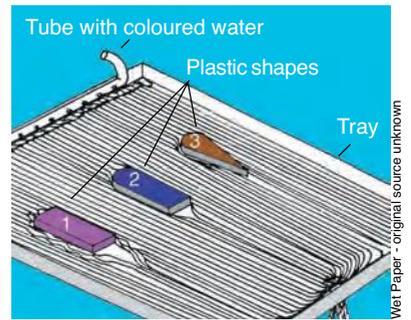


Figure 63.1 Streamlining tank experiment- square objects are not well adapted to moving through water.



Figure 63.2 Camouflage: spot the shrimp.



Figure 63.3 Schooling behaviour in fish



Figure 63.4 Rock cod

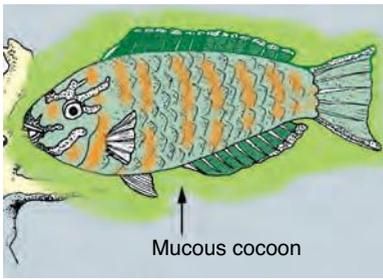


Figure 64.1 Parrot fish at night

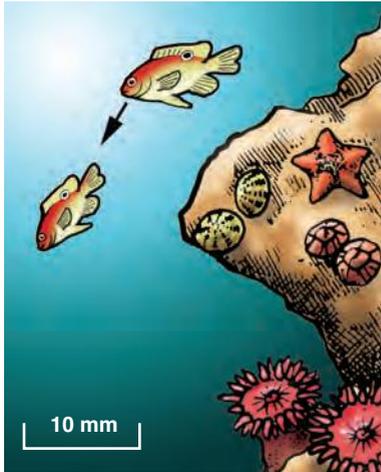


Figure 64.2 Damsel fish are very territorial.

Another behavioural adaptation is the mucous cocoon which the Parrot fish builds itself each night (Figure 64.1). This cocoon protects the fish from being caught by predators such as the Moray eel which detect their prey by body odour.

## Territoriality

An area which an individual or group of individuals defends is called its **territory**. In most cases it is a breeding place that is defended, but it may be a particular food supply or shelter. Once an animal or group of animals establishes a territory other animals tend to stay away from this area. Thus territorial behaviour tends to reduce fighting and competition for the resources. Territorial behaviour also helps to improve the species. The strong individuals gain the best nesting or feeding sites and the weaker individuals may not even attract a mate.

Thus, the weak individuals, or individuals with less desirable characteristics will not pass on their characteristics to the next generation. This behaviour also helps make sure the population does not outstrip its resources and a balance of numbers exists. Sometimes the territorial fights that one might observe taking place are only mock fights designed to establish physical supremacy. The Damsel fish shown in Figure 64.2 are very territorial.

## Populations and communities

### Producers and consumers

Figure 64.3 shows a group of microscopic plant plankton. These plants have the ability to make their own food using sunlight (see also page 290 Chapter 25).

### Photosynthesis

**Photosynthesis** is the process by which a plant uses the sun to make its own food (Figure 65.1). Plants that make their own food are called **producers**. So a diatom is a producer. Producers trap sunlight in a pigment called chlorophyll and use the **energy** to convert carbon dioxide and water into sugars and other organic compounds:



The plant uses the sugar and energy to grow and the oxygen is released into the atmosphere and into the sea where it is breathed by us and other animals on land and in the water. In some oceans of the world, diatoms are the largest producers of food and oxygen.

**Consumers** are animals that consume other organisms — plants, animals or both — to obtain their energy needs.

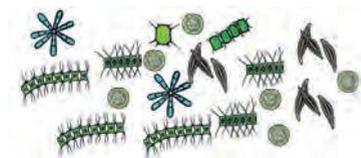


Figure 64.3 Producers - phytoplankton  
(Illustration Rose Bedford)

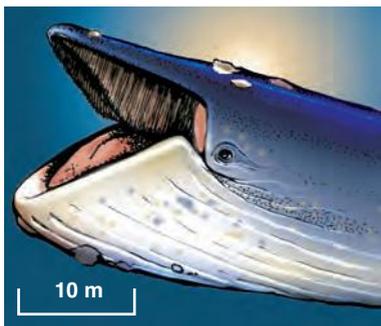


Figure 64.4 Omnivore - Baleen whale  
(Illustration Kerry Kitzelman)

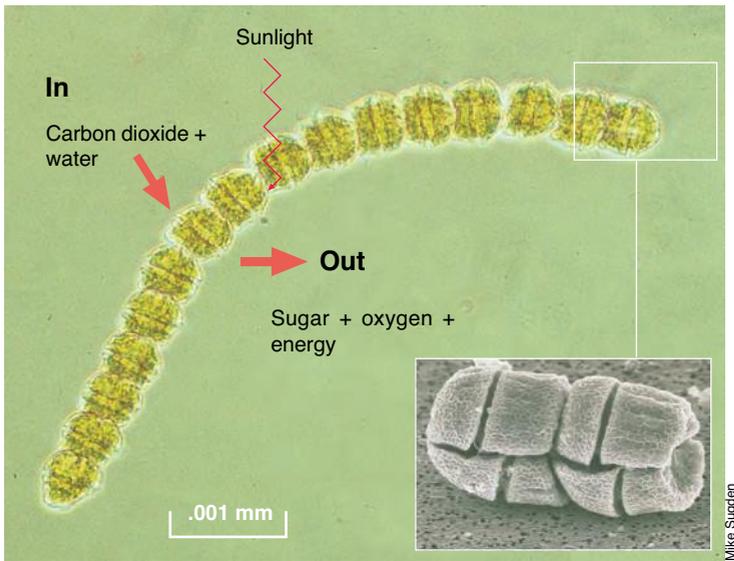


Figure 65.1 Phytoplankton diatoms in a chain

In the sea, phytoplankton, kelps and algae are the primary producers of food and provide the basis on which the bigger animals feed. On coastlines and estuaries, marine plants such as mangroves, seagrasses and Spinifex are food producers.

## Marine food chains

A **food chain** is a series of organisms linked by feeding. Each link in the chain feeds on, and gains energy from, the previous one and in its turn is eaten. The last animal which eats but isn't eaten is the top of the food chain. A simple food chain on land starts with grass growing in a field. Cows eat this grass, grow bigger and are killed by humans for food, so the chain is complete eg: Grass → cow → humans.

In the sea, there are different types of consumers. Animals that eat only plants, such as dugong or abalone, are **herbivores**. Animals that eat other animals are called **carnivores** and include Humpback whales, cod, bream, Barramundi and sea anemones. At the top of the food chain are the predators such as sharks (Figure 65.2). A marine food chain could be:

Algae → copepod → small fish → cod → tuna → shark.

Marine food chains are usually much longer than land food chains because, as marine scientists have discovered, there are a number of orders of consumer. Zooplankton which eat the original producers are called **first order consumers**. Small fish, next in line, eat the first order consumers and so are called **second order consumers**. The cod, tuna and shark then become third, fourth and fifth order consumers.

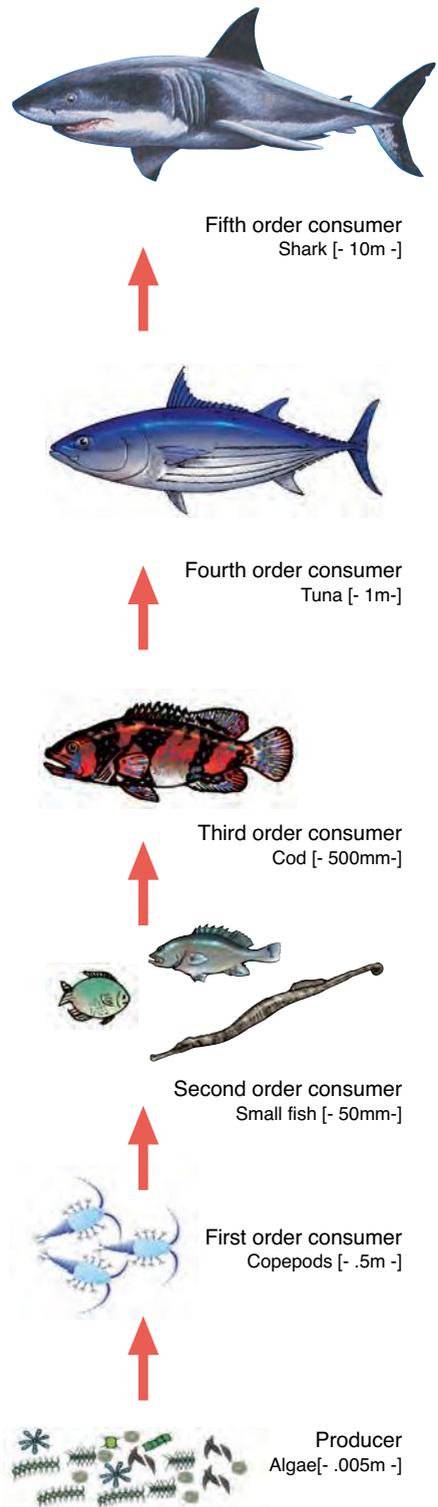


Figure 65.2 Food chain  
(Illustrations Sharyn Madder and Kerry Kitzelman)

## Diving deeper



1. Design a wall chart comparing adaptations to life on the land with life in the sea.
2. Design a rocky shore animal identifying the features that would help it survive a storm.
3. Research colour adaptations of reef fish and how colour is used to communicate



Justin Marshall University of Queensland

## Decomposer organisms

A **decomposer organism** breaks down the dead tissues of other organisms to release simple chemical substances such as minerals back into the sea. The main decomposers in the ocean and ocean's edge are bacteria and some fungi. Importantly, bacteria decay dead organisms and animal wastes, which recycles nutrients to the rest of the sea.

Decomposers are found in all environments including open oceans, mangroves and the beaches. The materials that decomposers eat are called **detritus** (Figures 66.1 and 68.1).

## Marine food webs

To better understand the energy flows in the sea, we need to know how organisms interact. Food webs provide this information.

**Food webs** are interconnected food chains that form a network. Food webs show the true relationships between organisms in an ecosystem and an example is shown in Figure 66.1 and 68.1. Once you have understood the food web, you can work out the energy flows in it.

### Sheltered shallow water ecosystem

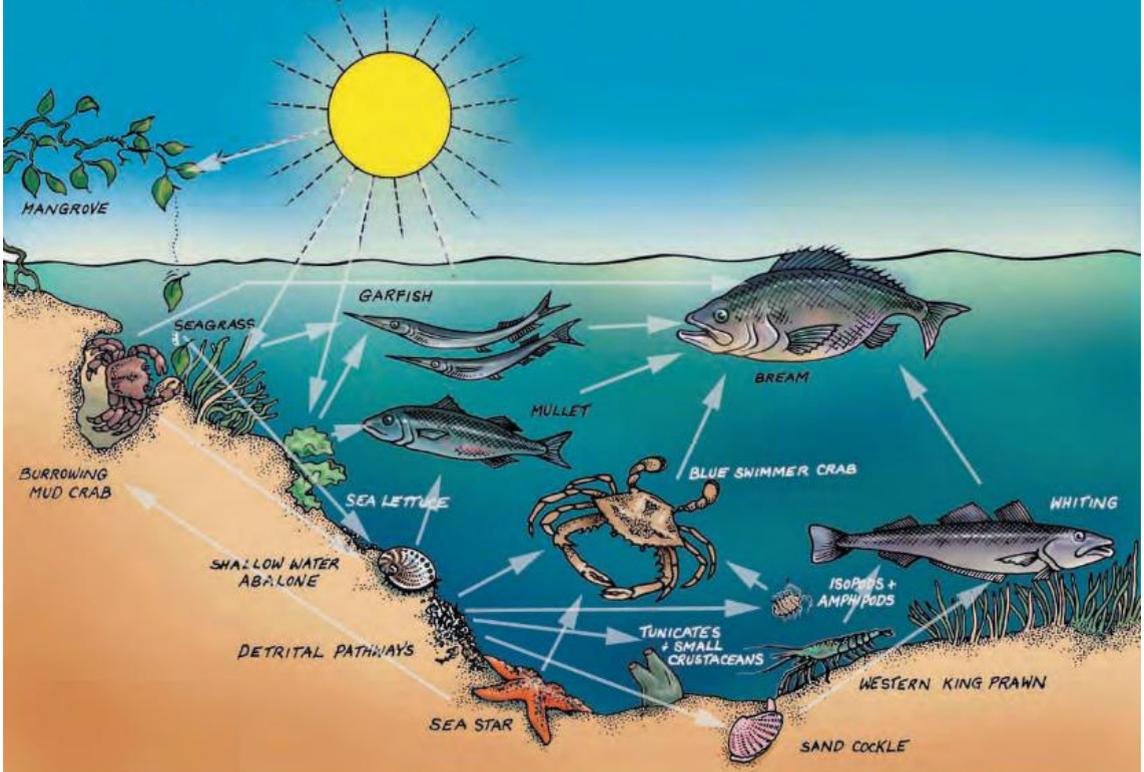


Figure 66.1 Sheltered coastline food web and ecosystem

Concept by Nancy Tsernjavski, Illustration by Sharyn Madder, copyright MESA, reproduced with permission.

# Food pyramids

Another way of demonstrating energy flows is to use a food pyramid to show how much bulk of food is consumed in a food chain (Figure 67.1) The seal may eat more than 1000 herrings in a day. Each herring, in turn, would consume up to 5000 copepods each day.

A copepod will consume up to 100 000 plankton each day. This means 500 000 000 000 plankton each day are ending up inside one seal. If marine scientists wanted to manage a seal reserve and needed to estimate the food supply, they would have to take accurate measurements of all aspects of the food chain and the amount of living matter in it.

# Marine ecosystems

**Ecosystems** are a combination of communities and can be as small as the space under a rock or as large as a barrier reef. The study of ecosystems becomes important when scientists try to get the big picture of life on this planet, and are discussed in greater detail in the book - *Marine Science for Australian Students*. Figure 67.3 shows two types of ecosystem. The open sea illustrated is from the continental shelf whereas the sandy beach could be found in most coastal areas.

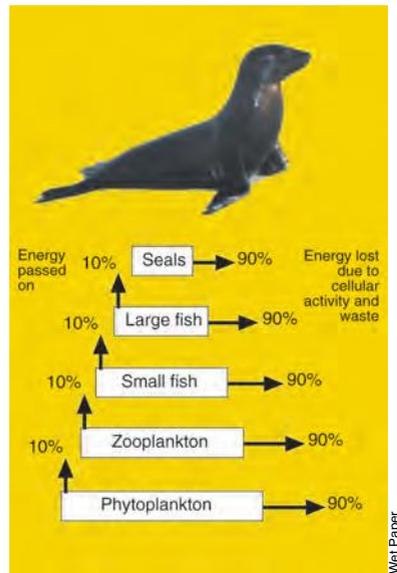


Figure 67.1 A marine energy pyramid

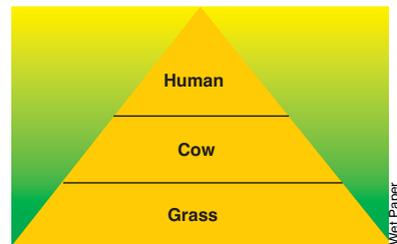


Figure 67.2 Land food pyramid

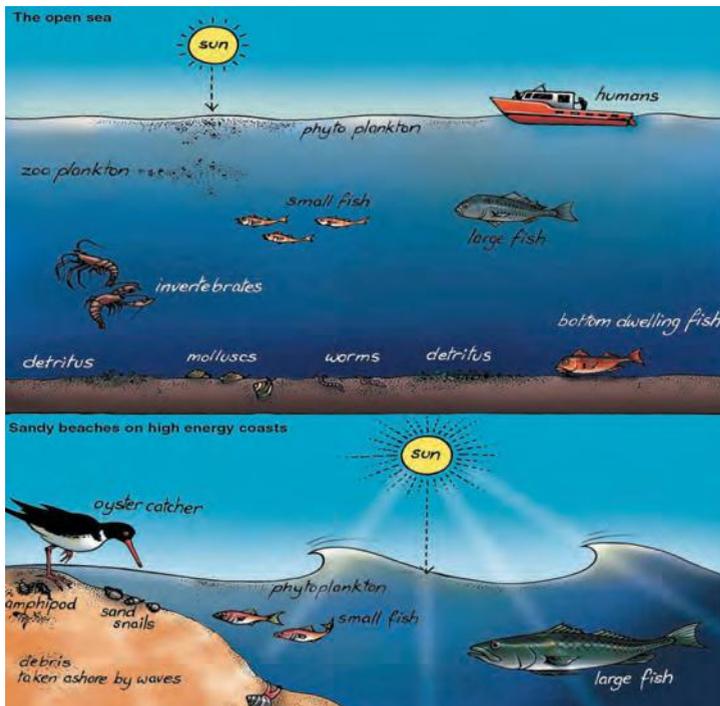


Figure 67.3 Open sea and sandy beach ecosystems  
Concept by Nancy Tsernjavski. Illustration by Sharyn Madder, copyright MESA, reproduced with permission.

## Energy pyramids

Scientists often use an **energy pyramid** to demonstrate the energy flow through a community.

An energy pyramid also shows how energy is lost along the food chain.

About 10% of the energy is passed to the next link in the food chain, with the remaining 90% lost as heat energy or just used up by staying alive.

On land, the loss is much less. Could this be why life on the land has evolved more rapidly than in the sea?



1. What is an adaptation?
2. What is the difference between a population and a community?
3. Name four differences between living on the land and living in the sea.
4. Give three examples of structural adaptations.
5. Write a definition for the term *territory*.
6. What is the difference between a functional and a structural adaptation?
7. Why are predators important?
8. What is the difference between a food web and a food chain?
9. Why do some fish have to be streamlined?
10. Would a filter feeder be well adapted to a muddy habitat? Give a reason for your answer.
11. Imagine you are a short rounded fish which could only move quickly in short bursts. Name two habitats that would give you the best chance of survival.

## Relationships

To survive in the marine environment, marine organisms often engage in a variety of relationships with other organisms. These are either predator - prey, scavenger or symbiotic relationships.

Other relationships such as competition between species for space or dominance hierarchies also affect individuals who live in populations.

### Predator - prey

In this relationship one animal, the **predator** hunts and consumes another animal, the **prey**. An example of this harsh relationship is demonstrated when a shark eats a fish. The shark is the ultimate predator of the ocean. The predator is mostly larger and more powerful than the prey.

Predators are very important in a community as they control the numbers of prey within that community. Without these natural enemies there would be a population explosion among the prey. The prey may then eat out its own food supply and eventually starve. It is therefore important for a community to have a natural balance of numbers within each species.

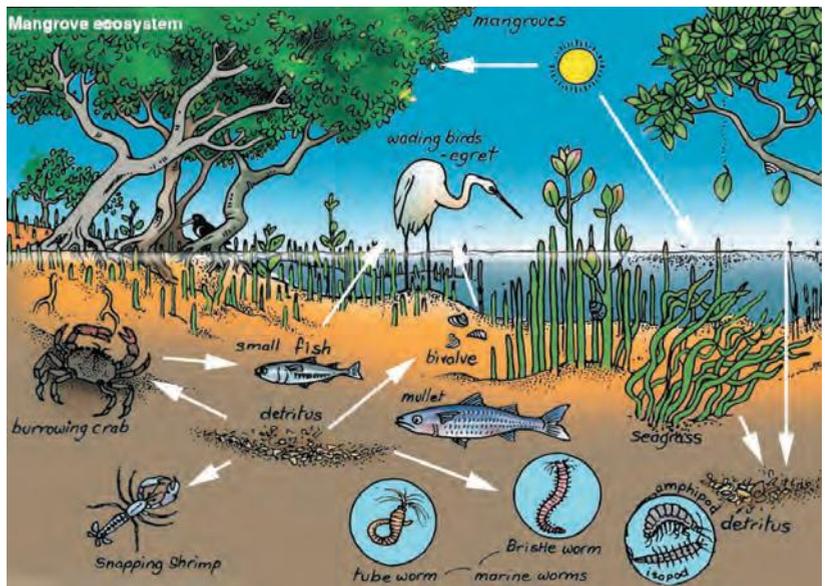


Figure 68.1 Mangrove food web

Concept by Nancy Tsernjavski, Illustration by Sharyn Madder and Kerry Kitzelman, copyright MESA, reproduced with permission.

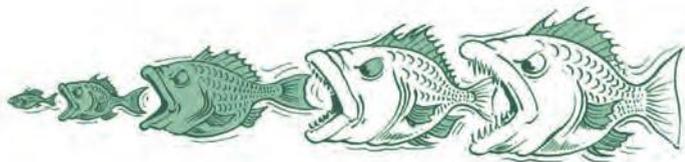


Figure 68.2 Predator - prey relationships

(Illustration Sharyn Madder)

## Scavengers

**Scavengers** are a special group of animal consumers that eat dead animals and plants. Ocean scavengers include crabs (Figure 69.1) which continually eat the scraps of uneaten food that remain in the food chain. Scavengers are also efficient at cleaning up the dead remains of others. Many species of sharks and fish also scavenge for food. Nothing in the sea is wasted.

## Symbiosis

**Mutualism** (or ++ relationship) is a close relationship between two organisms in which both organisms benefit greatly from the association. The association is necessary for the survival of the organisms.

An example of mutualism is the association or relationship between algae and clams (Figure 69.2). The Green algae (**zooxanthellae**) live inside the shell of the clam and provide it with the oxygen and food the clam needs to survive. The clam provides the algae with protection, carbon dioxide and nutrients (waste products). The clam would die without the algae.

One of the most intriguing examples of mutualism is the cleaning role of an elongated, striped fish called the Cleaner wrasse. They use their distinctive markings to attract other species of fish to an area then eat the parasites from the fish's bodies. Larger fish even open their mouths and gill covers so that the cleaner fish can swim into their mouths and clean the gills (Figure 69.3).

Another example of mutualism occurs in the eye of some fish. Bacteria live here where they are supplied with food and oxygen. The bacteria provide the light to feed at night.

**Parasitism** (or + - relationship) is a close relationship where one organism, the parasite, benefits from the association to the detriment of the other organism. The organism from which the parasite gains its nutrients is called the host. The host loses from or is harmed by the association.

Most large living things are at some time in their life affected by parasites. These parasites may be external or internal. A common external fish parasite is the fish louse or copepod. This crustacean attaches itself to the skin or gills of the fish and lives on the blood sucked from the fish (Figure 69.4).

The internal parasites of fish and aquatic mammals include flatworms, tapeworms, roundworms and threadworms. Some species, which are heavily invested with these parasites, have the digestive cavity filled by a wriggling mass of worms. Bacteria and protozoan also survive in the body of many aquatic organisms.

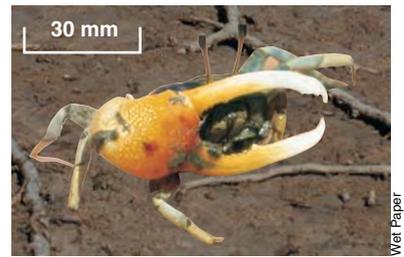


Figure 69.1 Fiddler crabs are an excellent example of a scavenger.

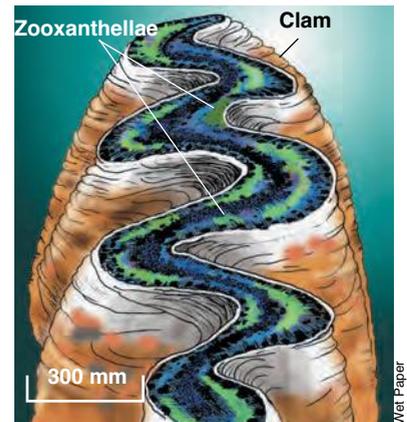


Figure 69.2 Giant clam and zooxanthellae  
(Illustration Steven Byers)

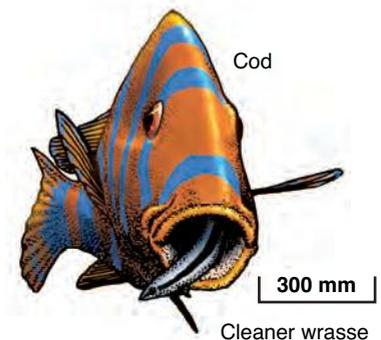


Figure 69.3 Fish and cleaner wrasse  
(Illustration Reef Ed)

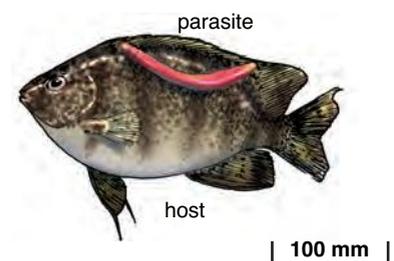


Figure 69.4 Fish and parasite  
(Illustration Steven Byers)



Figure 70.1 Clownfish and anemone

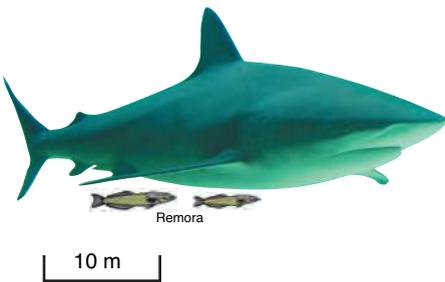


Figure 70.2 Remora and shark  
Courtesy Sea World



Figure 70.3 Penguin colony

**Commensalism** (or + o relationship) is a loose relationship that exists between two different organisms and which is beneficial to one or both, but is not necessary for their actual survival.

The animals having this relationship will have a better chance of survival in their environment.

There are varying degrees of commensalism. In most cases one species benefits from the relationship and the other is not affected.

Some associations make use of the same food source, but not in a competitive way. A good example of this is the anemone and the Clownfish (Figure 70.1). The fish benefits from the food the anemone kills with its tentacles, and the anemone benefits from the flesh that results from the fish tearing at the prey **but both** are capable of existing **without** each other.

A good example of commensalism is the Remora (shark sucker fish) and the shark (Figure 70.2). The Remora attaches itself to the shark's body and is transported around by the shark. The Remora feeds on the scraps of food from the shark's meals.

When the shark stops feeding the remora detaches itself from the shark and searches for its own food. It may then attach itself to another shark later on. The shark merely tolerates the presence of the Remora.

Some animals of different species live together and share the same shelter. Mostly both animals benefit from the association. Certain fish, crabs and worms find shelter in the burrows of other animals.

## Competition

Animals that live in the same area and use the same resources are likely to be competing for these resources.

Competition is where two or more organisms in the same space require the same resource (eg food, water, nesting space, and ground space) which is in limited supply to the individuals seeking it as shown in Figure 70.3.

Other examples example of competition, can be seen in a mangrove community (see Chapter 21). The seagrass is the food source for herbivorous fish, shrimp and crabs, so each of these will be competing against each other. Egrets, larger fish, pelicans and turtles eat small fish. Each of these predators is competing against the others.

Plants such as seagrass, melaleuca and coastal spinifex also compete with mangroves for sunlight, water, minerals and growing space.

## Types of communities

Communities are named after dominant animals or plants found in them. Figure 71.1 shows eight different communities found in or around Australian waters that marine scientists commonly agreed on.

**Tropical reefs** are found in Queensland and northern Western Australia and are discussed in Chapter 20.

**Temperate kelp** forests are found in southern Australia. They have sponge gardens, huge kelp beds which rise up from the sea floor and a huge diversity in marine life. Chapter 6, page 83 give a map and definition of temperate waters.

**Mudflats, seagrasses and estuaries** are found all over Australia in shallow waters near our coastline. They are extremely affected by human activities (see Chapter 21).

**Sand dunes** vary in height from less than a metre to over 80 metres in Queensland. They contain a variety of plants and form the boundary of land and sea.

**Rock or reef pools** are found on all coastlines around Australia and are under great threat from shell collectors or land pollution.

## Diving deeper



1. Fish have a great variety of size and shape of fin. Use the library or reference books to investigate these differences and suggest a reason for the different types of fins.
2. Research the behavioural adaptations of animals living in rocky pools which may help these animals survive.
3. Type in *hydrothermal vent* into your internet browser and make a poster on life in the deep sea.
4. Calculate the number of penguins in Figure 70.3

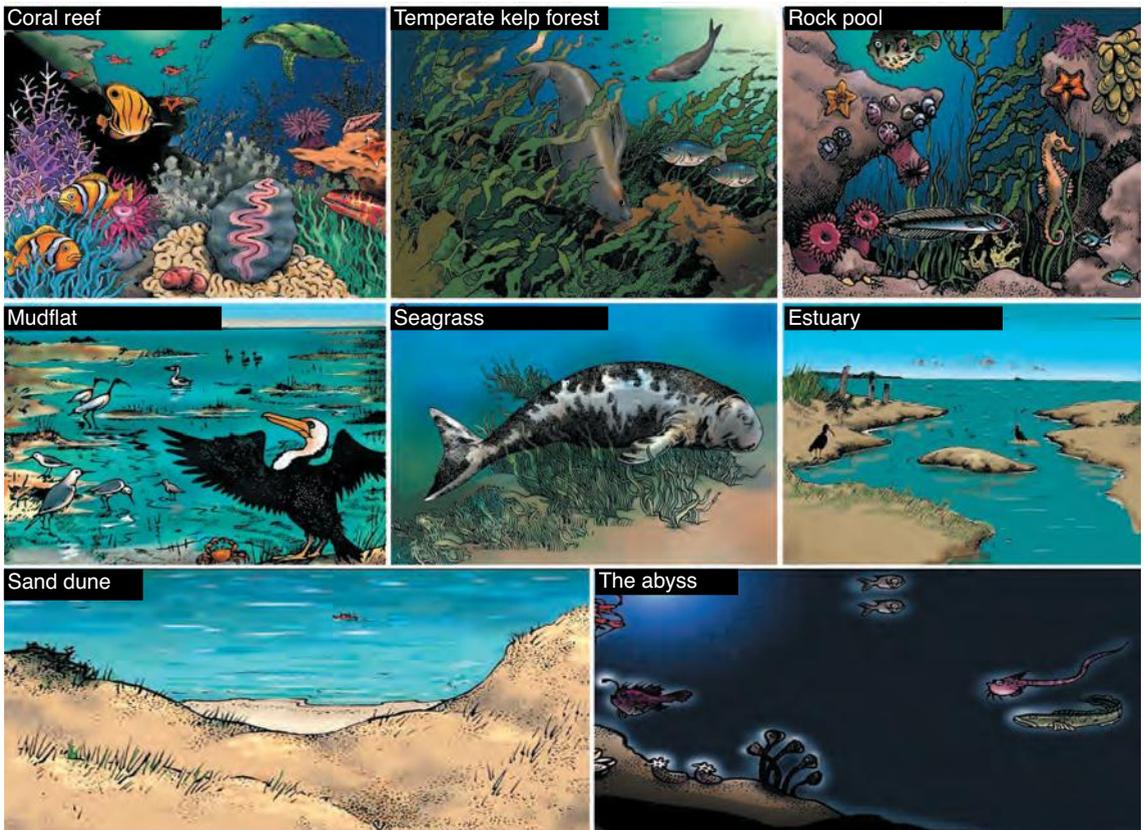


Figure 71.1 Eight types of marine community

Concept by Nancy Tsernjavski, Illustration by Sharyn Madder, copyright MESA, reproduced with permission.



Figure 72.1 Loosejaw

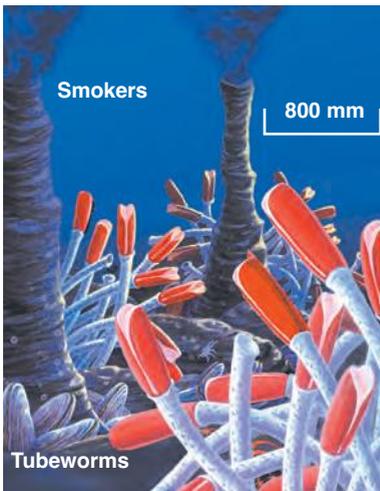


Figure 72.2 Deep sea smokers

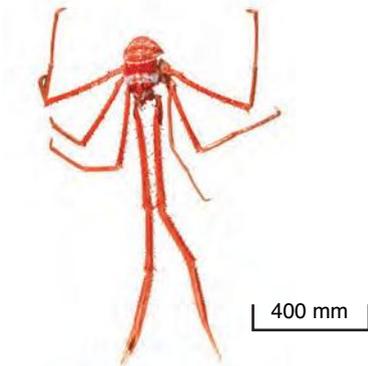


Figure 72.3 Deep sea lobster discovered 2005  
CSIRO Hobart Laboratories

## The abyss

The abyss is between 3 900 and 6 000 metres. The abyssal plains cover almost half of the deep sea floor and 90% of the ocean is in this zone. This is the soft bottom area of the sea that can range from coarse sand to muddy ooze. Animals living here live in total darkness, at enormous pressures, freezing temperatures and usually walk gently on the substrate or bury themselves in the mud or sand.

The shapes and sizes of fish varies and the diversity of life forms appears to be large.

The Loosejaw fish shown in Figure 72.1 has large eyes and a big mouth to maximise the chances of catching food.



Viper fish  
Source unknown

## Hydrothermal vents

Deep sea animals feed mainly off the food from above. Plants have to make their own food without light and unusual worms are able to obtain chemicals from the energy they extract from deep sea **hydrothermal vents** (Figure 72.2).

These vents form in some areas along the Mid-Ocean Ridge where the gigantic plates that form the Earth's crust are moving apart, creating cracks and crevices in the ocean floor. Sea water seeps into these openings and is heated by the molten rock, or magma, that lies beneath the Earth's crust.

As the water is heated, it rises and seeks a path back out into the ocean through an opening in the seafloor spewing up super-hot, mineral-rich water that helps support a diverse community of organisms. Although most of the deep sea is sparsely populated, vent sites teem with a fascinating array of life. Tubeworms and huge clams are the most distinctive inhabitants of Pacific Ocean vent sites, while eyeless shrimp are found only at vents in the Atlantic Ocean.

Marine scientists want to learn more about hydrothermal vents because they are believed to play an important role in the ocean's temperature, chemistry, and circulation patterns.

Scientists also are fascinated by the unusual life that inhabits vent sites. These creatures who live in darkness, from bacteria to tubeworms, may light the way to the development of new drugs, industrial processes, and other products useful to us all.

The giant squid also lives here. It is the largest of all invertebrates, over 50 metres long and more than a ton in weight. Some scientists believe the scarce food supply and low temperatures reduce the growth rate and increase the life span of these creatures. This, in turn, leads to their larger size.

## Key words

Abyss, adaptation, biotic, buoyancy, camouflage, carnivore, commensalism, competition, consumer, decomposer, desiccation, detritus, diversity, ecosystems, energy pyramid, food chain, food web, habitat, herbivore, hydrothermal vent, mangrove, parasite, pelagic zone, photosynthesis, predator, prey, producers, scavengers, symbiosis, territory.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

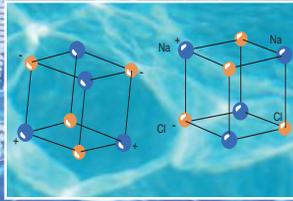
- The largest animals in the world are found in the sea. This is because [1] \_\_\_\_\_ can support a greater weight therefore sea creatures have a completely different [2] \_\_\_\_\_.
- The sea has many places where animals and plant populations live – they are called [3] \_\_\_\_\_. Marine [4] \_\_\_\_\_name habitats after characteristic features such as rocks, plants or the nature of the beach. The [5] \_\_\_\_\_lives in a [6] \_\_\_\_\_ pool habitat.
- An [7] \_\_\_\_\_ is a characteristic that helps an organism survive. This adaptation may be [8] \_\_\_\_\_, [9] \_\_\_\_\_or behavioural.
- [10] \_\_\_\_\_is the process by which a plant uses the sun to make its own food. Plants that make their own food are called [11] \_\_\_\_\_. So a [12] \_\_\_\_\_is a producer. Producers trap sunlight in a pigment called [13] \_\_\_\_\_and use the [14] \_\_\_\_\_ to convert carbon dioxide and water into [15] \_\_\_\_\_ and other organic compounds.
- A [16] \_\_\_\_\_ \_\_\_\_\_ is a series of organisms linked by feeding. Each link in the chain feeds on, and gains [17] \_\_\_\_\_from, the previous one and in its turn is eaten. The last animal which [18] \_\_\_\_\_but isn't eaten is the top of the food chain.
- A [19] \_\_\_\_\_ \_\_\_\_\_ breaks down the dead [20] \_\_\_\_\_of other organisms to release simple chemical substances such as [21] \_\_\_\_\_back into the sea.
- [22] \_\_\_\_\_are very important in a [23] \_\_\_\_\_as they control the numbers of prey within that community. Without these natural enemies there would be a population [24] \_\_\_\_\_ among the prey.
- [25] \_\_\_\_\_ \_\_\_\_\_ animals feed mainly off the food from above. Plants have to make their own food without light and unusual worms are able to obtain chemicals from the energy they extract from deep sea [26] \_\_\_\_\_ \_\_\_\_\_ .



- What is *mutualism*? Give an example of this type of relationship and indicate the effect of the relationship on each animal.
- Look at the food web on page 66 or 68.
  - List the groups of animals acting as competitors.
  - List some predator–prey relationships.
- Give one similarity and one difference between a parasitic and a predator–prey relationship.
- Give three examples of how an animal's behaviour can help it survive.
- How does a mucous cocoon help the Parrot fish at night?.
- What is the difference between *commensalism* and *mutualism*? Give one example of each.
- What is the difference between a producer and a consumer?
- Look at Figure 66.1 and draw three food chains.
- What is a *hydrothermal vent* and how do plants derive energy from them?
- Look at the deep sea lobster in Figure 72.3. List three adaptations that help it live in the abyss.
- Look at Figure 67.3 and construct a food pyramid comparing the sandy beach and open sea.
- Write a definition for an *ecosystem*.



# Chapter 6 Sea Water



## Web references

[www.seafriends.org.nz](http://www.seafriends.org.nz), [www.reefed.edu.au](http://www.reefed.edu.au)

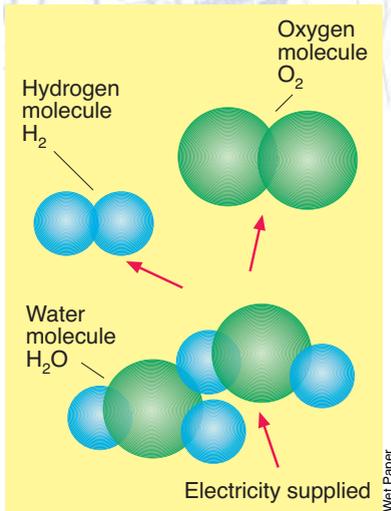


Figure 74.1 Water molecules and electricity's effect on them

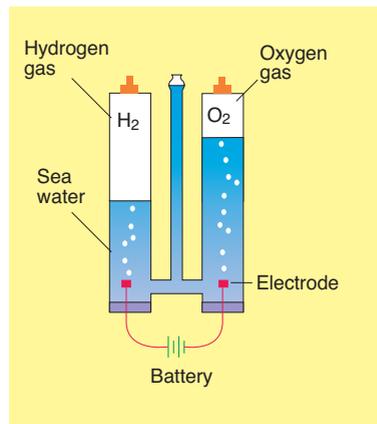


Figure 74.2 Hoffmann's voltameter

Estuaries can be classified by the amount of mixing of salt water - see Chapter 21

## The abiotic environment

*Note: Chapter 5 discussed the **biotic** or living aspects of the marine environment.*

This chapter discusses the non-living or **abiotic** part of the marine environment. Abiotic factors which influence what lives in the sea include temperature, currents, thermoclines, buoyancy, light and colour, water pressure, viscosity, relative density, sound and dissolved gases. However we first need to identify the properties of sea water and some of its chemistry.

### Properties of sea water

A study of sea water reveals that it has many unique properties:

- it accounts for over 85% of the mass of marine organisms and is the medium in which the chemical reactions that support life in the sea take place;
- it provides support in the form of **buoyancy** for some of the organisms that live in the sea; and
- it is less dense in its solid form than its liquid form, so it forms icebergs which float in the Arctic and Antarctic waters.

Sea water also shares the unique properties of all water:

- water is the only substance on the Earth's surface that can exist naturally in all three states as a solid, liquid and gas; and
- water can dissolve more substances than any other liquid.

### Composition

Water is made up of two **elements** - hydrogen and oxygen. The chemical formula for water is  $H_2O$ . Water can be split into these two elements by the use of energy as shown in Figure 74.1. Here water is decomposed by the use of an electric current called electrolysis. A Hoffmann's voltameter (Figure 74.2) is the apparatus used to demonstrate this process.

### Salinity

Sea water is salt water. You can make salt water if you take a teaspoon of salt from a salt shaker and stir it into a glass of water. Marine chemists call the salt the **solute**, the water from the tap the **solvent** and the end result a **solution**.

## Defining salinity

**Salinity** is the amount of dissolved salts in the water. The salinity of sea water is shown in Figure 75.1. Sea water has 30–35 g salt per litre. As you head up a river away from the sea the salinity will drop due to the influence of fresh water from rain entering rivers and creeks.

**Brackish** water (water that has some salt in it) is defined as water with a salt content of 0.517 grams/litre. Fresh water is defined as water with a salt content less than 0.5 grams/litre.

The oceans of the world are well mixed and, as a consequence, the chemical make-up of the oceans is relatively constant. The concentration of salt in a particular region depends on the balance between evaporation and precipitation. This can cause small but significant differences.

## Aspects of salinity

Salt water is heavier than fresh water so in an estuary you can find a salt-water wedge which is fresh water on the top and salt water on the bottom as shown in Figure 75.2. Salinity changes from ocean to ocean affect how ships are loaded (Figure 75.3). A ship will rise in the water as it passes through areas of high salinity and drop in the water in lower salinity. The line on the side of a ship, called the **Plimsoll line**, allows the shipmaster to load the vessel to account for differences in salinity and ocean temperature (see Figure 75.4).

Salinity also depends on the type of parent rock found on the seabed. If the rock has a large amount of limestone, the neighbouring sea will have a high concentration of calcium and carbonate ions.

Water temperature also affects the amount of salt dissolved in the water. Warm water dissolves more salt and minerals; as this water becomes saltier it sinks to the lower levels where it cools. This cooler water becomes rich in minerals and supplies energy for deep sea marine life.

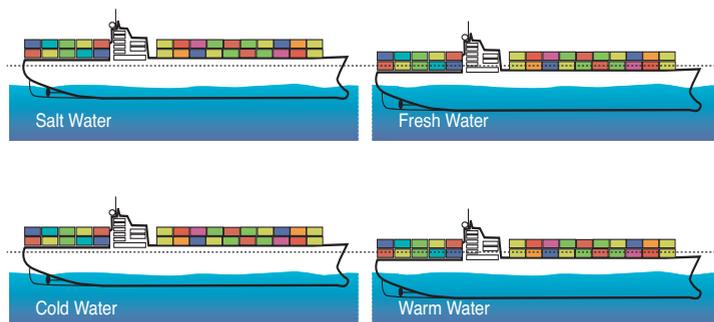


Figure 75.3 Effects of temperature and salinity  
Wet Paper

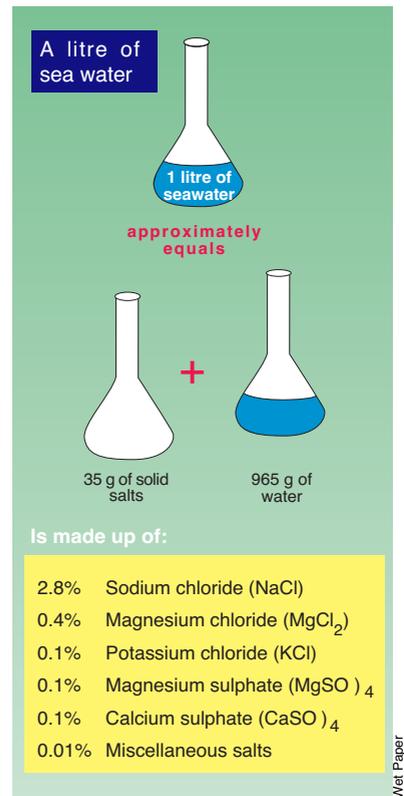


Figure 75.1 The salinity of sea water

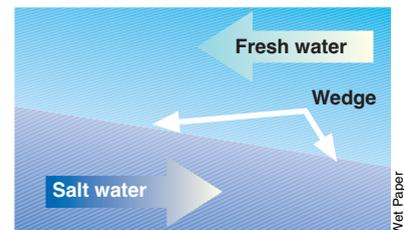


Figure 75.2 A salt-water wedge

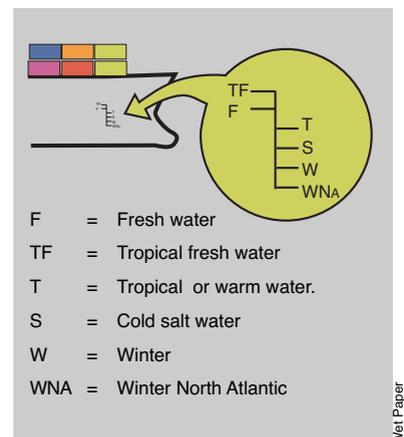


Figure 75.4 Plimsoll line



1. Name five unique properties of sea water.
2. Name four salts found in sea water.
3. Draw a diagram of the Hoffman's voltameter and show how it can be used to demonstrate the composition of water.
4. What is a salt-water wedge?
5. What is the difference between fresh, brackish and salt water?

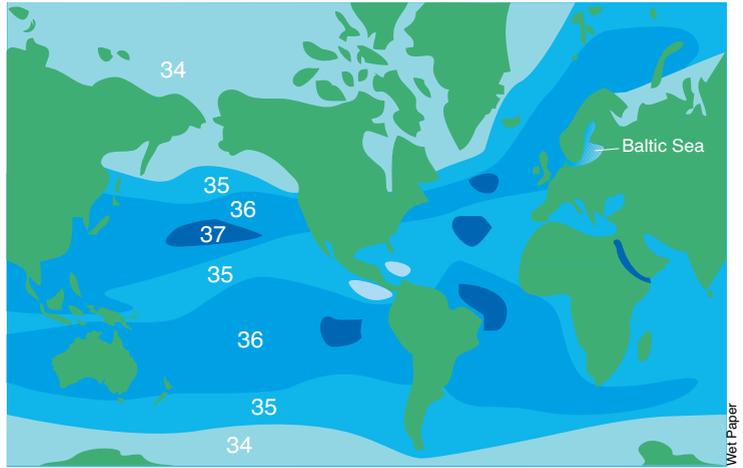


Figure 76.1 Isohalines are lines connecting the points on the Earth's surface which have the same salinity. Numbers represent the salinity percentage of sea water.

**Web references**

[www.marine.csiro.au/bluelink](http://www.marine.csiro.au/bluelink), [www.bom.gov.au](http://www.bom.gov.au)

**Isohalines**

**Isohalines** are lines which connect points on the Earth's surface which have the same salinity. Isohalines shown in Figure 76.1 indicate that sea water is saltier in the tropics.

**Temperature**

Oceans have similar temperatures at similar latitudes but these temperatures vary from 30°C at the equator to 0°C at the poles.

These variations of temperature cause the **ocean currents** of the world. The warm water of the tropics flows towards the poles and the icy water of the poles flows towards the equator (see Chapter 24).

Cold water, being more dense, sinks beneath the warmer water. Warmer water is found only at the surface because the energy from the Sun does not penetrate to the depths.

**Thermoclines**

Because only the surface of the ocean is heated by sunlight, the depths are cold and there is minimal mixing because warmer water cannot displace the deeper, colder water. The narrow band of water between the two layers where water temperature decreases rapidly with depth is called the **thermocline** (Figure 76.2). The thermocline stops many minerals from mixing and can affect ocean productivity.

**Temperature and volume**

The range of temperatures a marine organism has to cope with also depends on the volume of water in which it lives. For example the smaller the volume of water in the rock pool in Figure 76.3, the larger the range of temperatures.

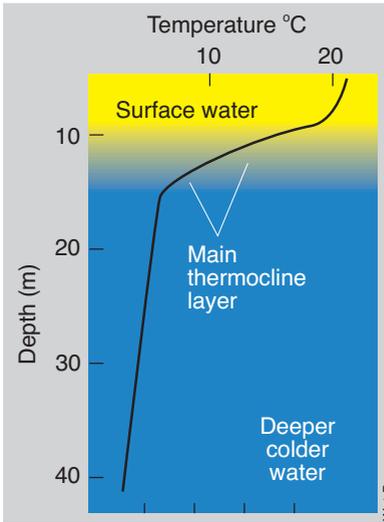


Figure 76.2 The thermocline

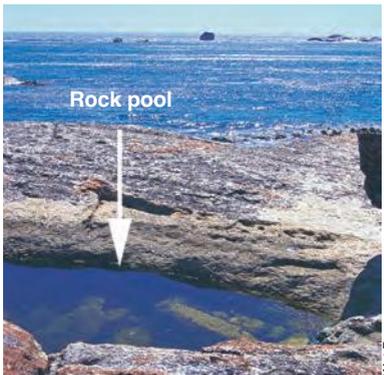


Figure 76.3 Rock pool and temperature

# Buoyancy

## Defining buoyancy

Buoyancy is the ability or tendency to float. Marine organisms that have the same density as sea water tend to be neutrally buoyant; but what is the force that keeps these animals from sinking?

## Upthrust

If a diver is put into a full tank of water, the water will overflow. If we weigh that water, we find that it is equal to the volume of the diver. The mass of the water that was displaced is called the **upthrust**.

If the diver wants to get as deep as possible, the weight needs to be controlled. This can be done by weight belts as shown in Figure 77.1. Figure 77.3 shows how we can also use upthrust to calculate the mass of objects.

We know the density of water is 1 kilogram/litre and the volume of water displaced by the diver is 80 litres. So we can calculate the mass of upthrust on the diver to be 80 kilograms. If the upthrust is greater than the mass of the diver, the diver will float.

## Measuring buoyancy

Sea water has a greater upthrust than fresh water. This is because salt water has a greater weight than the same volume of distilled water. This can be demonstrated by using a **hydrometer**. A hydrometer is an instrument made of a hollow glass tube weighted at one end (Figure 77.2) to float upright. The hydrometer sinks deeper in less dense liquids.

## Light

The **photic zone** is the zone or depth to which light penetrates in the sea and is the zone where the plants of the sea live.

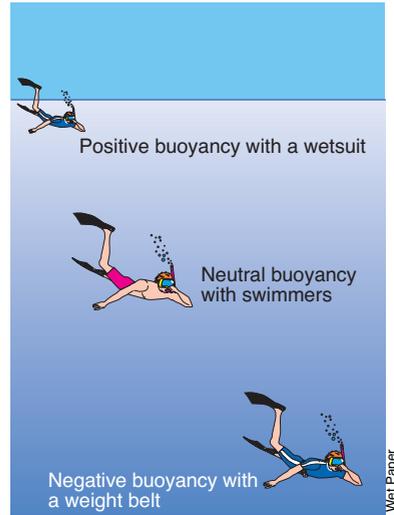


Figure 77.1 Buoyancy and upthrust

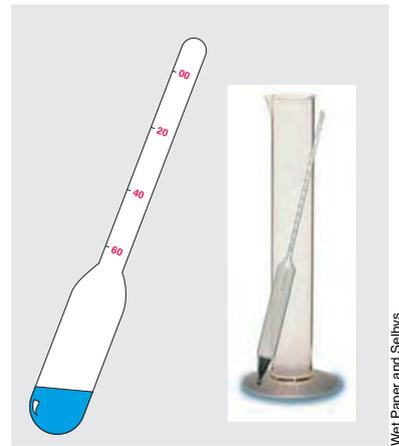


Figure 77.2 Hydrometer and measuring tube

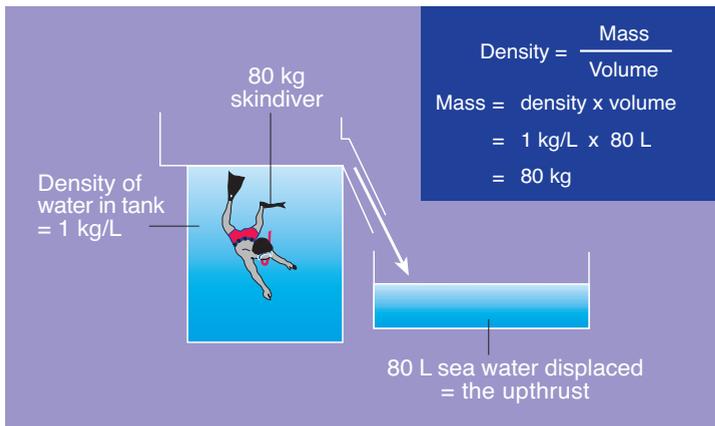
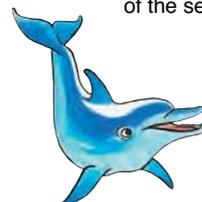


Figure 77.3 Calculation of mass

The **photic zone** is the zone where the plants of the sea live.



See also page 290



## Questions

Use your textbook to find the answers

- How are ocean currents formed?
- What is a thermocline and how does it affect sea life?
- Why does cold water sink below warm water?
- Define the terms *photic zone*, *buoyancy* and *upthrust*.
- What instrument is used to measure water clarity?
- What colour frequency of light is absorbed most quickly by water?
- Discuss the two major factors that determine the colour of the seas.
- How does a hydrometer determine if the water is salty or fresh?
- Explain how a diver may attain negative buoyancy.

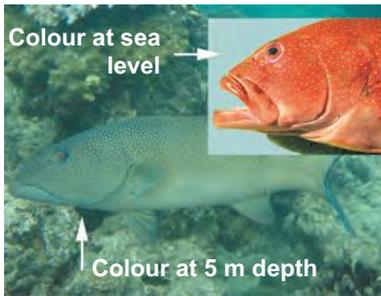


Figure 78.2 Red light is absorbed first by water



Figure 78.3 A secchi disc

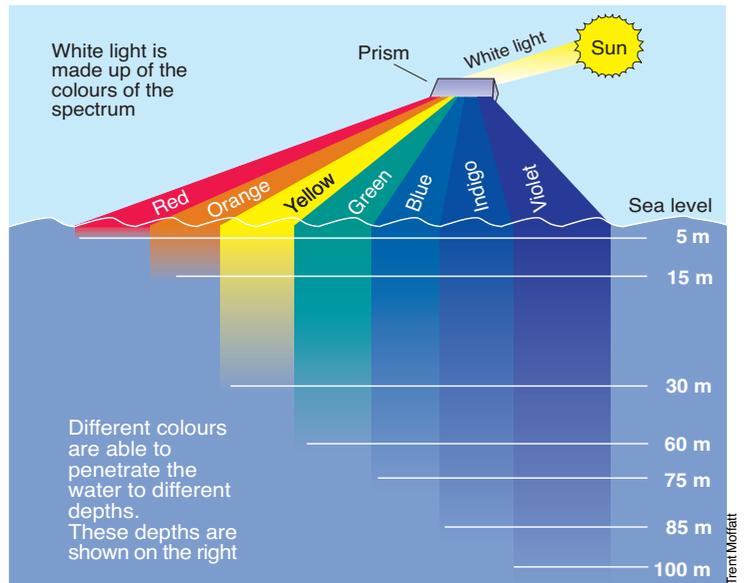


Figure 78.1 How the light spectrum is affected by depth.

### The colour of the seas

Salt water is transparent. This means it allows light to pass through it. The amount of light that penetrates the water depends on the dissolved minerals, silt and detritus material contained in it.

White light is made up of the full spectrum of colours of the rainbow. Red light is absorbed first by the water and does not penetrate as far as the blue or violet light. This is because the shorter the wavelength of light, the greater the depth it penetrates. Since an object will be the colour of light it reflects, a red fish at a depth of 5 metres will reflect no red light (see Figures 78.1 and 78.2). A red fish will appear black at this depth.

The colour of our seas and oceans depends on a number of factors. The two major factors are the amount of ions and the amount of plant life in the water. Blue water indicates that the surface water contains very few ions and so has little plant life, so it can be considered a 'desert' area.

Green sea water contains large concentrations of ions, which in turn cause an abundance of plant growth, which in turn attracts large numbers of animals.

The colour of the water is caused by the scattering and absorption of light by the water. Water of low density causes blue light to be more readily scattered, thus giving it a blue colour because blue light arrives back at the surface without being absorbed.

A simple instrument used to measure the clarity of water is called the **secchi disc** (shown in Figure 78.3).

## Water pressure

The pressure found in the air around the Earth is called **atmospheric pressure**. The pressure in the waters of the ocean is called **hydrostatic pressure**.

We become aware of this pressure when we dive under the water because our ear drums are sensitive to pressure and we notice the pressure increase the deeper we dive.

These are some important facts about pressure:

- pressure increases with depth (water pressure in the bottle in Figure 79.1 is greatest at C, compared to B and A);
- pressure acts in all directions, as it does in air (see Figure 79.2);
- changing the pressure affects air spaces in the body, lungs, ears, sinuses and even in the air spaces under fillings in your teeth;
- animals that live in deep oceans need to be able to withstand great pressures.

## Viscosity

### Defining viscosity

**Viscosity** is the resistance of a liquid flowing through or passing an object. Water is more viscous than air, just as syrup is more viscous than water.

Water is nearly 800 times denser than air and so it strongly resists movement. You can compare the viscosity of various liquids by measuring the time taken for a given volume of each liquid to flow through a very fine tube or funnel. A more viscous liquid will not flow as quickly as a less viscous one.

### Fish shape and viscosity

Fish that need to move rapidly through sea water need to be streamlined. These fish have an aerodynamic or cigar shape as shown by the tuna in Figure 79.3. Fish that spend more time floating without moving tend to be buoyant and round.

## Relative density

### Defining density

The **relative density** of a substance is the ratio of the density of that substance to the density of pure water (see Figure 79.4).

The relative density of sea water is determined by salinity and water temperature.

Dense water sinks and is found at the bottom of the oceans. Less dense water is found floating at the surface as shown in Figure 79.5.

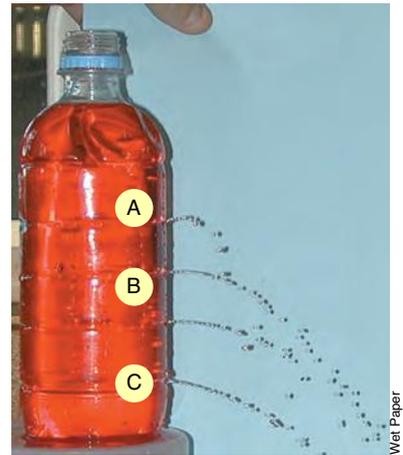


Figure 79.1 Hydrostatic pressure increases with depth.

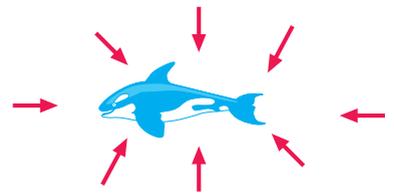


Figure 79.2 Pressure acts in all directions.

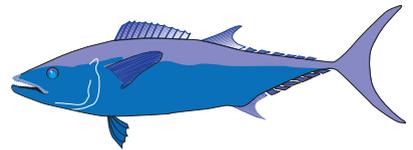


Figure 79.3 Fast-swimming fish need to be streamlined.

$$\text{Relative density} = \frac{\text{Density of substance}}{\text{Density of pure water}}$$

Figure 79.4 Relative density formula

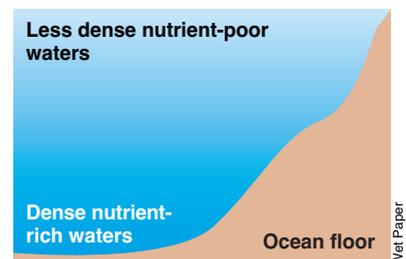


Figure 79.5 Density and water masses

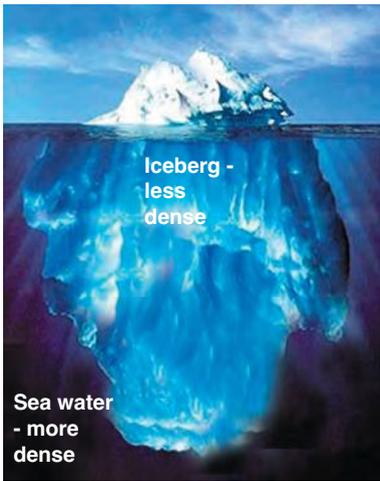


Figure 80.1 Density and icebergs

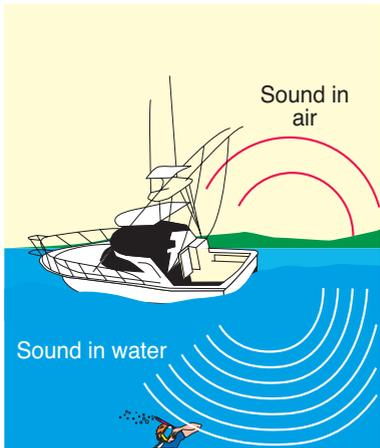


Figure 80.2 Sound in water

**Questions**  
Use your textbook to find the answers

- How would temperature variations in a rock pool compare with those in a lake?
- How do animals adapt to living in hydrostatic pressure?
- What is the difference between atmospheric pressure and hydrostatic pressure?

Objects that are more dense than water have a relative density greater than 1. These substances sink in pure water.

### Example

Objects which have a relative density less than 1 will float. For example, the iceberg in Figure 80.1 floats because the density of the water in the iceberg is 0.92 grams/cubic centimetre compared with the density of the sea water which is about 1.05 grams/cubic centimetre.

### Freezing point

The freezing point of water is also affected by the salt concentration. The presence of salt inhibits the formation of ice. The higher the salt concentration the lower the freezing point of the solution. Ice can be made colder if you throw some salt on it. However the salt does not become a part of the ice. In fact, Arctic ice can be melted to form pure water.

This means that as the ice forms in the oceans, the waters become even more concentrated, decreasing the freezing point of water even more. Salt water, therefore, does not completely freeze at a given temperature, unlike pure water, so salt water has no fixed freezing point.

### Sound in water

Figure 80.2 shows that sound travels almost four times faster in water than in air so vibrations are more easily detected.

Fish have an acute sense of hearing and can respond to sound waves up to 7000 hertz. The greatest range of hearing is found in catfish and carps.

Many people, especially skindivers and swimmers, believe that the watery world is a silent world. In fact, the underwater world has a multitude of sounds and most of these sounds are made by fish. Some fish make sound by rubbing together body parts such as their teeth, spines or any rough surface on their bodies.

A second method uses their body movements to cause currents or vibrations in the water which can then be detected. Injured fish move differently to healthy ones and these movements can be recognised by predators.

Modern lures mimic these sounds to attract fish. Some lures contain a metal ball which vibrates to create an attractive sound. Other lures are manufactured in shapes which cause water disturbances.

A final method by which fish make sound is by using the gases found in their **swim bladder**. A catfish, for example, makes a grunting sound. Schools of fish can also be located by using sophisticated sonic equipment known as fish finders.

However, native fishermen are believed to have located schools of fish by placing a trident shell into the water and listening for sound.

### Safety note

Almost no sound is transmitted from air to water or water to air so divers must be very aware of the dangers of boats when they are surfacing.

## Gases in sea water

### Importance

The gases dissolved in the sea are important for respiration and **photosynthesis** (see Figure 81.2).

The two major gases dissolved in water and involved in these chemical reactions are carbon dioxide and oxygen. Oxygen ( $O_2$ ) is the basis for life in the sea and is produced by marine plants; carbon dioxide ( $CO_2$ ) is the by-product of photosynthesis. Carbon dioxide and oxygen can also dissolve directly from the atmosphere. The rate at which gases dissolve can be increased by turbulence, water temperature and salinity.

### Turbulence

In turbulent water, such as fast-flowing streams or areas of high wave action (Figure 81.1), the amount of oxygen that can dissolve in water increases.

### Temperature

If there is an increase in the temperature of the water, the amount of gas dissolved in the water decreases. This can be demonstrated when a bottle of soft drink is left in the sun, and then opened. Large amounts of gas are released on opening which would normally be dissolved in the cold liquid.



Figure 81.1 Strong wave action

### Diving deeper



1. What are some adaptations animals have which allow them to overcome the buoyancy of the water?
2. How is the eye of a fish different to the human eye? What is peripheral vision?
3. Discuss some of the adaptations plants may have that allow them to float near the surface in the photic zone.
4. Suggest why the colour of algae vary with the depth at which they are found.
5. Research the electro-chemical series and its role in sacrificial anode design.
6. Design an experiment to compare the rate at which the following metals corrode in sea water: zinc, iron, aluminium, stainless steel and copper .
7. What is so special about the salinity in the Red Sea?
8. Make a poster comparing marine animals and plants from temperate and tropical bioregions.

*Photosynthesis (plants) occurs in upper layers of the ocean*



*Respiration (plants and animals) occurs throughout the ocean*



Figure 81.2 Photosynthesis and respiration in the sea

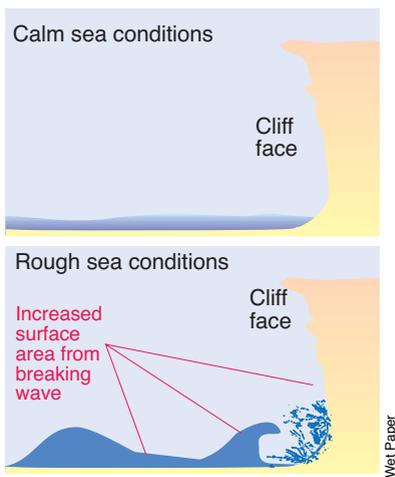


Figure 82. 1 Increased turbulence allows more oxygen to dissolve in sea water.

Figure 82.1 shows that the **surface area** is increased by turbulence. In rough weather, the waves crash into the cliff face making more area for the oxygen in the atmosphere to dissolve.

## Salinity

If the salinity of water changes, the amount of dissolved gases changes too. Therefore fresh water contains different concentrations of dissolved gases to salt water.

The amount of carbon dioxide found in sea water is unusually large and is 20 times more soluble in water than in oxygen. Little of the carbon dioxide from the atmosphere is dissolved as molecules. Oxygen dissolves in water as molecules but the amount or concentration of oxygen in the oceans is irregular. This is because plant life in the oceans carry out photosynthesis and convert carbon dioxide into oxygen.

Figure 82.2 shows that the concentrations of nitrogen, oxygen and carbon dioxide are very different in the sea compared to the air we breathe.

Air and water comparison	
<b>1 L of water</b> At temperature of 20°C and with a salinity of 36 parts / 1000 contains:	<b>1 L of air</b> contains:
48% N <sub>2</sub>	78% N <sub>2</sub>
36% O <sub>2</sub>	21% O <sub>2</sub>
15% HCO <sub>3</sub>	0.03% CO <sub>2</sub>

Figure 82.2 Gases in the sea compared to the land

## Metals in sea water

### Sea water and corrosion

When some metals are left in sea water, coatings form on the metal's surface. This process is called **corrosion** and it shows that a chemical reaction has occurred, for example, when oxygen reacts with the metal. Some metals are more prone to corrosion than others.

### Prevent corrosion

The rusting of iron is a form of corrosion. It can be stopped by mixing iron with other metals. Stainless steel, which resists corrosion, is made by adding another metal such as nickel or chromium to iron and carbon. These mixtures are called alloys.

Corrosion can be also be stopped by painting the metal because this stops the oxygen getting to the metal. Metals can also be coated with plastics. If iron is coated with a more reactive metal such as zinc, the zinc will corrode first. This process is termed **galvanising**.

Another method is to place a large piece of reactive metal such as zinc on the hull or motor of a ship.

The zinc corrodes instead of the iron.

The zinc is sacrificed for the iron and is called a **sacrificial anode** (Figure 82.3).

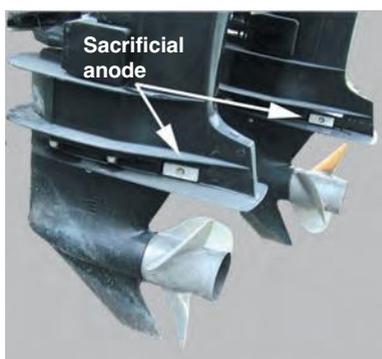


Figure 82.3 Sacrificial anodes on an outboard motor

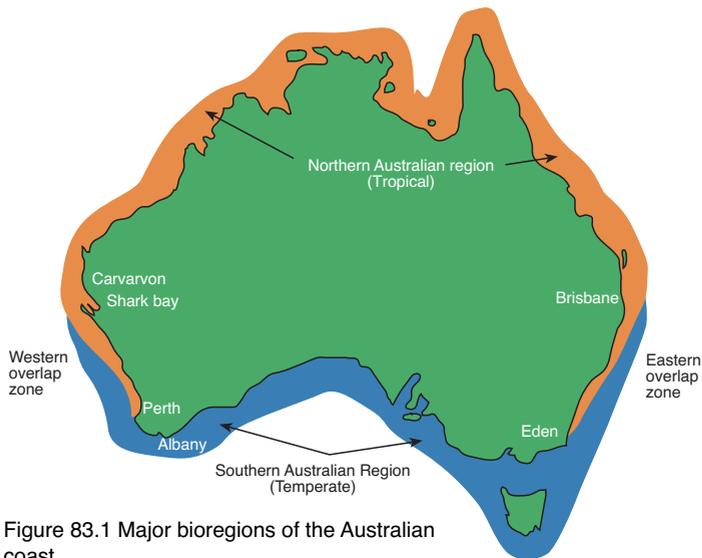


Figure 83.1 Major bioregions of the Australian coast

Wet Paper

## Australian seas

Sea water temperatures vary greatly in Australian waters.

If you fell off a boat in winter in South Australia you would have less than 6 hours to live (Figure 83.2). If you went snorkelling in Eden in June you would have to wear a thick wet suit (Figure 83.3) compared to surfing in Queensland in June where you could wear your swimmers.

Animals and plants too live in different water temperatures and Australian seas can be divided into two **bioregions** as shown in Figure 83.1. The boundary between the tropical and warm temperate provinces coincides approximately with 18-20°C winter minimum surface temperature but this is variable and dependant on the influence of the East Australian Current and the Leeuwin Current (see Chapter 24).

The distribution patterns seen today on our coastline and in our seas are the result of evolution of marine organisms from a long time ago.

### Tropical waters (Northern Australia)

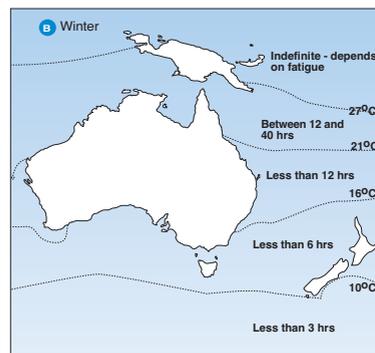
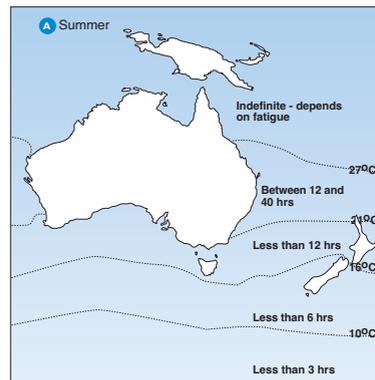
Open shores in northern Australia have extensive growths of coral reefs. Sheltered shores support over 30 species of mangrove (Figure 83.5) and have little salt marsh vegetation. Northern coral reefs have a high diversity of fish and invertebrates.

Tropical waters are characterised by warm water and a great range in water quality caused by monsoon rains.



Murray Waite and Assoc

Figure 83.4 Corals can only grow in warm waters.



Wet Paper

Figure 83.2 Survival times for summer and winter waters



Wet Paper

Figure 83.3 The gear you wear will be determined by the latitude of where you live.



Old Fisheries

Figure 83.5 Tropical mangrove



Bob Moffatt

Figure 84.1 Kelp

### Temperate waters (Southern Australia)

Rocky shores in southern Australia are typified by extensive growths of massive brown seaweeds, called kelps. Sheltered shores support extensive salt marshes and only one species of mangrove.

Temperate waters have the world's highest diversity of life and 80% to 90% of southern Australian marine species are found nowhere else in the world.

Physical characteristics of temperate marine ecosystems include water temperatures less than 20 degrees and a high concentration of dissolved oxygen.

This allows enormous amounts of microscopic marine life to grow thereby providing a huge food supply for larger marine animals and more sophisticated marine plants (Figure 84.1).

### Differences between tropical and temperate waters

If you walk to the end of a jetty in Queensland and look down and compare what you see from a jetty in Victoria, you will be surprised to see a huge difference in plant life. Put on a snorkel and dive down and you won't believe the difference.

The greater variety and numbers of animals in temperate waters is quite remarkable. This is caused primarily by strong antarctic winds and cold ocean currents that impact on these temperate waters.

There are also submerged ocean canyons and sea mounts that provide homes for many deep sea animals and deep sea fisheries. These have been exploited with very little research done as to their sustainability.



Bob Winters

Figure 84.2 Seal



Gould League

Figure 84.3 Fairy penguins

## Key words

Abiotic, atmospheric pressure, bioregion, brackish water, buoyancy, ocean currents, electrolysis, freezing point, galvanising, hydrometer, hydrostatic pressure, iceberg, isohalines, photic zone, photosynthesis, plimsoll line, relative density, respiration, sacrificial anode, salinity, salt-water wedge, solute, solution, solvent, surface area, swim bladder, temperature, thermocline, upthrust, viscosity, water pressure .

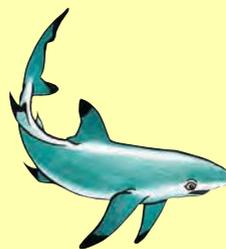
## Summary questions

Fill in the gaps in these sentences. All the missing words can be found in the chapter.

- a. [1] \_\_\_\_\_ factors which influence what lives in the sea include temperature, currents, [2] \_\_\_\_\_, buoyancy, light and colour, water [3] \_\_\_\_\_, viscosity, relative [4] \_\_\_\_\_, sound and [5] \_\_\_\_\_ gases.
- b. Salt water is [6] \_\_\_\_\_ than fresh water so in an [7] \_\_\_\_\_ you can find a salt-water [8] \_\_\_\_\_ which is fresh water on the top and salt water on the bottom.
- c. The line on the side of a ship, called the [9] \_\_\_\_\_, allows the [10] \_\_\_\_\_ to load the vessel to account for differences in salinity and ocean [11] \_\_\_\_\_.
- d. If a diver is put into a full tank of water, the water will [12] \_\_\_\_\_. If we [13] \_\_\_\_\_ that water, we find that it is equal to the [14] \_\_\_\_\_ of the diver. The mass of the water that was displaced is called the [15] \_\_\_\_\_.
- e. The [16] \_\_\_\_\_ is the zone or depth to which light [17] \_\_\_\_\_ in the sea and is the zone where the plants of the sea live.
- f. The [18] \_\_\_\_\_ of the water is caused by the scattering and absorption of light by the water. Water of low density causes blue light to be more readily [19] \_\_\_\_\_, thus giving it a blue colour because blue light arrives back at the surface without being [20] \_\_\_\_\_.
- g. [21] \_\_\_\_\_ is the resistance of a liquid flowing through or passing an object. Water is more [22] \_\_\_\_\_ than air, just as syrup is more viscous than water.
- h. The rusting of iron is a form of [23] \_\_\_\_\_. It can be stopped by mixing iron with other metals. [24] \_\_\_\_\_ steel, which resists corrosion, is made by adding another metal such as nickel or [25] \_\_\_\_\_ to iron and carbon. These mixtures are called alloys.
- i. Animals and plants too live in different water temperatures and Australian seas can be divided into two [26] \_\_\_\_\_.



18. Why is it difficult to tell the direction from which sound is coming when you are underwater?
19. What is viscosity? Give an example.
20. List the three factors that affect the amount of gas that can dissolve in water.
21. Why are some fish streamlined?
22. Define these terms: 'relative density' and 'corrosion'.
23. Which metals are most likely to rust?
24. How can the rusting of steel hulls be reduced?
25. Outboard motors often have pieces of magnesium attached to them. Suggest a reason for this.
26. A ship has been built with a density of 2.3 grams/cubic centimetre. Will it float or sink if placed in water of density 1 g/cm<sup>3</sup>?
27. Will a diver float or sink if the upthrust is greater than the mass of the diver?
28. What is an alloy?
29. What is the difference between the two equations for photosynthesis and respiration.





**Web references**  
[www.safeboating.org.au](http://www.safeboating.org.au), [www.waterways.nsw.gov.au](http://www.waterways.nsw.gov.au), [www.dpi.wa.gov.au](http://www.dpi.wa.gov.au), [www.amc.edu.au](http://www.amc.edu.au)

Australians own about one boat for every 25 people if you count sailing and power-driven craft. The boating industry is one of our largest recreational industries, employing hundreds of thousands of people and injecting millions of dollars into our economy.

‘Just messing around in boats’ has provided many of us with a lifetime of enjoyment and relaxation, as have associated sports such as fishing and water skiing. If you are interested in boating, studying the subject is important because you will have the opportunity to learn new terms and skills, as well as how to work as a team and take on new responsibilities on vessels like those shown in Figure 86.2 and Figure 86.4.

## Types of boating

Canoeing, sailing and driving a power boat are three popular types of boating. Most young people would learn to use one of these small vessels under the direction of more experienced people or at school.

**Canoeing** (Figure 86.1) is fun, relatively inexpensive and allows you to experience a degree of success almost immediately. The basic requirement for canoeing is the right attitude, a degree of fitness and the ability to swim.

Sailing involves more skills and more expensive equipment and is usually taught from a sailing school like that shown in Figure 86.2. Types of small sailing craft vary from catamarans to racing **dinghies**; racing these craft is part of a sailing tradition that spans centuries. **Sailboarding** is a new type of sailing that involves a mast positioned into a surfboard (Figure 86.3). Sailboarding is limited to one person at a time and requires a high degree of fitness when the sailboard is used in surf.

Power boating requires different skills yet again. To operate a power boat you will usually have to obtain a **licence** by demonstrating your skills to a testing officer (Figure 86.4) and sitting for a theory exam to ensure you know the boating rules. Licence requirements and ages vary from state to state.



Figure 86.1 Canoeing for fun



Figure 86.2 A sailing school



Figure 86.3 Sail board  
 Wet Paper



Figure 86.4 Power boating practical exam  
 Wet Paper

# Sailing

Look at the names of the different parts of the sailing boat in Figure 87.1. Additional terms for parts of a sail training boat are given below and shown in Figures 87.2 - 87.4.

- The boat in Figure 87.1 has two sails – the **mainsail** and the **jib**. Different boats have different sails used in different ways.

The mast and **boom** are connected by the gooseneck and the position of the boom is controlled by the **main sheet**.

- The hull in this boat is made of fibreglass because it is a durable material that is easily shaped.
- The **mast** is held in position by the forestay and side stays. The mast is made of aluminium and its purpose is to support the sails.
- There are two types of ropes: **halyards** are ropes or wires used to make the sails go up and down; and **sheets** are ropes used to adjust the angle of the sails.
- Sheets and halyards are held in place by **cleats**.
- The **rudder** steers the boat and is connected to the tiller.
- The **centreboard** helps keep the boat in a straight line and is put down when the boat is in deeper water.

The boat is rigged and launched into the wind for safety and stability reasons.



Figure 87.4 Training dinghy parts

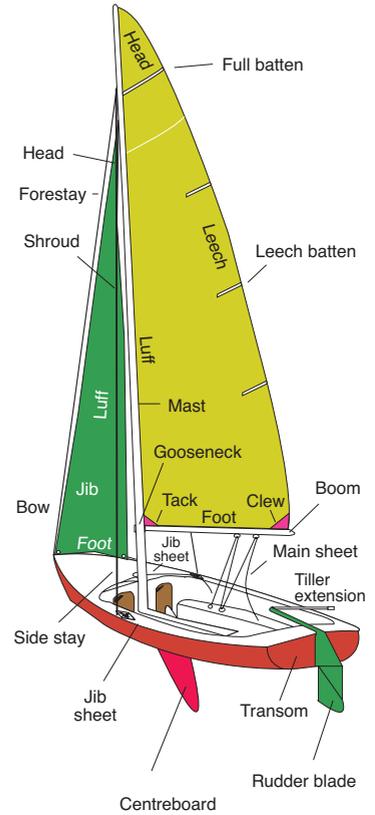


Figure 87.1 Some sailing terms



Figure 87.2 Locking the mast into the deck



Figure 87.3 Connecting the boom



Figure 88.1 Preparing to sail



Figure 88.2 Broad reach



Figure 88.3 Sailing around a course

## Sailing skills

Learning to sail under the Australian Yachting Federation TL1 scheme involves a training logbook through which a number of skills are learnt and signed off by a sailing instructor. Some of the activities to learn include the following:

- launching and rowing a small dinghy around a short course;
- learning how to handle a sailing boat inshore;
- rigging a boat for sailing;
- adjusting sail and sail settings according to the weather;
- basic sailing manoeuvres;
- person overboard drill; and
- righting a capsized dinghy.

Sailing is all about learning to work with the wind. The sailboard is a modern invention but sailing boats have been around for over 2500 years.

To use the wind to propel your boat, you will have to learn how to make the sailing boat go with the wind and against it.

**Tacking** (Figure 88.4) and **reaching** are two ways this can be achieved. To reach is to sail with the wind hitting the boat somewhere about the beam, that is, neither dead astern or ahead. To tack is to sail as much into the wind as you can with the wind alternately on one bow and then the other. Look at Figure 88.3 while reading the following points on how to sail around a course.

On starting out, the **beam reach** (when the wind is abeam) changes through a broad reach and then to a beam reach on the opposite side. You have now sailed half the circle course. **Jibing** is where you are running before the wind.

To complete the circle, head into a starboard tack. To return to the start, turn the boat through a head reach (when the wind is dead ahead) and into a port tack.

**Tacking** is where the sailing boat needs to maintain a forward course in a zigzag.

By tacking, sailing vessels can travel up and down the coast no matter what direction the wind is blowing.

Sailboarding uses similar principles except it is physically demanding and can only be done for relatively short periods.

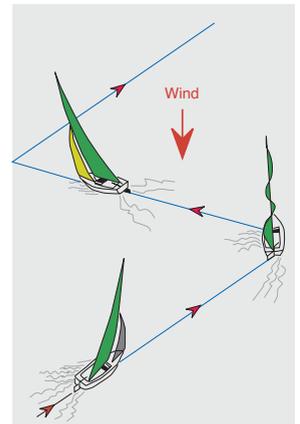


Figure 88.4 Tacking

# Canoeing and kayaking

Canoes can carry one or more passengers, are pointed at both ends and are propelled by **paddles**. Most canoes are made out of durable, easily repaired material.

Canoe paddles have only one blade and a t-grip handle. They are made of a variety of materials. Paddles with aluminium shafts and plastic blades are commonly used in schools because they are light, durable and inexpensive. In a canoe, you will inevitably get wet and perhaps capsize at some time. Suitable personal flotation devices (PFDs) as shown in Figure 89.3 must be worn all the time and wear a helmet if you are shooting rapids or travelling down fast-flowing streams.

Your clothing should be comfortable and quick-drying. Synthetic materials are best, particularly in winter, because they are warm and dry quickly rather than sitting cold and wet next to the skin. Wear a number of light layers rather than just one thick garment so that you can regulate your body temperature easily. Protect yourself from the sun at all times.

Canoe parts are listed below.

- The **thwarts** hold the canoe in shape, and the seats double as thwarts.
- The **deck** is the part of the hull that is covered. The deck stops water entering the hull.
- Bulkheads separate the hull into sections like the walls of a house.
- Each end of the canoe should have a handhold on the deck for carrying the canoe. In some cases, the bulkhead will have an inbuilt handle;
- The keel line is usually strengthened to minimise damage.

## Canoeing skills

For more information on clubs, training and events you can visit [www.canoe.org.au](http://www.canoe.org.au).



Figure 89.1 Kayaking



Figure 89.2 Basic canoeing



Figure 89.3 Canoeing

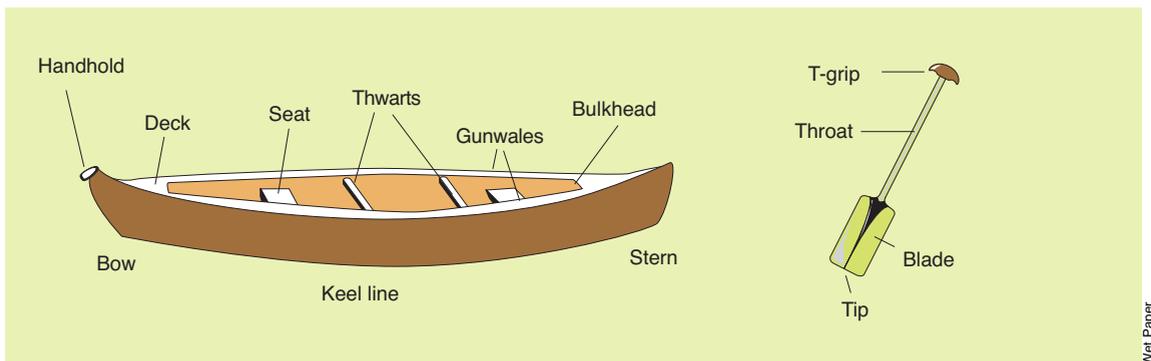


Figure 89.4 Parts of a canoe

# Power boating

## Terms

Common boating terms are listed below and illustrated in Figure 90.2 - 90.4.

- **Hull** refers to the body of the boat in which the passengers travel. The hull is designed to float on water and move easily through it.
- The **gunwale** is the top edge of the boat, often where the deck joins the sides.
- The **bow** is the front part of the craft, generally it is more pointed than the stern or rear part.
- The centre line at the bottom on the outside is called the **keel**.
- The left side is always called **port** and the right side is always **starboard**.
- The **oar** (Figure 90.2) goes through a **rowlock** and has an oar stop, grip, shaft and blade. You should have two oars with stops and rowlocks which are strapped down so they don't move about.
- The **transom** plate at the back is where an outboard motor can be attached.
- **Ribs** reinforce the inside of the hull.

When the boat is in the water, certain terms describe certain places and positions (Figure 90.3):

- **aft** is from the middle of the boat to the stern;
- **forward** is from the middle of the boat to the bow;
- **ahead** is the water in front of the boat; **astern** is the water behind the boat and
- the **beam** is the widest part of the boat.



Figure 90.1 Power boat

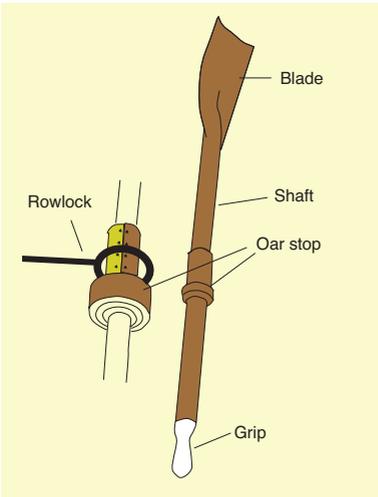


Figure 90.2 Parts of the oar

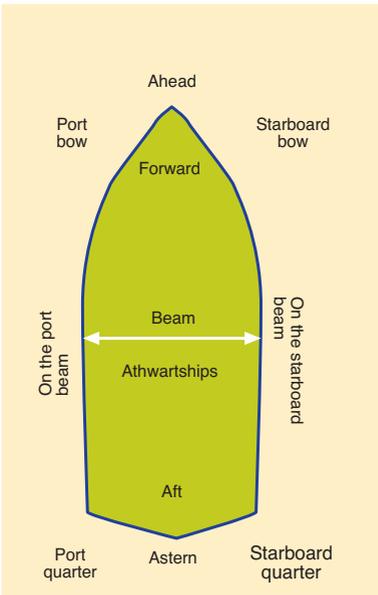


Figure 90.3 Positions on a boat

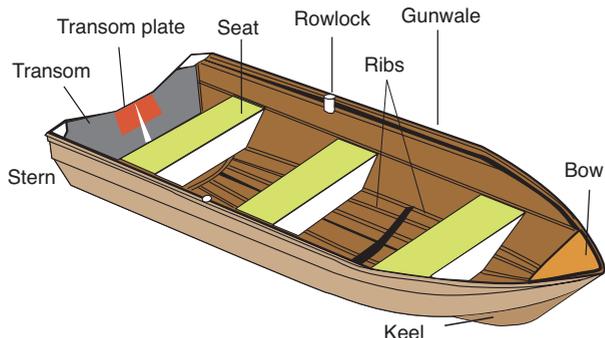


Figure 90.4 General boating terms

Wet Paper

Hulls are made in different shapes, however the flat bottom and V-bottom shown in Figure 91.1 are common.

## Safety equipment

Boating safety regulations cover such things as carrying compulsory safety equipment, speed limits and rules of the road.

Safety equipment varies according to a vessel's size, shape and area of activity. For example, a small aluminium dinghy would require less safety equipment than an ocean-going vessel.

Refer back to Chapter 1 for information and photographs of a fire extinguisher, EPIRB, flares, marine radio, yachting safety line, first aid kit, signalling horn and compass.

Another item of safety equipment is a V-sheet — a sheet of orange plastic with a black V painted on it (Figure 91.2). Tie it to your boat where it can be clearly seen when you are in distress. Other ways of signalling at day and night are shown in the two different types of flare (Figure 91.5).

## Outboard motors

Outboard motors get their name from where they sit — the whole unit is hung over the stern completely outside the boat. Clamps hold the motor to the **transom**.

The **outboard motor** is made up of a motor, leg and propeller (Figure 91.3). The motor is almost always a petrol engine that runs on a mixture of petrol and oil.

This special outboard mixture can be mixed yourself or purchased from local service stations.

Petrol is delivered to the motor by a flexible fuel line from the **fuel tank**, which is placed in the boat. The fuel line usually has a primer bulb in it to pump fuel to the motor when the line is first connected.

The leg contains a drive shaft from the motor to a right-angle drive at its base. This drives a small shaft to the **propeller**.

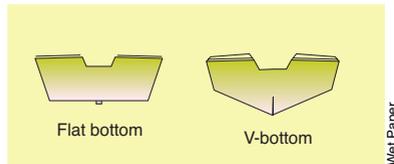


Figure 91.1 Some types of hull



Figure 91.2 V sheet



Figure 91.3 Outboard motor

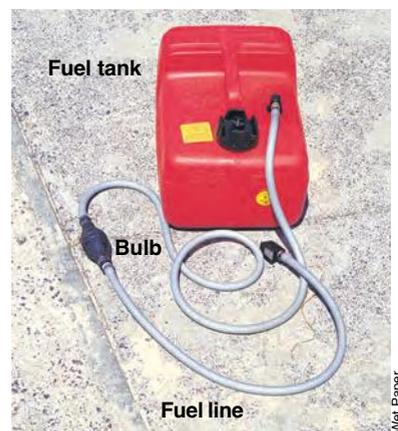


Figure 91.4 Fuel tank



Figure 91.5 Orange (day) and red (night) flares



Figure 92.1 Anchor on a yacht

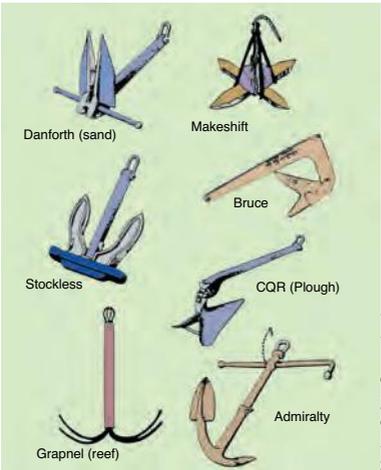


Figure 92.2 Anchor types



Figure 92.3 Fitting the bung



Figure 92.4 Getting into a small boat

The drive shaft also drives a small pump which takes water up to the motor to cool it. Run water through the motor whenever you use it. Flush the motor with fresh water after each use in salt water to prevent corrosion. The propeller (or prop) is designed to push the boat forward or pull it backwards depending on the direction of the rotation.

### Anchors

An **anchor** is mostly used to control a boat in currents. An anchor rope connects the anchor chain to the boat. The chain helps weigh the anchor down, making the **fluke** (Figure 92.1) stick into the ocean bed. In large boats, the anchor chain is extremely important because it stops the anchor from dragging. A variety of anchors have been designed to hold boats on different sea beds.

### Bailers

In normal operations, particularly in choppy conditions, some water is bound to enter the boat over the bow or the gunwale. You need a bucket or **bailer** and rope to remove water from inside the boat. Obviously the baler will be very handy if you hole your hull, capsize the boat or forget to put in the bung (Figure 92.3).



Bailer

### Skills

#### Embarking and disembarking

**To get into** a dinghy, grip the gunwale with one hand and step in with one foot into the boat as shown in Figure 46.3. Now rest your other hand on the seat or the far gunwale and lift the other leg in.

Now that you are in, remember that when your body shifts, so does the centre of gravity and the boat will move accordingly. Always distribute the load evenly in the boat to make it as stable as possible. If others are in the boat, they should assist by leaning away from you as you get in.

**Disembarking** is almost the reverse of embarking. The key to getting out is to make sure you are in shallow water! Don't jump. Instead, grip the gunwale, rest one hand on the seat to steady the boat, and disembark one foot at a time. Always be careful when disembarking because oysters, broken glass and sharp objects can seriously injure your feet.

#### Rowing

**Rowing** is a skill that is easily mastered, but practice continues to make perfect. In European countries, we row sitting down with our backs to the bow. In many Asian countries, rowing is done standing up, facing the bow.



Wet Paper

Figure 93.1 Rowing a small boat

### Rowing suggestions

- Sit in the middle facing the stern as shown in Figure 93.1.
- Get comfortable, make sure the boat is well balanced and that you are centred in the middle of the seat.
- Make sure the rowlock ring is located correctly in the oar stop and then place the rowlock shaft in the rowlock block.
- If necessary, adjust the oar stops to suit your boat. The oar grips should not hit each other when the oars are in the rowlocks.
- Take the oar grips in each hand and turn the oars so the blades are perpendicular, then push down and away from your body. This will place the blades towards the bow, out of the water.
- Lift the grips to dip the blades into the water and pull back until the blade passes you (your hands are nearly at your abdomen now).
- Push down (to lift the oars) and away from you to return the blades towards the bow.

Repeat the cycle. Notice that your hands are almost doing a circle as you row. Here are some hints to improve your rowing:

- don't try too hard, a nice, slow rhythm is best;
- use equal strength on each oar;
- dip the blades just under the surface; and
- line up a couple of landmarks and keep looking at them as you row. This will keep you rowing in a straight line.

### Steering

When rowing, you are the propulsion unit working through the oars. If both oars are pulled with equal strength, you go forward. If both oars are pushed with equal strength, you go backwards. If the oar in your right hand is pulled, then the boat goes to starboard. If the oar in your left hand is pulled, the boat goes to port. All manoeuvres, including turning, are based on this.



1. Which type of PFD would you wear in the following situations?
  - a. canoeing on a dam;
  - b. water skiing on a coastal river;
  - c. yacht racing on Sydney Harbour;
  - d. going out in a cray boat off Geraldton.
2. If your aluminium dinghy capsized in the river, draw a flow diagram to show the steps you could take to get it back to shore.
3. Why tie your baler onto the boat?
4. Why is it necessary to tell someone your planned leaving and return times, as well as where you intend to go, before going boating?
5. Explain these statements using everyday English:
  - a. Whale off the starboard bow.
  - b. Full speed astern.
  - c. Outboard motors are fastened to the transom.
6. Name any five strokes or manoeuvres you could learn while canoeing.
7. In sailing, what do the halyards do?



Wet Paper

Figure 93.2 Learning how to row



Figure 94.1 Starting the motor

Wet Paper

## Starting the motor

Outboard motors run on fuel from a fuel tank as shown in Figure 94.2. Connected to the tank is a fuel line which is connected to the outboard motor as shown in Figure 94.3. The **primer bulb** is used to deliver fuel to the motor when starting. The **starter cord** is used to ‘kick the motor over’ in neutral gear just like the starter motor in a car. It’s a good idea to start the motor while you are inside the boat while one of your team mates holds the boat steady. Once the motor is started, your friend can push you out and you are ready to get under-way.

## Under-way

The propeller on the outboard motor moves the boat and is controlled by two gears – forward and reverse.

The speed of the boat is governed by the **throttle** which controls how much fuel you give the motor. Open the throttle and you will go faster, close the throttle to slow down but remember boats don’t have brakes and you will need to learn a new set of skills when learning to stop in the water.

When stopping the boat you have to judge how far you will travel once the throttle is turned off and when you need to put the engines in reverse.

## Slow water skills

An outboard motor mounted at the back of a boat as shown in Figures 94.1 and 94.3 behaves differently to the steering wheel of a car. If you turn the motor one way, the boat will go the other and the best way to learn these new skills is at slow speed. A lot can be learnt by driving in forward and reverse. You can observe which way you are going by looking at the direction in which the motor is pointing.

## Advanced water skills

The Wet Paper student workbooks on power boating and navigation provide the theory behind your boat licence and Australian Yachting Federation programs. The books are available from Wet Paper at:

[www.wetpaper.com.au](http://www.wetpaper.com.au)

Further qualifications can be obtained through a training service provider or

[www.yachting.org.au](http://www.yachting.org.au)

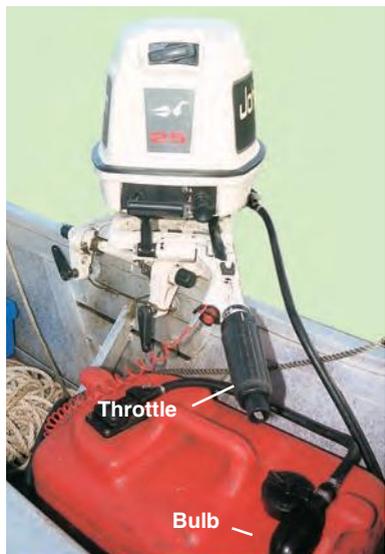


Figure 94.2 Parts of the fuel system

Wet Paper



Figure 94.3 Slow water skills

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Figure 94.4 On the plane

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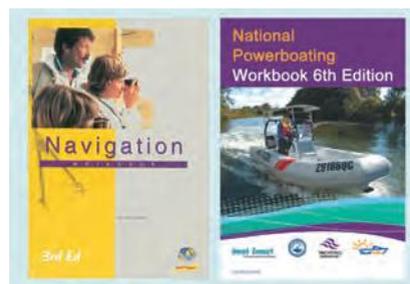


Figure 94.5 You can read more about navigation and boating in the Wet Paper Workbooks.

## Boat licencing and registration

Each state has its own scheme for licencing and registration and your telephone directory will help you locate the relevant government department. Licence and registration requirements rarely apply to canoes or sailing boats.

**Registration** refers to the numbers and stickers that are placed on a registered powerboat. Governments demand that power boats be registered and they then use the money collected to provide services to the boating public: boat ramps, charts, navigation lights and safety education programs.

## Boating and the environment

The type of boating you choose depends on personal preference. Canoeing is the most environmentally friendly because it is short term, requires little maintenance or equipment and you supply the energy. Sailing and power boating require a lot of gear, high energy in manufacturing the craft and accessories and often a vehicle and a motor to get the boats to the water and power them when there is no wind.

In addition, many anti-fouling chemicals used on sailing boats wipe out entire coastal populations of animals. Today laws make it compulsory for boats to have **pump out facilities** (Figure 95.3).

It is also important to follow the simple rule of ‘Stow it – don’t throw it’. What ever you take out with you, make sure you bring it home. Good meal preparation and planning helps obey this rule. For example consider taking minimal packaging. Drinks in reusable bottles and tins that can be crushed easily all make for easy stowage.

Plastic that blows overboard causes many marine animals serious harm and death in extreme cases.



Figure 95.4 Stow it - don't throw it!



Figure 95.1 Private provider training



Figure 95.2 Boat licence schemes



Figure 95.3 Modern pump out facility on a house boat



Figure 95.5 Plastics harm marine creatures

# Boat building

## Boat design

In ship building, scale models are used to test the design. These models are basically small versions of the ship that the designer wants to make. It is important that the model looks like the ship and acts like the ship (Figure 96.1).

**Ship designers** often do their testing on models in order to develop cost-effective, high-performance ships. Testing is cheaper, less time-consuming, and safer when carried out on models rather than on full scale ships. By placing the model in a test tank (Figure 96.2), designers can measure handling characteristics such as stability in heavy seas, resistance to forward motion, and power required to move at a certain speed.

Sometimes ship designers must build and test several models, particularly if they are working under strict requirements regarding speed, fuel cost, and the ship's effect on the environment. Years ago, one or two tests were enough to ensure that the actual ship would satisfy design requirements.

Today, however, ship designers must find ways to lower fuel costs and reduce pollution from engines, so it has become more important to design efficient hulls. Designers often test models and make modifications many times for each design.

One measure of ship designers' success with models is how much they can reduce the cost of running a ship over a 20 - year lifespan. It is not unusual to obtain a 10 - 15% improvement as a result of careful model testing. These gains can be obtained by making small changes in the shape and finish of the hull, the size of the propellers, or the power of the engine.

## Parts of a hull

Important parts of a hull are shown in Figures 96.5 and 97.1.



Figure 96.1 Test hull

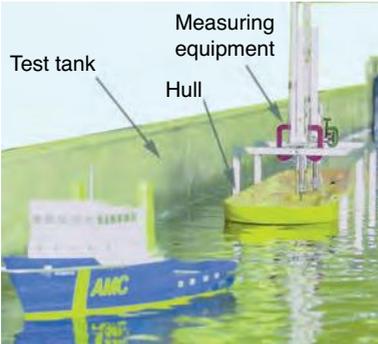


Figure 96.2 Test tank

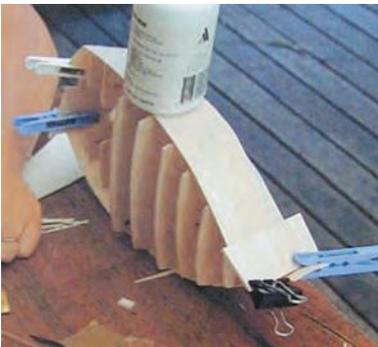


Figure 96.3 Student model hull design



Figure 96.4 Aluminium dinghy fabrication

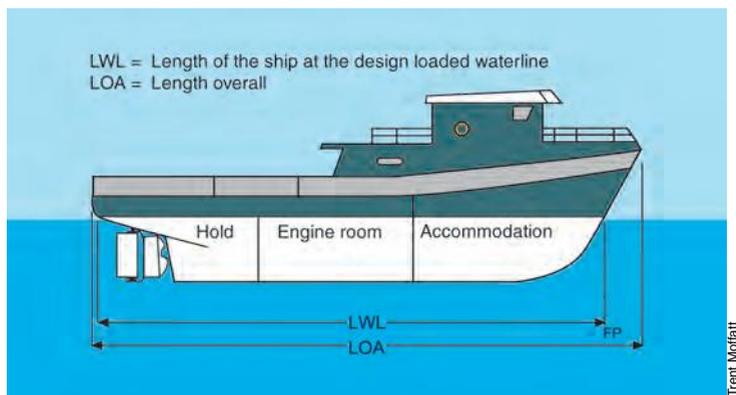


Figure 96.5 Parts of a hull

(From Small Ships Manual Courtesy Marine Safety Queensland)

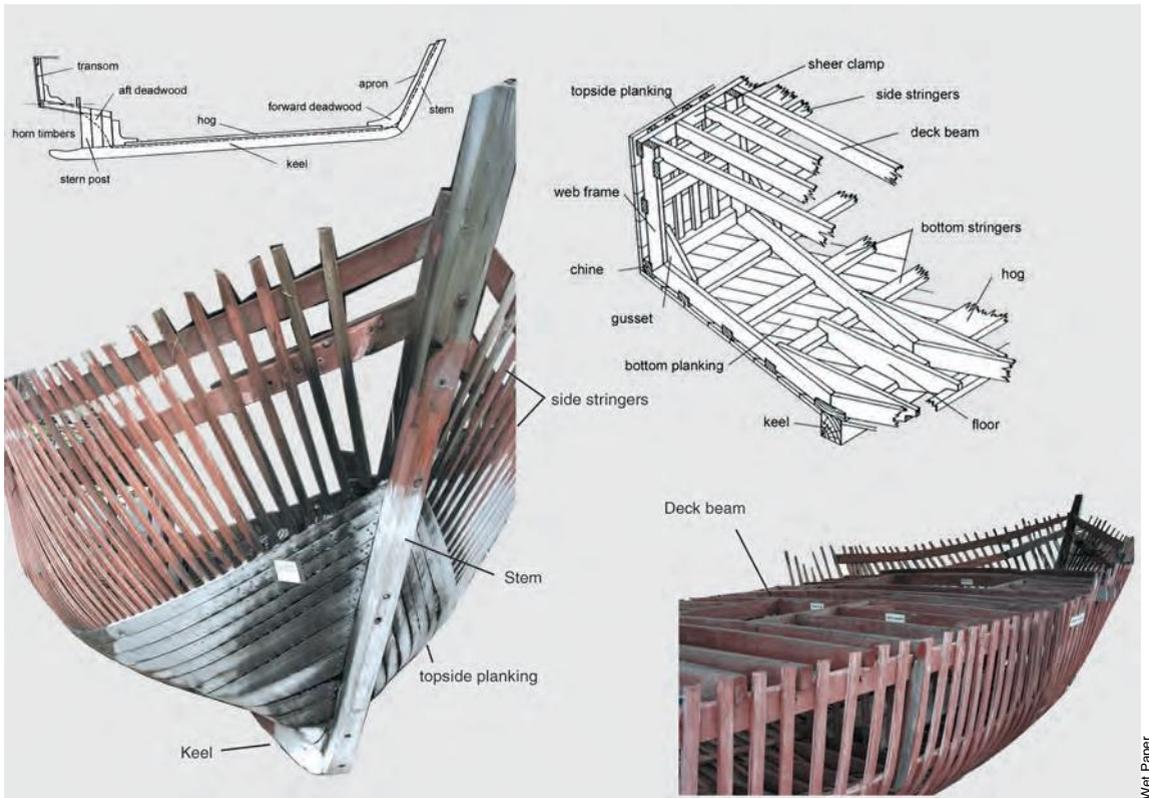


Figure 97.1 Parts of a hull  
Marine Safety Queensland

## Employment opportunities

A variety of boatbuilding techniques like glassing and fibreglassing are available in boat building as well as the opportunity to develop into a highly-skilled tradesperson.

As a boatbuilding apprentice you would learn how to build boats of all sizes, construct the frames through to the completion of the hull and superstructure, design and fitout of the interior and secure the exterior components of the vessel. Apprentices working in boatbuilding companies have the opportunity to build aluminium powerboats, classic harbour cruisers, super yachts, right through to luxury sports boats.

Building boats is practical work, and the biggest reward is seeing the new boat that is ready for launching and knowing you helped build it. It is a creative enterprise that enables boatbuilders to plan and work with their hands and minds to take the concept and design of a boat through to the finished product.

The marine industry offers various career prospects including boat manufacturing, boat sales, marina operations, boat servicing, sail making, mechanical repairs and charter operations.



Figure 97.2 School project boat



Figure 97.3 Completed school boat

## Diving deeper



1. Use the library to research the voyages and adventures of Sinbad the sailor.
2. See what you can find out about the spice trade and the voyages made from Europe to the spice islands.
3. Find out the uses for the anchors in Figure 92.2.
4. Talk to your teacher about setting up a simple experiment to test the effects of salt and fresh water on the materials used to build boats.
5. Look up the meanings of nautical terms at the Seaman's Vade Mecum website on the Internet.
6. Obtain a hull design and make a model boat as shown in Figure 96.3. Test it in a wave tank.
7. Build a tender boat as shown in Figures 97.2 and 97.3.
8. Search for boating history on the internet or in your library. Find out what the *coracle* was and who invented it.
9. Visit a maritime museum.
10. Take a family trip on a houseboat and keep a trip diary.
11. Visit the Australian Maritime College web page and list the research undertaken on their flume tanks.



[www.amc.edu.au](http://www.amc.edu.au)

## Key words

Aft, ahead, anchor, astern, bailer, beam, beam reach, boat hull test tank, Boatsafe, boom, bow, centreboard, cleats, deck, dinghies, fluke, gunwale, halyard, hull, jib, keel, licence, main sheet, mainsail, mast, oar, outboard motor, paddle, port, primer bulb, private provider, propeller, pump out facility, reaching, registration, ribs, rowing, rowlock, rudder, sailing school, sheets, starboard, starter cord, tacking, throttle, thwarts, transom.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Power [1] \_\_\_\_\_ requires different skills yet again. To operate a power boat you will usually have to obtain a [2] \_\_\_\_\_ by demonstrating your skills to a testing [3] \_\_\_\_\_ and sitting for a [4] \_\_\_\_\_ exam to ensure you know the boating [5] \_\_\_\_\_ .
- b. To use the wind to [6] \_\_\_\_\_ your boat, you will have to learn how to make the sailing boat go **with** the wind and [7] \_\_\_\_\_ it. [8] \_\_\_\_\_ and [9] \_\_\_\_\_ are two ways this can be achieved.
- c. [10] \_\_\_\_\_ can carry one or more passengers, are pointed at both ends and are propelled by [11] \_\_\_\_\_. Most canoes are made out of [12] \_\_\_\_\_ , easily repaired material.
- d. [13] \_\_\_\_\_ motors get their name from where they sit – the whole unit is hung over the stern completely outside the boat. [14] \_\_\_\_\_ hold the motor to the [15] \_\_\_\_\_ .
- e. An [16] \_\_\_\_\_ is mostly used to control a boat in currents. An anchor rope connects the anchor chain to the boat. The chain helps weigh the anchor down, making the [17] \_\_\_\_\_ stick into the ocean bed.
- f. To get into a [18] \_\_\_\_\_ , grip the [19] \_\_\_\_\_ with one hand and step in with one [20] \_\_\_\_\_ into the boat. Now rest your other [21] \_\_\_\_\_ on the seat or the far gunwale and lift the other leg in.
- g. The [22] \_\_\_\_\_ of the boat is governed by the [23] \_\_\_\_\_ which controls how much fuel you give the motor.
- h. As a boatbuilding [24] \_\_\_\_\_ you would learn how to build boats of all sizes, construct the frames through to the completion of the hull and [25] \_\_\_\_\_ , design and fitout of the interior and secure the exterior [26] \_\_\_\_\_ of the vessel.

# Chapter 8 Snorkelling

Note: Snorkeling (American English)



## Web reference

<http://www.snorkeling.info>

As land animals, humans have no adaptation for life in water because we -

- cannot breathe underwater,
- cannot see well underwater,
- have difficulty propelling ourselves through it,
- loose heat and
- we have problems staying afloat.

Because of this many of us never go to sea and those that do tend to stay on the surface.

**Snorkelling** and snorkel diving require equipment that helps us overcome some of our body's limitations when we go into the sea. We put on a glass safety mask to trap air in front of our eyes so we can see; we extend our windpipe with a snorkel so we can breathe; we use fins to lengthen and flatten our legs for propulsion and we wear an artificial skin to keep us warm.

Using this equipment we can experience marine life in its natural environment. We can feel the water pressure and observe how light changes as we dive deeper into the sea. We can quickly see how the seascape differs from the landscape.

On land, we can build fences, cut down trees and build roads. We can control the land and influence the lives of the land animals and plants that we share it with. When you snorkel under the sea, you quickly learn that the seascape is largely unaltered by humans; its topography so far has been left unchanged and we have little control over sea life.

Snorkelling shows us the underwater world in its untouched state, something that is difficult to find on the land because we have altered it so much. If the world under the sea is to remain untouched so that our children will be able to appreciate the natural wonders of the ocean world, we will have to change our attitudes about changing the land.

## Our underwater history

Carved stone tablets from ancient civilisations contain the first records of humans swimming underwater (Figure 99.3).



Figure 99.1 Snorkelling inshore



Figure 99.2 Snorkelling enables us to observe underwater life.

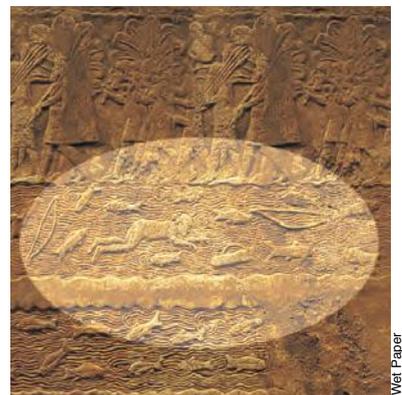


Figure 99.3 Ancient tablets show people swimming with fish. (Photo taken at the Louvre, Paris)



Figure 100.1 The reed snorkeller  
After Sea World

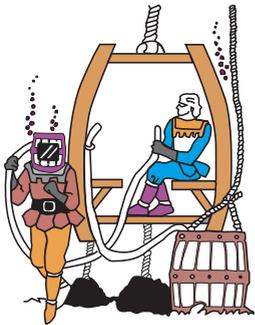


Figure 100.2 Halley's bell  
After Sea World



Figure 100.3. The helmet diver  
After Sea World



Figure 100.4 The modern diver  
After Sea World

The first snorkellers (shown in Figure 100.1) probably used a reed to breathe underwater. Records as far back as 2250 BC tell us that divers held their breath while diving to bring back pearls and other valuables from shallow water.

Other diving methods included filling a bag made of goat skin with air then breathing from it underwater. However, as the diver breathed in the fresh air, he breathed back into the bag, which soon filled with carbon dioxide. Many divers blacked out underwater and drowned.

Edmond Halley (1656–1742) invented the **diving bell** (Figure 100.2), using the principle of air trapped underwater. Try turning a glass upside down and carefully pushing it underwater.

You can see that air is trapped as long as you hold the glass straight. Large rocks kept Halley's bell vertically submerged and the air inside the bell was replaced by fresh air from barrels on the surface. Halley claimed that he could stay submerged for more than an hour.

However, divers still wanted the freedom of being able to walk around underwater. The breakthrough came in 1840, when August Siebe invented the hard-hat **diving suit** consisting of a metal helmet, with three glass plates for vision, that was secured to a leather suit using a heavy, watertight, metal collar (Figure 100.3). The diver used lead boots to stay submerged and air was supplied by a hose connected to a pump on the surface.

Robert Boyle (1627–91) had discovered that water pressure on the body increased as the diver descended. People using Siebe's suit experienced the problems of diving deeply for the first time, including pressure on the eardrums. Many divers suffered terrible injuries as a result.

In 1943, Jacques Cousteau and Emile Gagon invented the **regulator**, a device which allowed divers to breathe compressed air. For the first time, breathable air could be carried in a small cylinder light enough to be strapped to the diver's back, leaving their hands free to swim and explore underwater.

The combination of air tanks, regulator and mouthpiece became known as self-contained underwater breathing apparatus or scuba (Figure 100.4).

## ***The joy of snorkelling***

Snorkelling takes us back to the first reed-breathing divers and can be enjoyed by people of all ages. **Scuba diving** is expensive and not suitable for everyone, but snorkelling is easy to learn and only needs basic equipment.

A **snorkel** is the name given to the actual tube that enables you to breathe while floating face down in the water.

Snorkelling enables you to appreciate the underwater world first-hand (Figure 101.3). To watch barnacles feed, to see fan worms come out of their tubes or to experience your heart racing as you see a white-tipped reef shark is to experience the joy of snorkelling.

## What you will learn snorkelling

Learning to snorkel teaches you, among other skills, how to enter the water, float, duck dive, clear your mask and be comfortable underwater (see Figure 101.2).

Figure 101.1 shows two ways to enter the water. Use the giant stride to enter a pool and a backward roll to get into the water from a boat

Once you enter the water you will probably want to have a good look around. Floating face down while breathing through your snorkel is an excellent way to do this (Figure 101.3).

You may see something interesting and want to duck dive to get close to it. On the way down you will need to **equalise** or make the changing **pressure** comfortable in your ears. Equalising is done by pinching your nose, closing your mouth and blowing gently (see part of Figure 101.2).

Once you come up for air, you will need to clear your snorkel by blowing the water out. Your mask may get some water in it and you will have to learn how to clear it.

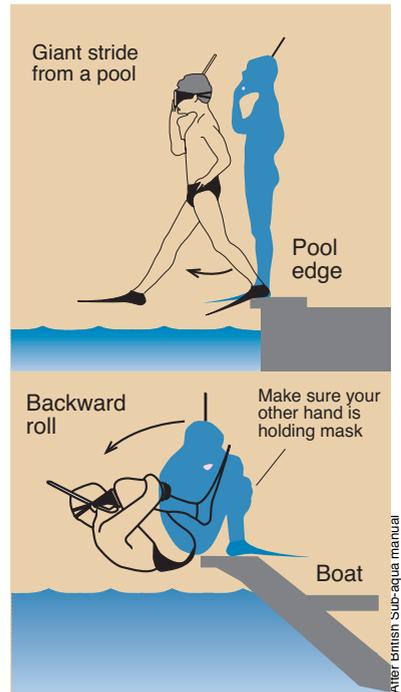


Figure 101.1 Two ways of entering the water



Figure 101.2 Some snorkelling skills  
Rose Bedford



Figure 101.3 Some things you will see and learn while snorkelling.



You can learn more about snorkelling in this workbook  
[www.wetpaper.com.au](http://www.wetpaper.com.au)



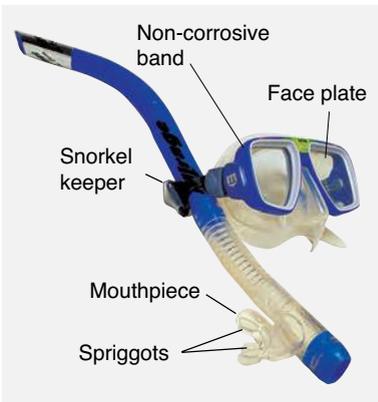
Rob Lucas

Figure 102.1 A mask helps you see better underwater.



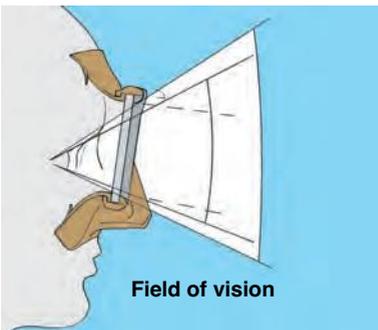
Wet Paper

Figure 102.2 Testing your mask for fit



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Figure 102.3 Parts of a mask and snorkel



NAUI

Figure 102.4 Features of a mask

## Snorkelling equipment

The basic equipment for snorkelling is a mask, snorkel, fins, wetsuit (for colder climates), stinger suit (for tropical summer climates), sandals or booties and a weight belt. In general, the choice of equipment is based on three principles.

- Firstly, comfort. Any piece of equipment selected must be a good, firm but comfortable fit which can be worn for long periods without causing any discomfort.
- Secondly, how much money do you have to spend? Look for quality when purchasing equipment even though it may cost more.  
Cheap, inferior equipment does not last long and may even be a threat to your safety, for example, a mask that is made with safety glass is more expensive but is less likely to damage your eyes if broken.
- Finally, suitability. Different localities or activities may require specialised equipment: for example, a thicker wetsuit for colder water and a stinger suit to protect you from jellyfish in tropical summers.

### Masks

A **mask** places a layer of air between your eyes and the water and allows you to see better underwater (Figure 102.1). Modern masks made from silicone compounds are practical and comfortable. They are more expensive than rubber ones, but they last longer and are generally less affected by ozone and chlorine. When choosing a mask, think about the following points.

- The mask should be a comfortable, watertight fit, preferably with a soft double seal. Check the fit by placing the mask on your face (without using the straps) and inhale gently through the nose (Figure 102.2). A mask that fits should stay in place.
- The face plate(s) or window must be made of safety glass and should be secured with a non-**corrosive** band (Figure 102.3).
- The mask should be made of good quality **silicone** and have compensation depressions in the bottom. Purge valves are optional devices which make clearing the mask easier but may leak.
- A flexible but heavy, split strap with easily adjustable locking devices provides greater security and comfort underwater.
- A low-volume mask is easier to clear, and increases your field of vision (Figure 102.4).

After you have bought your new mask, remove the manufacturer's film on the glass by scrubbing the surface with

a soft toothbrush and mild toothpaste. This will reduce fogging. After use, all masks need to be washed clean with fresh water, dried away from sunlight and stored in a container. Never leave masks near heat.

### Safety note

Never wear ordinary swimming goggles when snorkelling because there is no way you can equalise pressure around your eyes or clear water from inside during a dive.

## Snorkels

Snorkels can be made of silicone, plastic or rubber (silicone lasts longer). They are usually a smooth, contoured J-shape without any sharp bends.

Snorkels have a soft **mouthpiece** with tags called **spriggots** for you to grip with your teeth while breathing (Figure 102.3). The tube is made of a flexible material to prevent it snagging. This reduces the risk of injury, or of having your mask flood.

The snorkel is usually attached to the mask straps on the left side of your head with a snorkel keeper or rubber band. Snorkels with a smooth inside surface trap less water. Extend your lips so the snorkel mouthpiece seals between your teeth and lips (Figure 103.1). This will stop water getting into the snorkel.

Figure 103.2 shows two snorkels. The snorkel on the right (B) has a larger bore than the one on the left (A), so (A) would suit you better if you had a small lung capacity.

## Fins

Rubber or synthetic polymer **fins** are worn on the feet to propel the snorkeller through the water.

Fins can be open-heel or full-booted. Which you choose is a matter of budget and personal choice, however, the following points should be considered.

- Open-heel fins require wetsuit booties to be worn inside. These fins are secured by adjustable buckles. They should be light, neutrally buoyant, with a semi-rigid, wide blade extending forward of the toes by at least a foot length and ending in a flexible whip tip (Figure 103.3).
- Full-boot fins are less expensive and should be slightly larger than your shoe size to reduce cramps. They should have the other features of the open-heel fin. These full-boot fins can come off when you are swimming.
- Remember that the longer or wider the fin blade (resulting in increased power), the more effort you must use to swim.



Figure 103.1 Some tips to make sure your mask and snorkel do not leak.



Figure 103.2 Snorkels range in size, shape and bore size



Figure 103.3 Open-heel fins and booties



## Questions

Use your textbook to find the answers

1. How is the sea different from the land and how does snorkelling help us appreciate this difference?
2. Why was Halley's bell considered such a great advance in underwater exploration?
3. Give three points to consider when selecting snorkelling equipment.
4. What is the difference between open-heeled and full-booted fins?



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Figure 104.2 Fins used by snorkel boat operators



NAUI and Stinger Suit

Figure 104.3 Wet suits (L) Stinger suit (R)



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Figure 104.1 Fins help propel you through the water.

New technology has made fins stronger, lighter and more efficient but you must use them correctly. The best place to learn snorkelling skills is in a pool under the guidance of a qualified instructor.

### Stinger suits

In Northern Australia, snorkellers use stinger suits (Figure 104.3 (R)) to protect themselves from sea jellies and marine stingers. The fabric of the suit protects the skin from the dangerous stinging cells of the box jellyfish and Irukandji (See pages 37 and 47).



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### Wetsuits

The **wetsuit** is made of rubber **neoprene** impregnated with millions of tiny nitrogen-filled cells. When cut, it looks like a sponge. Wetsuits reduce heat loss in the water and therefore reduce the chances of cramps and or **hypothermia**.

The wetsuit traps a thin layer of water between your skin and the rubber (Figure 105.1). This stops fresh cold water from circulating around the skin and cooling your body. The trapped water actually heats up because of friction and heat coming from the body. This helps the wearer keep warm.

A wetsuit should fit snugly so that none of this heated water can escape while you are swimming. For complete warmth, add booties and a hood to prevent heat loss from the feet or head. Your wetsuit will also protect your body against cuts, abrasions, stings, bruises and sunburn while snorkelling.

Your choice of suit depends upon the type, locality and duration of your snorkelling as well as how much you can afford to spend. You should think about the following points.

- The wetsuit should fit closely and neatly to prevent water flow, but not so tight as to cause chafing or restrict circulation.

- When trying on a suit, make sure there are no spaces under the arms, neck, crutch or the extremities of the sleeves or trousers.
- The thickness and length of your suit depend on the temperature of the water in which you are going to use it. A spring suit made of 3 millimetres thick neoprene (Figure 105.2) would be quite adequate in warm tropical waters but you should wear a full-length, thicker suit in cold climates (Figure 105.3).
- A made-to-measure suit may be expensive but necessary if a well-fitting suit cannot be purchased off the rack.
- Tapes protect seams and provide easy identification. Lined seams reduce water leakage thus keeping the snorkeller warmer while sewn seams strengthen the joints by adding strength to places where materials join.

## Additional equipment

### Weight belts and gloves

**Weight belts** allow the snorkeller to achieve **neutral buoyancy** in water (see Chapter 6 - Sea water ). This is especially helpful when wearing a wetsuit because the neoprene makes the wearer more buoyant than normal. The weights on a weight belt are strapped to nylon webbing which allows the number of weights to be adjusted to suit your needs.

**Gloves** can be cumbersome if you want to take photos or need the full use of your hands. But they are ideal for protection against rocks, shells or fish life and can be a real comfort to the beginner.

### Underwater cameras and housings

Modern digital cameras now have underwater settings and housings which take great photos underwater (Figure 105.5).



Figure 105.5 Underwater camera housing  
Photo courtesy Canon

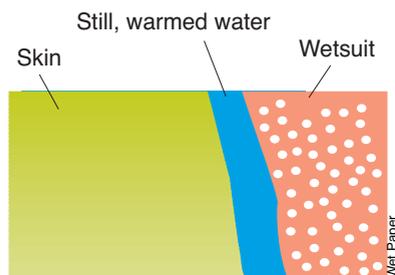


Figure 105.1 How a wetsuit works.



Figure 105.2 Use a spring suit in tropical waters.



Figure 105.3 A full-length suit is used in colder waters.



Figure 105.4 Weight belt and gloves

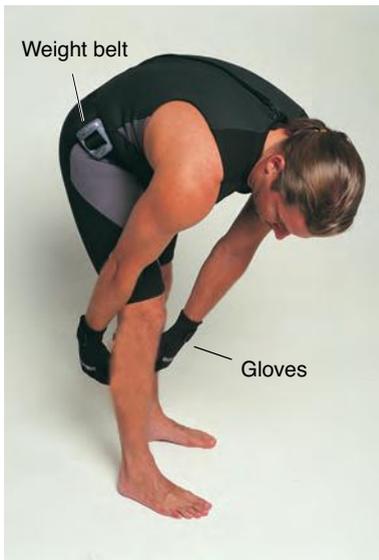


Figure 106.1 Additional snorkelling equipment

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## Caring for your equipment

See also Chapter 4

If you look after your equipment, it will last for a long time.

- Mark all your equipment for ease of identification, especially if you are going on a group excursion.
- Most fins, masks and snorkels last well as long as they are washed with fresh water after use and kept away from heat.
- Store your mask, fins and snorkel in a lightweight box sprinkled with talcum powder. The talc prevents rubber parts from perishing over a long period of time. After drying your equipment, load the items in the box, seal and shake. When you need them, just shake off the talc.



Snorkel gear carry bag

## Snorkelling safety

Make safety a priority when you are snorkelling. You can never predict what will happen underwater. Remember these points.

- Make sure you undertake a snorkelling course with a qualified instructor (Figure 106.2).
- Only snorkel in suitable weather.
- Check tide and current directions.
- Ensure you have safety equipment on the shore and an emergency plan (for example, where is the nearest phone?).
- Be reasonably fit, you will enjoy yourself more.
- Have some warm, dry clothing back on shore and a hot drink for your return.
- Be alert for boats in the area that may cause you safety problems.
- Always snorkel with a buddy, especially on offshore islands and reefs.
- If cramps occur you should be able to relieve these by holding onto the top section of your fin (the one attached to the cramped leg). Pull it towards you to stretch the fatigued muscle. Your buddy can also help you do this.



5. What are some of the activities you will learn while snorkelling?
6. How can you stop a new mask from fogging up?
7. What is a low-volume mask and why is it useful?
8. In selecting a snorkel for a child, what should you consider?
9. Why is silicone a better choice than rubber in mask construction?
10. Draw up a snorkelling flowchart to show you would clear your mask.
11. Explain the term *neutral buoyancy*.
12. Justify the use of stinger suits in warm climates.
13. Estimate how many weights you would need to become neutrally buoyant.



Figure 106.2 Make sure you learn snorkelling from a qualified instructor.

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## Key words

Camera housing, corrosive, diving bell, diving, equalise, fins, hypothermia, mask, mouthpiece, neoprene, neutral buoyancy, pressure, regulator, safety, SCUBA, silicone, snorkel, spriggots, weight belts, wetsuit.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- [1] \_\_\_\_\_ shows us the underwater world in its untouched state, something that is difficult to find on the land because we have [2] \_\_\_\_\_ it so much.
- In 1943, Jacques Cousteau and Emile Gagon invented the [3] \_\_\_\_\_, a device which allowed divers to breathe compressed air. For the first time, breathable air could be carried in a small cylinder light enough to be strapped to the diver's back, leaving their hands free to swim and explore underwater.
- Snorkelling enables you to [4] \_\_\_\_\_ the underwater world first-hand. To watch [5] \_\_\_\_\_ feed, to see fan worms come out of their tubes or to experience your heart racing as you see a white-tipped [6] \_\_\_\_\_ is to experience the joy of snorkelling.
- The basic [7] \_\_\_\_\_ for snorkelling is a [8] \_\_\_\_\_, snorkel, fins, wetsuit (for colder climates), stinger suit (for tropical summer climates), [9] \_\_\_\_\_ or booties and a [10] \_\_\_\_\_ belt.
- A [11] \_\_\_\_\_ places a layer of air between your eyes and the water and allows you to see better underwater
- Snorkels can be made of [12] \_\_\_\_\_, plastic or rubber (silicone lasts longer). They are usually a smooth, [13] \_\_\_\_\_ J-shape without any sharp bends.
- Rubber or synthetic polymer [14] \_\_\_\_\_ are worn on the feet to propel the snorkeller through the water.
- Fins can be open-heel or [15] \_\_\_\_\_. Which you choose is a matter of budget and [16] \_\_\_\_\_ choice.
- The [17] \_\_\_\_\_ is made of rubber [18] \_\_\_\_\_ impregnated with millions of tiny nitrogen-filled cells. When cut, it looks like a sponge. Wetsuits reduce heat loss in the water and therefore reduce the chances of cramps or [19] \_\_\_\_\_
- Weight belts allow the snorkeller to achieve [20] \_\_\_\_\_ in water (see Chapter 6 – Sea water). This is especially helpful when wearing a wetsuit because the neoprene makes the wearer more buoyant than normal.

## Diving deeper



- Research the term '*hyperventilation*' and explain why it is dangerous.
- Find out what a buoyancy compensator is and write a paragraph on why it is useful.
- Find out how you can get cramps while snorkelling. and the best method for relieving the pain.
- Find out the name of your local dive shop and whether they run snorkelling courses and have a snorkelling or diving club.  
You may like to join.
- Invite an underwater naturalist to come and talk to your class and show some underwater photos.
- Watch the television guide for old movies on a Saturday or Sunday involving diving for underwater treasure.  
Invite a group of your friends over to watch them one afternoon.
- Make up a simple table to show obvious differences between the land and the sea.  
Use old colour magazine photos to illustrate your answer.
- Research the formula for Boyle's Law and make a poster on its importance to scuba divers.



# Chapter 9 Fishing

Warning. This chapter may contain the images of Aboriginal and Islander people now deceased.



## Web references

[www.fishnet.com.au](http://www.fishnet.com.au), [www.dpi.qld.gov.au](http://www.dpi.qld.gov.au),  
[www.fisheries.nsw.gov.au](http://www.fisheries.nsw.gov.au)



Figure 108.1 Fishing from the shore



Figure 108.2 Crabbing



Figure 108.3 A tackle box



Figure 108.4 Making a fishing rod

For thousands of years, fishing has provided many people with a lifelong recreation. Family life is enhanced by older generations passing on their knowledge to younger people.

Many Pacific Island nations still derive their sole source of animal protein from the sea, despite pressures on fish stocks in recent years because of increased use of better fishing equipment. Many nations now face severe fish shortages because of overfishing. Inappropriate methods such as dynamite fishing also reduced stocks before this type of fishing was banned throughout the world because of its devastating affect on the whole food chain.

Used properly, most fishing methods do not encourage overfishing. You can fish with a fishing rod (Figure 108.1), traps (Figure 108.2), a speargun, or a hand line. Spearfishing usually selects out the older fish that have already reproduced because spearfishers have the advantage over line fishers in that they can see and select the fish they catch. Crabbing is regulated to restrict people to catching only large male crabs.

Fishing brings many urban people close to the reality of life and death of our fellow animal species and underlines how dependent we are on animal protein in our diets.

Successful fishing combines knowledge of fish behaviour, understanding of different fishing methods, the skills of hooking the fish and the right attitude to take only the fish allowed.

## Amateur fishing

People fish for many reasons. Some people fish for food as discussed later and in Chapter 15, some for competition or as a sport, and others as a family activity. People who do not sell their fish are **amateurs**. The value of amateur or **recreational** fishing should not be underestimated as the amount of money spent on **tackle**, boats, travel and guided tours is enormous.

There are a number of ways in which amateur fishers catch their prey. Most amateur fishers are **anglers**, using a hook and line from the shore or small boat to catch fish.

# Fishing gear

## Catching fish

As a general rule, to catch a fish means you have to understand its structure and behaviour.

- Fish with teeth bite and can be used with a baited hook or a lure (Figure 109.1) that looks and behaves like food that the fish likes.
- Fish only eat certain food and bait must be on a hook that will fit into the fish's mouth.
- Fish move in estuaries with tides and eat at certain times of the tide.
- Fish seek shelter and feed by darting out at passing food while some are territorial and attack other fish that enter their territory.
- Fish congregate at reefs and under rocky outcrops.

To catch fish, all you need is a line, hook, sinker and some bait. A rod and reel make it easier to land fish. Other methods of catching fish involve nets, spears or traps.

## Fishing tackle

**Tackle** is the term used to describe items such as hooks, sinkers, lines or the make-believe bait called **lures**. A **tackle box** (Figure 108.3) contains additional items such as knives, hook releasers and sharpening stones.

A fishing tackle book (Figure 109.4) allows fishers to plan their fishing trip and select the correct bait, hooks, sinkers, time and tide.

## Hooks

Figure 109.2 shows the anatomy of a hook. The point is usually kept sharp with a file or sharpening stone though, in some cases, hooks can be sharpened chemically. The gape and throat determine the hook's size. Generally, the bigger hooks are used with larger baits to catch bigger fish.

## Lines

Fishing lines vary in thickness and composition. The **breaking strain** of a line determines the strength of the line and is measured by loading the line against a set of scales until it breaks. When you want to tie a knot in the line, wet the knot with a little saliva to cool and lubricate it as it tightens.

## Swivels and sinkers

A **sinker** takes the line, hook and bait down to the area where fish are feeding. The swivel is designed to stop the line from tangling.



Figure 109.1 A collection of lures

Dave Clardige

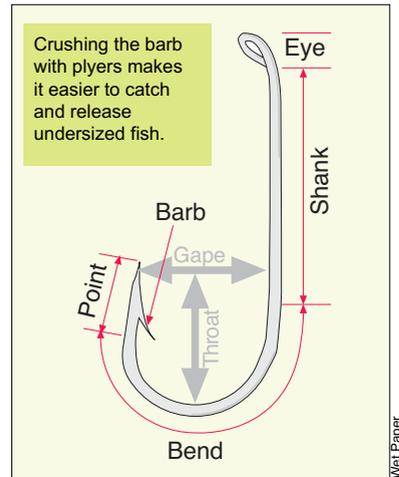


Figure 109.2 Anatomy of a fish hook

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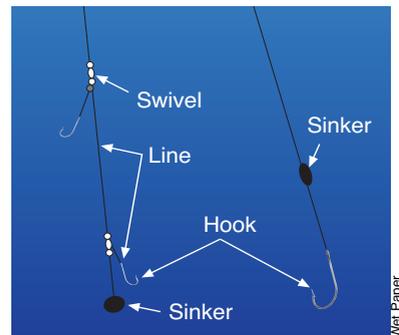


Figure 109.3 Terminal tackle

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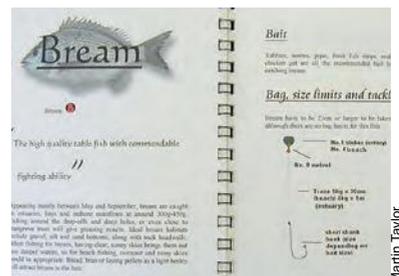


Figure 109.4 Fishing tackle book made by Year 9 student.

Martin Taylor



Figure 110.1 Beach fishing outfits

## Lures

Lures can be made in the classroom from a variety of materials such as wood, metal and even spoons. The lures can be painted with an air brush.

## Handlines

Handline casting is when the fisher throws their baited hook, line and sinker into the sea. Before casting, the handline may be wound onto a plastic or wooden spool, a cork or even an old bottle. A handline is sensitive and brings the fisher into very close contact with the line so that when the fish is hooked, the fisher can easily feel the pull that is the signal to haul the fish ashore or onboard. Handliners have to put up with the disadvantages of restricted casting abilities and the inability to reach over obstructions, as well as the odd cut finger or two from hauling in heavier fish. They also have to cope with line tangles if a freshly caught fish rolls around in their gear.

## Rods

The combination of a rod and reel is called an outfit; it makes casting easier and helps to prevent tangles. One type of outfit used by beach anglers is shown in Figure 110.1. To enjoy angling, make sure that the outfit you are using is properly balanced. A balanced outfit is one where the weight of the reel, the size of the line, the power of the rod and the lure or bait and sinkers all match. A big game reel loaded with 60 kilogram breaking strain line would be out of place on a light spinning rod designed for casting 5–10 gram lures. Local tackle shops can offer advice.

Modern rods are usually made from fibreglass, graphite or kevlar. A typical rod design is shown in Figure 110.2 and consists of the following parts:

- a butt, rear and foregrip that is used to hold the rod;
- a winch fitting used to hold the reel;
- the blank or shaft; and
- runners through which the line is fed.

## Reels

The **reel** is the circular drum around which fishing line is wound when using a rod. The **line** is attached loosely to run from the reel to the tip of the rod. Reels can be turned with handles which enable the successful fisher to wind the line back in when a fish is caught on the hook, and so retrieve the catch. Common types of reel are described on page 111.

## Sidcast

You can fish with a sidcast reel by releasing a swivel clip, turning the reel at right angles to the rod, and casting the tackle into the sea.

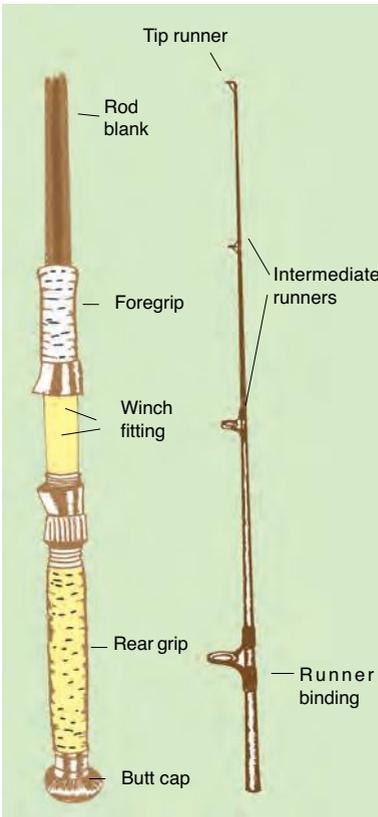


Figure 110.2 Parts of a rod  
Greg Wirth

Then bring the reel back to the position shown in Figure 111.1 and reel in the line by turning the handle. The biggest problem of the sidecast reel is line twist and you must use a small swivel above any terminal tackle.

These rugged reels are also rather heavy, although newer models use graphite to reduce weight. The sidecast reel's advantages are that it can cast very light weights and is rugged. For casting weighted baits from beaches or rocks, the sidecast reel is ideal and a sidecast is most likely to survive being dunked in the sea or sand.

Plain sidecast reels have no drag, fish are controlled with the palm of the hand. If there is a drag mechanism fitted it should be set in the same way as a spinning reel.

### Spinning and overhead

In a spinning reel, the line comes off the side of the spool so these reels are easy to cast without tangles or backlashes.

To use a spinning reel, release the bail before casting so that the line runs out (see Figure 111.2), then bring the bail back to its original position to hold the line steady for when you want to reel in the line. Spinning reels make it easy to cast very light lures or baits. Overhead reels have spools, which revolve when casting or retrieving. This makes them harder to use than some reels.

### Trapping fish

Recreational fishers use pots or traps to catch non-fish species now that nets are largely banned. Blue swimmer crabs and mud crabs can be caught by trapping or a line. Trapping uses a baited wire cage or wooden basket. Mud crabs or lobster are attracted to the bait, crawl inside the trap and then cannot get out.

### Pumping yabbies

Live bait is sometimes used to catch estuarine fish. A **yabbie pump** is used to suck the yabbie out of its burrow as shown in Figure 111.4. Sometimes a sieve is used to stop the yabbies from getting away. Once you have your yabbies, they need oxygen to survive and changing of water will keep them alive.



### Spearfishing

Fish can be caught with either a hand spear or a spear mounted in a gun (Figure 111.5). It is recommended that you join a spearfishing club to gain qualifications and experience as there are many health and safety considerations involved.

Figure 111.5 Speargun



Figure 111.1 Sidecast reel (After Alvey)

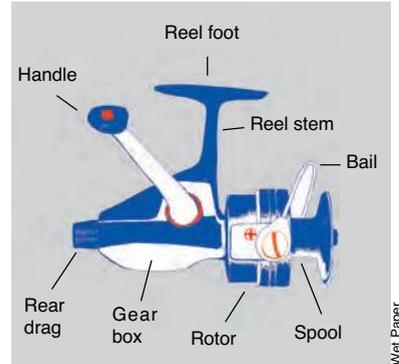


Figure 111.2 Spinning reel



Figure 111.3 Fish trap

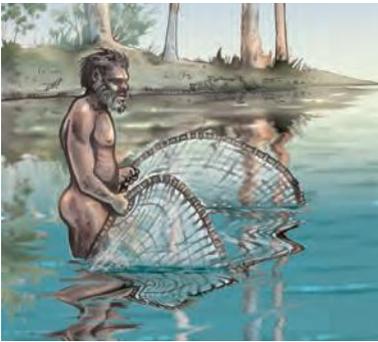


Figure 111.4 Pumping yabbies



Old fisheries

Figure 112.1 The sea is an important food source for coastal aboriginal people.



Kerry Kitzelman

Figure 112.2 Gombemberri fish net



Bob Moffatt

Figure 112.3 Island fish trap



Figure 112.4 Spears bound with plant fibre, about 1-2 metres long

## Aboriginal and Torres Strait Islander fishing

The sea is important to many of Australia's indigenous people, the Aboriginal and Torres Strait Islanders. Scattered around Australia's shores are huge mounds or middens of oyster, cockle and other shells, some many metres high and hundreds of metres long. These are the accumulated remains of Aboriginal peoples' meals, over many thousands of years. One of the oldest dated middens, on North Stradbroke Island (Qld), is over 25,000 years old. In Shark Bay (WA) shell middens have been dated at 22,000 years old.

Early European visitors to Stradbroke Island (Qld) described how the Quandamooka people used dolphins to chase mullet schools into their long nets. Each fisherman would have his 'pets', and call them by splashing spears on the water. Dolphins were sacred 'totems' or spiritual ancestors to some clans. The Quandamooka (meaning 'dolphin people') also hunted dugongs by harpoon, and with long, large-meshed, tangle nets. They collected pipis on ocean beaches, and oysters and other shellfish on sand banks. Today some of the Quandamooka people are commercial fishers and oyster farmers, and still harvest mullet schools as they migrate into Moreton Bay. They use modern beach seine nets, but still hold dolphins in special regard.

### Traditional fishing methods

The Gombemberri people of Southport (Qld) also hunted mullet with dolphins using spears and nets as shown in Figures 112.2 and 112.5. Aboriginal people of North Queensland made a brush fence of timber and wood swiches (Figure 112.3). The fish were forced into the nets on either side.



Kerry Kitzelman

Figure 112.5 Gombemberri people fish with dolphins  
Based on story from Graham Dillon, Kalwun Corporation, reproduced with permission

## Hooks and nets

Aboriginal and Torres Strait Islander hooks were made from shells such as abalone or pearl by burning in the centre of the shell to make it brittle (Figure 113.1). The hook is made by grinding into a crescent shape with a piece of coral or hard rock. The shell hook is then bound with plant fibre. Hooks were also made from kangaroo leg bones with the line made from twisted bark fibres.

Nets were often made using tough plant fibres and woven as shown in Figure 113.2.

## Torres Strait Islander fisheries

The Torres Strait Islanders, who live on the small islands scattered between Australia and New Guinea, are a sea people, and rely on the sea for most of their protein. Torres Strait is strewn with coral reefs and shallow seagrass banks, and its waters are rich in nutrients and flushed by strong tides.

At low water women gather clams and other bivalves and crustaceans from the coral reefs, and big mud crabs from the mangroves. Large stone traps or weirs were used to catch foraging reef fish as the tide receded (Figure 113.3).

As the tide comes in, women fish in the shallows with light lines for small colourful reef fish such as juvenile snappers, cods and wrasses. The men fish and hunt offshore for bigger game. Once they used big outrigger canoes, which they traded from the forest tribes of Papua.

Today these have been largely replaced by alloy dinghies and outboards which they use to troll for big Spanish mackerel, Queenfish and Trevally (Figure 113.4). They still hunt turtles and dugongs by harpoon from motor boats, slowly drifting down onto the feeding animals.

## Traditional fisheries management

Aboriginal and Islander people were careful not to over-exploit their marine resources. They protected their sea estates like their land, for their clan's immediate needs, and their future generations.

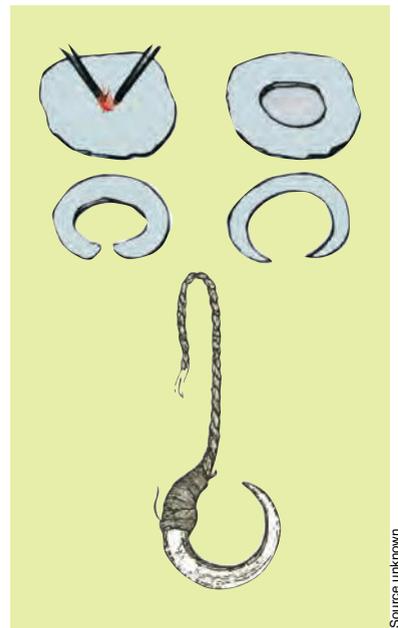


Figure 113.1 Making a fishing hook



Figure 113.2 Fishing net  
Wet Paper



Figure 113.3 Large stone trap



Figure 113.4 Aboriginal and Torres Strait Islander fishers today



Figure 114.1 Many family businesses rely on fishing.



Figure 114.2 Gill net

## Diving deeper



1. Visit a prawn trawler or local fishing vessel and ask the skipper to give a short talk on how the boat works. Take a small gift to show your thanks.
2. Visit a fish market and see what types of fish are available for sale. Write a short report.
3. Invite a local fishing club representative to your school and learn how to make your own fishing rod.
4. Ask your industrial arts section to help you design and construct your own fishing lures.

# Commercial fisheries

The text on the next three pages has been adapted from Chapter 20, *Marine Science for Australian Students* and was written by Prof. Leon Zann.

Australia's commercial fishing industry ranks fourth amongst the nation's rural food-based industries. Some 220 000 tonnes\* of fish, worth \$2 billion a year are caught in Australian waters. Prawns, lobster, abalone, scallops, oysters and tuna are most important. Finfish (sharks and bony fish) make up more than 60% by weight, but the high value invertebrates like abalone, prawns and crayfish provide 75% of the earnings. Fish are caught in a fishery and Figure 114.3 shows the tuna fishery.

## Employment

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 metres in length, and owner-operated. Deepwater trawlers and long-liners are much larger, over 15 metres in length.

## Commercial fishing techniques

Commercial fishing aims for economic efficiencies by using mass-capture techniques such as trawls, traps, nets and multiple-hooks and long-lines.

### Gill nets

Gill nets (Figure 114.2) are used to catch coastal fish such as mullet, luderick, Australian salmon, Threadfin salmon and barramundi. Depending on the mesh size, larger fish trying to pass through become entangled by their gill covers or fins.

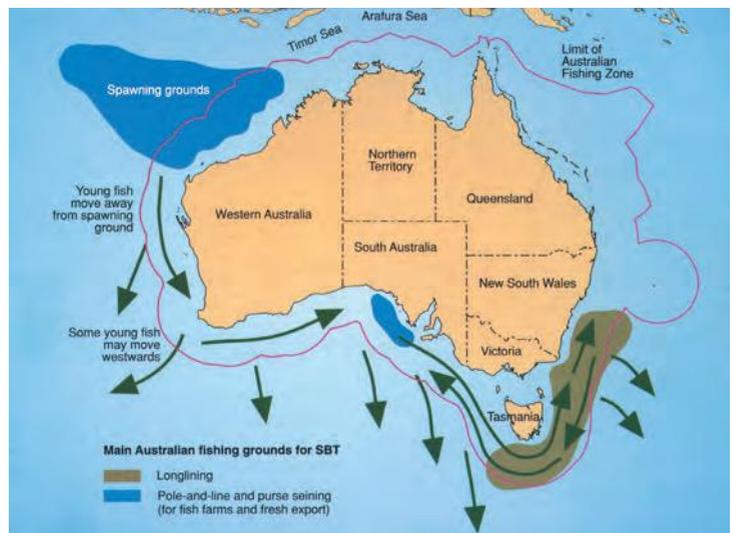


Figure 114.3 Size of the Australian Tuna fishery

\* data supplied by Prof. Leon Zann, SOMER report 1996

They are made of clear nylon filament (almost invisible to fish), with floats and weights to keep them upright. Gill nets are hung in areas where fish pass on the surface, sea floor, or are allowed to drift. Minimum mesh sizes are regulated by law so they don't catch small fish. The 10 kilometres long ocean drift nets have been prohibited in Australia and most other countries because they also capture turtles, dolphins, whales, billfish and sharks.

Ring nets or encircling gill nets are set out behind a moving boat to surround a tight school of fish such as mullet or Australian salmon. They are set in shallows to prevent fish from diving under the bottoms.

### Beach seines

Beach seines or power hauls are set from a beach by a boat to encircle a mullet or other school. Each end is hauled back onto the beach, manually or with a power winch on a 4-wheel drive.

### Purse seines

A modified type of seine is used in the open sea to take schools of pilchards, Jack mackerel and tuna. The net is shot around the school, sometimes by a large tender launch. The bottom of the net is pulled closed with a rope, like a draw-string purse (Figure 115.2). Tuna purse seines are kilometres in length, and up to 100 metres deep. The tender launch itself may be over 10 metres long, with a 1 000 horse power motor to drag the heavy nets. Some purse seiners carry helicopters to spot schools and direct the laying of the seine.

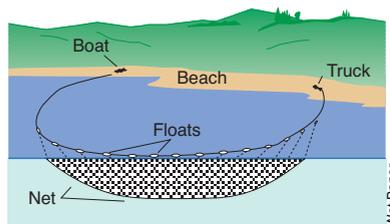
### Trawl nets

Trawl nets are dragged along the seafloor by a powerful vessel to scoop up bottomfish and prawns (Figure 115.3). They operate in depths from a few metres to 1 500 metres, and are also used in mid-water. The entrance of smaller trawl nets are sometimes held apart by a beam (beam trawls).

The entrance of larger nets are separated by two boards or paravanes. The angles of these are carefully adjusted so they try to fly to either side, thereby keeping the net mouth open. The net bottom is weighted with heavy chain so it sinks and drags along the sea floor. The top is floated up with buoys. Trawl nets taper conically, ending in a heavy bag or *cod end* where the catch is concentrated. When the net is lifted out of the water the cod end is pulled open, and the catch released onto the deck.

Trawls and other nets are very efficient but they are non-selective, taking many other, unwanted fish or invertebrate, termed 'bycatch'. Trawl bycatch or *trash* may constitute of 90% of a catch.

Beach seining



Wet Paper

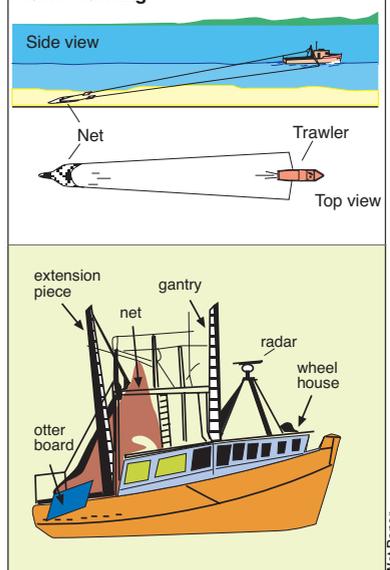
Figure 115.1 Some net fishing methods



NSW Fisheries

Figure 115.2 Purse seine

Prawn trawling



Wet Paper

Figure 115.3 Prawn trawling



Figure 116.1 Prawn trawler deck with cooker and sorting tray

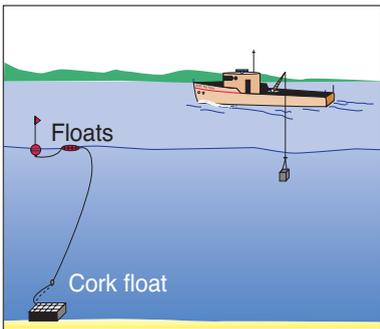


Figure 116.2 Trapping



Figure 116.3 Crayfish pot  
Pot made by Graeme Sawyer

Trawl nets can sweep whole areas clear of sponges, corals and other attached species, which are important biodiversity and fish habitat.

### Scallop dredges

A scallop dredge uses a heavy steel box or **dredges** that is dragged along the sea floor. They are environmentally destructive as they can plough up many attached species and damage bottom habitats.

### Hook and line fishing

Many types of hooks, lures and lines are used for trolling (towing) for fish like Spanish mackerel and Barracouta. Poles with short lines and lures are used to catch feeding tunas. Baited hooks are used to catch reef fish such as Coral trout, snappers and emperors, and floating lines are used for pelagic species. Catch rates are increased by using multiple hooks and power reels.

### Longlines

Catches are greatly increased by using very long lines (Figure 116.4). These consist of a main line, to which are clipped many short branchlines (*snoods*), each with baited hooks. They can be laid along the bottom for sharks, sea perch and ling. Surface drifting longlines are used for pelagic tunas, marlin and swordfish. These commonly range from 10-80 kilometres in length, and carry from 200-3 000 hooks.

### Traps

Baited traps (Figure 116.3) are used to capture rock lobsters and crabs, and reef fish such as snapper. Lobster pots are often woven like baskets, with a top entrance. They can have gaps built in, so undersized animals escape. Fish traps are larger and rectangular, with several side funnel entrances that are easy to enter and difficult to escape from. Traps also act as habitat, and attract fish seeking shelter.

### Crab dillies and snares

Flat hoops of wire and loose netting and bait are used to snare crabs by their spiny legs. They are commonly used for Mud and Swimmer crabs, and for deepwater Spanner crabs.

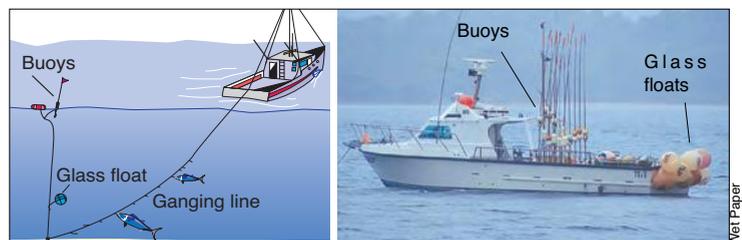


Figure 116.4 Longlining

## Diving

Abalone are caught by divers using scuba equipment or, more often, a **hookah** (air pumps in a boat pumping air to the divers below through a tube). The divers use special tools shaped like tyre levers to prise the abalone from the rocks on which they live. Because the waters in which abalone are found are often inhabited by Great White sharks, the abalone diver often works in a motorised cage for protection. There is a lot of money to be made by abalone fishing, but the risks are high. Apart from the shark threat, divers also risk suffering the bends, embolisms and barotrauma, as you will learn if you do a SCUBA diving course.

## Aquaculture

Increasingly, the commercial fisher is using aquaculture techniques to farm seafood, for example, oysters. Aquaculture is discussed in Chapters 12 - 14.

## Fishing and conservation

**Don't take undersized fish and obey the rules.**

Talk to 'old timers' and they will almost invariably tell you that there are not as many fish as there used to be. They will tell you of the huge catches they used to take in 'the good old days'. As our world population increases, there will be more commercial and amateur fishers and greater demand for fresh, unpolluted seafood. We must conserve and protect our stocks of fish for future generations and control land-based pollution affecting our inshore fisheries.

## Regulations

The need to preserve fish stocks means that we must not take too many fish. We must allow them to reproduce and we must conserve their environment. Fisheries regulations are designed to achieve these aims so they are very strict and can involve jail sentences for offenders. In some areas, commercial fishing is not allowed at all.

### Bag limits

Some authorities set a maximum catch number called a **bag limit**. For example, a maximum catch of four fish per person per day may be set for amateur anglers; and a set number of fish per day for professional fisherman in a particular area.

### Legal length

Minimum, and in some cases maximum limits state the legal size range in which fish may be caught. These limits give fish and other species the chance to breed.



Figure 117.1 Crayfishing boat



Figure 117.2 Abalone aquaculture

## Diving deeper



5. Make a bait bag, borrow a yabbie pump and collect some live bait.
6. Make a crab pot or lobster trap as shown in Figure 116.3.
7. Design a fishing tackle book for fish from your local area as shown in Figure 109.4.
8. Make a fishing rod or invite a local fishing group to help.
9. Fish piracy.

Fish piracy, or illegal fishing activity, depletes global fish stocks. Research this topic and write a pressrelease explaining a recent incident in the Southern oceans

**Web reference**  
[www.oecd.org](http://www.oecd.org)

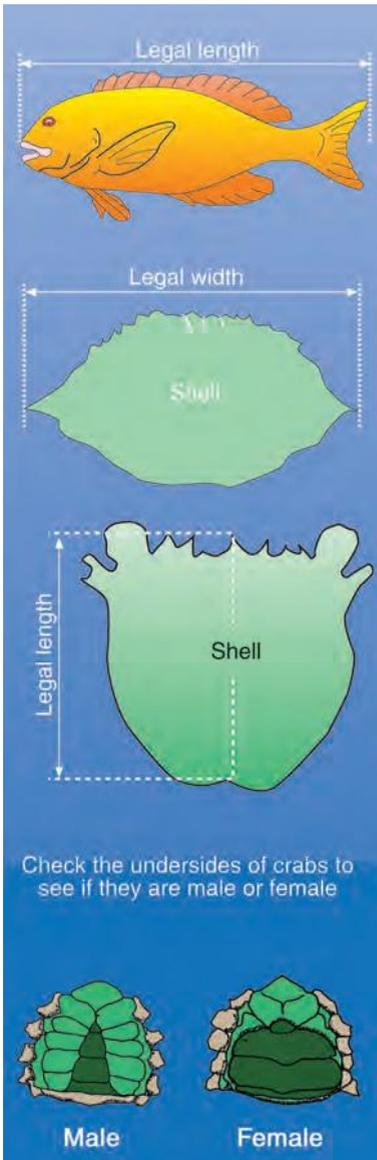


Figure 118.1 You must know what size and which gender of fish you want to catch.

The minimum legal length or width is set at or above the size at which an animal of a particular species first breeds. Maximum size limits protect large breeding fish. Size or width limits apply to both commercial and recreational fishers.

Conservation hint - Crushing the barb of a hook with pliers makes it easier to catch and release undersized fish.

### Gear limits

There are limits on the type of gear you can use. On the Mary River in the Northern Territory, it is illegal to use bait upriver from the barrage at Shady Camp. Lures used at this location are only allowed to carry a single hook.

### Gender restrictions

Mud crabs are protected by gender restrictions. Only male crabs of a minimum legal size can be taken and this size is set by each state fish management authority. Crab fishers must learn to distinguish male and female crabs by their two different types of abdominal flap (Figure 118.1).

### Habitat areas and closed seasons

Aquatic reserves may be established to protect fish habitat or breeding grounds. These reserves may simply exclude professional activity, or may ban all fishing. The reserves may operate all year round or may be closed on a seasonal basis.

Closed seasons apply for a number of salt-water species. These are usually timed to protect fish during their breeding seasons because fish are often easier to catch while they are breeding.

### Licensing

Commercial fishers have to be licenced. Their catches are monitored by government agencies and they may have quotas which limit the quantity of fish they are allowed to take. Each state and territory has a fisheries management authority to enforce regulations. Fisheries officers have a difficult job because many people in our community are ignorant of fisheries laws or deliberately disobey them.

### Getting a fishing licence

In some Australian states you need a recreational fishing licence. For example in Western Australia you must have a recreational fishing licence from the Department of Fisheries for fishing for rock lobster, marron, abalone, netting and freshwater fish. When you're fishing in NSW waters, both freshwater and saltwater, you're required by law to carry a NSW fishing licence (Figure 118.2). This also applies when spear fishing, hand lining, hand gathering, trapping and bait collection and prawn netting. You can buy a recreational fishing licence for three days, one month, a year or three years from -



Figure 118.2 NSW Fishing licence

# Key words

Abalone, Aboriginal and Torres Strait Islander, amateurs, anglers, bag limit, beach seine, breaking strain, closed seasons, cod end, commercial fisheries, crab dillies, fisheries management, fishing licence, fishing tackle book, gill nets, habitat areas, handline, hookah, hooks, lines, lures, recreational, reels, rods, sinker, swivels, tackle, Torres Strait Islander, trapping fish, yabbie pump.

# Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Fishing brings many [1] \_\_\_\_\_ people close to the reality of life and death of our fellow animal species and underlines how dependent we are on animal [2] \_\_\_\_\_ in our diets.
- b. Fishing lines vary in thickness and [3] \_\_\_\_\_. The [4] \_\_\_\_\_ of a line determines the strength of the line and is measured by [5] \_\_\_\_\_ the line against a set of scales until it breaks.
- c. The [6] \_\_\_\_\_ is the circular drum around which fishing line is wound when using a rod. The [7] \_\_\_\_\_ is attached loosely to run from the reel to the tip of the rod.
- d. Live bait is sometimes used to catch [8] \_\_\_\_\_ fish. A [9] \_\_\_\_\_ is used to suck out the yabbie out of its burrow.
- e. Early European visitors to Stradbroke Island (Qld) described how the [10] \_\_\_\_\_ people used [11] \_\_\_\_\_ to chase [12] \_\_\_\_\_ schools into their long nets. Each fisherman would have his 'pets', and call them by splashing spears on the water. Dolphins were sacred '[13] \_\_\_\_\_' or spiritual ancestors to some clans.
- f. Gill [14] \_\_\_\_\_ are hung in areas where fish pass on the surface, sea floor, or are allowed to drift. Minimum [15] \_\_\_\_\_ are regulated by law so they don't catch small fish.
- g. A [16] \_\_\_\_\_ uses a heavy steel box or [17] \_\_\_\_\_ that is dragged along the sea floor. They are environmentally [18] \_\_\_\_\_ as they can [19] \_\_\_\_\_ up many attached species and damage bottom habitats.
- h. Some authorities set a maximum catch number called a [20] \_\_\_\_\_. For example, a [21] \_\_\_\_\_ of four fish per person per day may be set for [22] \_\_\_\_\_ anglers and a set number of fish per day for [23] \_\_\_\_\_ fisherman in a particular area.



- 1. Describe how Aboriginal and Torres Strait Islander people made hooks from pearl shells. Use a diagram to illustrate your answer.
- 2. What's the difference between a sidecast and a spinning reel?
- 3. What is the difference between an Aboriginal stone trap and river fish trap?
- 4. What is the biggest problem with a sidecast reel?
- 5. What is the relationship between a hook and its bait?
- 6. Draw the main parts of a spinning reel.
- 7. Draw the main parts of a rod.
- 8. What is the most valuable part of our Australian fishery?
- 9. What are longlines and how are they used?
- 10. How are fish caught on a drop line?
- 11. Distinguish between recreational and commercial trap fishing.
- 12. Distinguish between beach and purse seining.
- 13. How are prawns caught?
- 14. Evaluate long line fishing benefits to Australian fishing.
- 15. What is the difference between a *bag limit* and a *closed season*?
- 16. What regulations govern how mud crabs are caught?

# Chapter 10 Making a surfboard



## Web references

[www.surfingaustralia.com](http://www.surfingaustralia.com), [www.shapers.com.au](http://www.shapers.com.au)

*This chapter has been written with the assistance of Surfing Australia and Nev surfboards.*

## Design features

Surfers need to have an understanding of the surfboard – its shape, function and the terminology for the various parts.

A modern surfboard is made of two pieces of **polyurethane** foam core which are glued to a wooden **stringer** (Figure 120.1) and coated with a fibreglass resin skin.

### The nose

The **nose** on modern surfboards is mostly pointed. Fitting a nose guard (a rubber protector that is glued onto the nose of the board), is a way of helping prevent injuries which may occur as a result of your surfboard hitting someone else.

### The fins

The most common fin system is the thruster, or three fin surfboard. Thrusters are more stable than single, or twin fin surfboards and are also more manoeuvrable.

### The rails

**Rails** are the curved sides of the board which direct the flow of water and allow the board to hold in the face of the wave. A beginner's surfboard should have soft rails because they are more forgiving and easier to turn.

### The tail

The **tail** of the board is one of many factors affecting how the board performs. Beginners should avoid using a board with a narrow or pointy tail.

Choose either a rounded square tail, or a rounded pin tail. They will be less dangerous, and are more stable because of the extra width in the tail.

Other surfboards and types of tails are shown on the page opposite however the most common type of board is either a mal or a short board and the most common tail shapes are the square and rounded-pin.

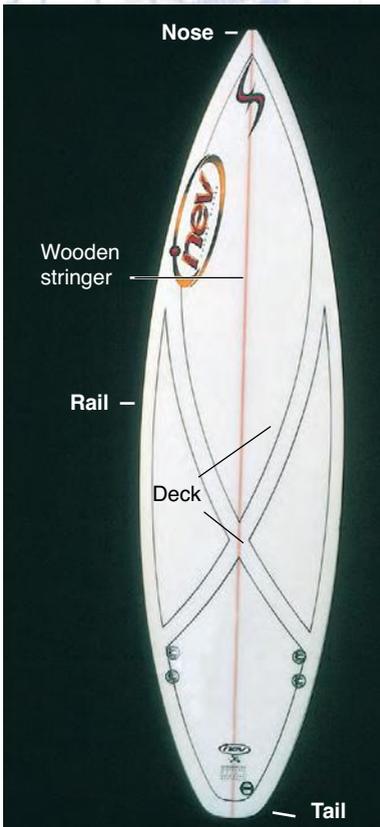


Figure 120.1 Parts of a surfboard

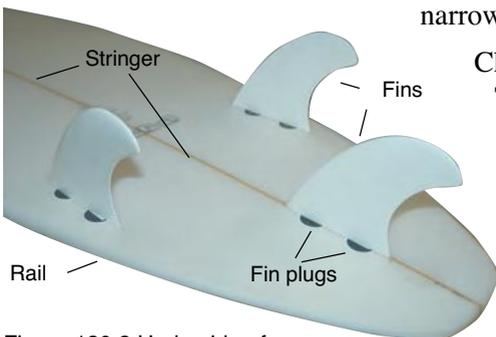


Figure 120.2 Underside of surfboard



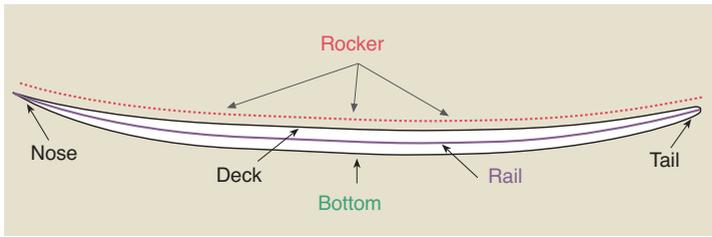


Figure 121.1 The rocker - an important design feature  
With input supplied by Eddie Valladares

**Rocker**

**Rocker** is a curve along the bottom, top, and rail of the surfboard and is an extremely significant design feature (Figure 121.1). The rocker will determine how well a surfboard performs.

**Bottom contours**

The bottom shape of a surfboard determines stability, acceleration, speed, and control.

The four main types of bottom shape are flat, vee, concave and channel. To check what sort of bottom a board has, pick up the tail of the board and look along the bottom from the tail to the nose; you should be able to tell whether the board is concaved, has a vee or is flat. Flat bottom boards are suitable for beginner surfers. Concaves, vees and channel bottoms are good for experienced surfers.

**Thickness**

The thickness of a surfboard determines how well it will float and needs to be considered when designing for surfers with different weights. The heavier the surfer the thicker the board.

**Size**

**Shortboards**

The **shortboard** is a high performance surfboard with a design to allow a surfer to carve radical moves. Speed, acceleration and the ability to control the surfboard are all important features to be considered in design. A shortboard must be kept moving all the time. Short boards range from 6-7ft.

**Longboards**

Longboards were designed from the birth of surfing till the early 1960's. They are not designed to perform radical moves.

Longboard designs allow the surfer to make slower turns and catch waves further out to sea. As they gain momentum the wave propels the surfer towards the beach. Longboards range from 8 - 10ft in length. *Note: Surfers use imperial measurements because of a surf culture that rejected the change to metrics in the 1960's.*

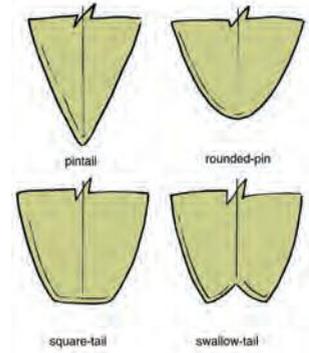


Figure 121.2 Tails come in variety of shapes for different types of surfing.  
Data supplied by Nev Future shapes



Figure 121.3 Checking the bottom contours of a surfboard blank

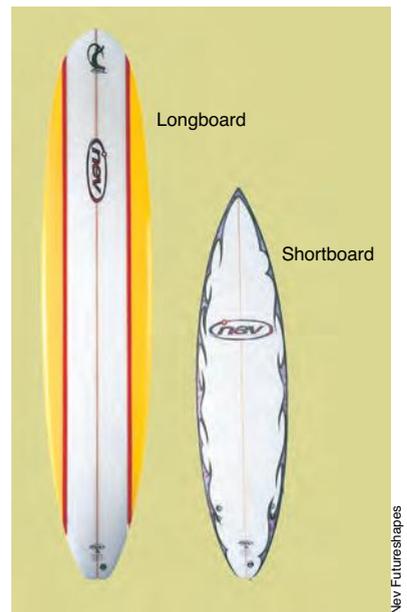


Figure 121.4 Two types of surfboard



Figure 122.1 Surfboard manufacturer and customer

Figure 122.2 Surfboard order form



Figure 122.3 Roll of fibreglass cloth

## The measurements of the board

The customer's design of a surfboard is recorded on an order form (Figure 122.2), which will detail the length, width and thickness, as well as any particular design or colours you want on your new board.

Measurements are usually given in feet and inches. Surfboard makers use the following as the standard measurement – 1 inch = 25.4 mm.

### Board length

**Board length** is measured as the distance along the stringer, from the nose to the tail. Beginners should look for a board around 8-12 inches (20 – 40 cm) longer than your height to provide reasonable paddling speed and flotation.

### Width

The width of the board is the widest point on the board from rail to rail. An ideal width for beginners is about 19 inches wide. A more narrow board could be unstable for a beginner, and anything wider may be harder to carry or sit on comfortably.

### Thickness

Generally the heavier you are, the thicker the board should be. Beginners should start with a board about 2.5 inches thick to give them the buoyancy they need for paddling.

### Design

You can buy a clear board or a board with a design. As a general rule, the more design work you want, the more expensive the board will be. Stickers can also be added to the design and you will need to choose these and decide exactly where you want them.

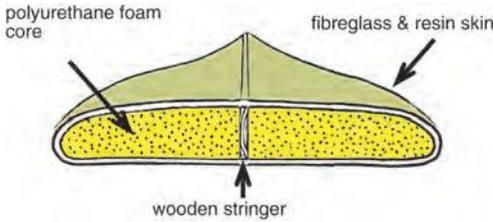
### Fibreglass

The surfboard manufacturer will generally want to make your board as lightweight as possible, and will recommend that you have one layer of **fibreglass** on the bottom of the board and two layers in the top deck. You can have more fibreglass, but this will make the board heavier and less manoeuvrable.

## Construction

Most boards are made from **polystyrene** foam core blank, and are finished by hand to specific dimensions and sealed with fibreglass cloth and polyester resin (Figure 122.3).

The foam core is cut lengthwise, and a wooden or composite material is glued in between the two halves to provide longitudinal strength.



After a big surf, see if you can find a broken surfboard and bring it to class

Figure 123.1 Cross-section of a surfboard

**Surfboard blanks** (Figure 123.2) are made from a mixture of foam and chemicals that are allowed to expand in a large mould under huge pressures. This makes a strong yet lightweight blank that is ready for shaping.

Surfboards are made in a factory using materials such as **resin** and fibreglass. The surfboard blank is delivered from the manufacturer to the factory where skilled tradespeople shape, sand, glass and finish coat the surfboard.

### Shaping

Once the blank arrives in the **shaping bay** as shown in Figure 123.3, it is ready to be either hand or machine shaped.

Most surfboards are machine shaped to a computer-designed template that has been programmed for wave heights or specific conditions.

As a general rule the ‘bigger the wave’ the longer and thinner the shape. A big wave board needs to travel down the face of the wave with minimum drag to allow the surfer the greatest chance of making the wave.

A small wave board is wider and shorter to allow for a wide range of surfing manoeuvres such as deep slashes or 360’s, where the board is quickly turned from the tail.

Shaping a surfboard is done in a shaping bay (Figure 123.3) where the shaper uses a variety of tools including electric planes, shaping blocks and a template (Figure 123.4).

It is one of the best parts of the process because it does not involve any chemicals.



Figure 123.3 Surfboard shaping bay



Figure 123.2 Surfboard blank delivery

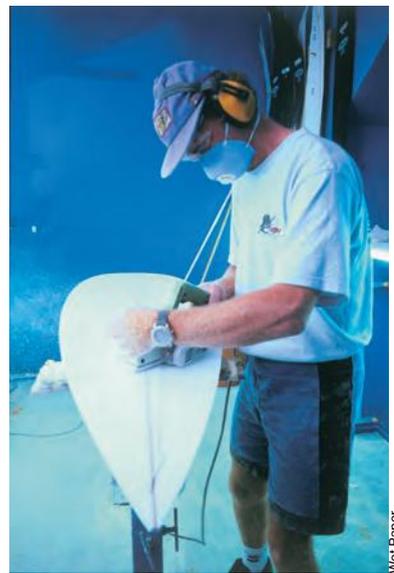


Figure 123.4 Surfboard shaping



Figure 124.1 Fibreglass matt being cut



Figure 124.2 Adding catalyst



Figure 124.3 Applying filler resin to the fibreglass

## Glassing

The first stage of the glassing process involves cutting pieces of fibreglass for the top and bottom decks. Usually, one piece of 6 oz glass is cut for the bottom deck, and two pieces of 4 oz glass are cut for the top deck. The fibreglass comes off a long roll and the glasser cuts out as shown in Figure 124.1.

The second stage involves mixing the fibreglass polyester resin with a hardener or **catalyst** (methyl ethyl ketone Figure 124.2). Protective gloves and a mask are now used to protect the glasser's lungs from these dangerous chemicals. The two substances are mixed in a bowl. The glasser is careful of the temperature of the resin so that he or she can have enough time to apply the resin with a plastic squeegee over the fibreglass before it hardens or "goes off".

The working time is about ten minutes, during which time the glasser has to apply the resin into the fibres, add any stickers and lap the fibreglass over the rails. Figure 124.3 shows the glasser applying resin to the blank.

After this, another resin, called polyester filler coat resin with a thickness of around 1 - 1.5 millimetres, is added to seal the board. Most surfboard manufacturers use a spray gun to do this.

### Adding the fin plugs

Most surfboards have special sockets, called **fin plugs**, where the fins are inserted. This allows the fins to be added after the surfboard has been finished.



Figure 124.4 Fin plug tools

Where surfboard manufacturers still ‘glass on’ the fins, special fibreglass strips called rovings are applied to the fins to add strength. To add a fin plug, a hole is drilled, and then the template plugs are glassed in using a special filler resin. To stop them from moving, the template plugs are taped (Figure 125.1).

## Sanding

After about 24 hours the board must be sanded back to its original shape.

This is done with a disk sander in a special room equipped with a large exhaust fan to remove all the dust. The sander wears a mask to protect the lungs from the glass dust as shown in Figure 125.3. **Sanding** is a specialist art. The sander has to recreate the original board design while sanding the filler resin layer to less than 1 mm. A sander can completely ruin the surfboard manufacturing process.



Figure 125.1 Adding the fin plugs.

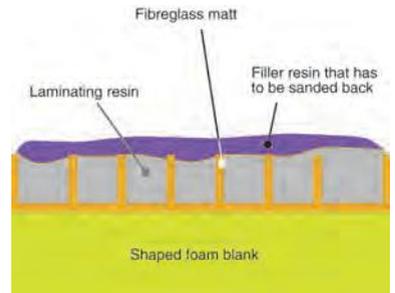


Figure 125.2 Relationship between laminating and filler resin



Figure 125.3 The sander wearing a protective mask

## Diving deeper



1. See your industrial arts teacher to see if you can learn to fix your dings.
2. Visit the surfing Australia web site - [www.surferaustralia.com](http://www.surferaustralia.com)
3. Design and make a model surfboard like the ones shown below.



Kingston SHS



Figure 126.1 Airbrush artist



Figure 126.2 Pro-finishing a board



Figure 126.3 Adding the fins into their plugs

## Art work

It is the job of the airbrush artist to add any special designs to the board. The artist can either follow a set design, or crank up the music and use his or her artistic talents to create an original design as shown in Figure 126.1.

## Finish coating

The last job is to spray a layer of acrylic (clear) paint to seal the surfboard, or paint a fine finish coat of resin followed by a light sanding with wet and dry sandpaper. This process is called pro-finishing (Figure 126.2). The finish coat may be made shiny with a buffing sander, or the board can be left with a matt finish.

## Adding the fins

The fins are usually added back at the surf shop where the customer is shown how to replace them if they are damaged or lost in a surfing accident. Figure 126.3 shows how the fins fit into their fin plugs.

# Employment opportunities

Source: Edith Cowan University, Surf Science and Technology web page  
<http://southwest.ecu.edu.au/surff/career>, [www.surfingaustralia.com](http://www.surfingaustralia.com)

The **surf industry** is very diverse with jobs available as a surf board designer, shop manager, clothing designer, event manager, tourism operator or surfing instructor.

Surf management companies tend to want to hire people who are in touch with the surf culture, who surf and who understand the requirements of the equipment manufacturers sell. They are also looking for people with formal qualifications who understand how the industry and the equipment work.

Some of the skills they look for are computer skills, public speaking skills, time management, financial management, people management, team oriented people with a customer focus. An understanding of the science involved in surfing and surf equipment is a definite bonus.

Edith Cowan University in Western Australia is one of the few universities that offers qualification in surfing. The Surf Science and Technology degree they offer is a great option for those who are serious about working and making money in the booming business of surf-related products.

Employers in the industry are searching for people serious about surfing, but serious about being a professional in the business as well.



Wet Paper workbook Safe Surfing

# Key words

Art work, catalyst, fibreglass, fin plugs, finish coating, glassing, longboard, nose, polyurethane, rails, resin, rocker, sanding, shaping bay, shortboard, stringer, surf industry, employment, tail.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Generally the [1] \_\_\_\_\_ you are, the [2] \_\_\_\_\_ the board should be. Beginners should start with a board about 2.5 inches thick to give them the [3] \_\_\_\_\_ they need for [4] \_\_\_\_\_ .
- b. The [5] \_\_\_\_\_ is a high performance surfboard with a design to allow a surfer to carve radical moves. Speed, [6] \_\_\_\_\_ and the ability to control the surfboard are all important features to be considered in [7] \_\_\_\_\_ . A shortboard must be kept [8] \_\_\_\_\_ all the time.
- c. Board [9] \_\_\_\_\_ is measured as the distance along the [10] \_\_\_\_\_ , from the nose to the [11] \_\_\_\_\_ .
- d. Shaping a surfboard is done in a [12] \_\_\_\_\_ where the shaper uses a variety of tools including [13] \_\_\_\_\_ planes, shaping blocks and a [14] \_\_\_\_\_ . It is one of the best parts of the process because it does not involve any [15] \_\_\_\_\_ .
- e. Most surfboards have special sockets, called [16] \_\_\_\_\_ , where the fins are inserted. This allows the fins to be added after the surfboard has been [17] \_\_\_\_\_ . Where surfboard manufacturers still 'glass on' the fins, special fibreglass strips called [18] \_\_\_\_\_ are applied to the fins to add strength.
- f. [19] \_\_\_\_\_ is a specialist art. The sander has to [20] \_\_\_\_\_ the original board design while sanding the [21] \_\_\_\_\_ layer to less than 1 mm. A sander can completely ruin the surfboard [22] \_\_\_\_\_ process.
- g. The last job is to spray a layer of [23] \_\_\_\_\_ (clear) paint to seal the surfboard, or paint a fine [24] \_\_\_\_\_ of resin followed by a light sanding with wet and dry sandpaper. This process is called [25] \_\_\_\_\_ . The finish coat may be made shiny with a buffing sander, or the board can be left with a [26] \_\_\_\_\_ finish.
- h. Surf management [27] \_\_\_\_\_ tend to want to hire people who are in touch with the surf [28] \_\_\_\_\_ , who surf and who understand the requirements of the equipment [29] \_\_\_\_\_ sell.



1. What is the difference between the rail, nose and tail of a surfboard?
2. Draw a diagram of a surfboard to distinguish between the three different rockers.
3. What determines the acceleration, speed and control in a surfboard design?
4. What determines the thickness in designing a custom made surfboard?
5. Why do surfers still use imperial measurements when they talk about surfboard design?
6. What are the four main types of bottom shape in surfboard design?
7. Draw a cross section of a surfboard to distinguish between the foam core, fibreglass skin and stringer.
8. Why does a big wave board need to be longer?
9. Distinguish between the two stages of glassing.
10. Surfers talk about the resin *going off*. What does this mean and how is it crucial to the glassing process?
11. What is so special about the sanding process?
12. When is the art work usually added to the manufacturing process?
13. When are the fin plugs added? Why are they added then?
14. What is finish coating?
15. Construct a flow chart for the manufacture of a surfboard.

# Chapter 11 Aquariums



## Web references

[www.fao.com.au](http://www.fao.com.au), [www.reefed.edu.au](http://www.reefed.edu.au),  
[www.fish.wa.gov.au](http://www.fish.wa.gov.au)



Figure 128.1 Classroom marine aquarium



Figure 128.2 School project aquariums



Figure 128.3 Inexpensive aquarium

Studying aquariums shows you the basic requirements for life in the food chain as well as underlining the importance of unpolluted water.

In building an aquarium, you gain skills and knowledge about different materials as well as the characteristics of fresh and salt water.

A small aquarium can be used to raise small zooplankton to feed larger fish in other aquariums so you can learn about animals and plants in food chains (Chapter 5). Aquariums also provide the opportunity to learn about bacterial filters containing living bacteria which remove the build-up of toxic chemicals. This chapter also looks at how to design different bacterial filter systems and how to stock your aquarium.

Most people use aquariums to keep fish. The aquarium must provide space, shelter, food, oxygen and warmth for animals. At the same time solid and dissolved wastes produced by these animals must be removed from the water.

## What is an aquarium?

An **aquarium** is a place where freshwater and salt-water animals and plants are kept, away from their natural habitat. A good aquarium should copy the natural conditions of the captured environment of plants and animals as closely as possible.

A classroom marine aquarium (Figure 128.1) enables students to make a long-term study of marine animals whereas a commercial aquarium like the one shown on page 130, allows visitors to make short-term observations of marine life.

Most people set up aquariums to keep either freshwater or saltwater fish. As you become more adventurous and experienced, you can add plants and other animals to make the tank look good and to set up a natural system within the aquarium. Waterweed and a variety of snail species often accompany freshwater fish whereas anemones, corals, molluscs and algae are used in marine tanks.

# Types of aquariums

## Freshwater aquariums

With fresh water aquariums, it is important to remember that the water is where the animals and plants live as we live in air. If our air smells, is full of dust, smoke or other impurities, we feel uncomfortable and upset.

Fish will ‘stress out’ and die if their water quality is not kept as pure as possible. It is not difficult to keep the water clean but remember that animals produce solid wastes. Excess food supports other microscopic organisms that compete for oxygen, and fish produce poisonous ammonia.

Aquariums cannot be filled with water straight out of the tap. Check your town water before you fill your aquarium. It will contain chlorine and possibly, during winter, a long-term active chlorine compound called chloramine.

Both these compounds may be removed simply by letting the water stand in a container for 24 hours, or by bubbling air through it.

Boiling the water will remove all gas, including oxygen, so if you get rid of the chlorine by boiling, bubble some air back through the water before putting the water in your aquarium.

## Salt-water aquariums

Salt-water aquariums need real sea water.

Collect water on an incoming tide to reduce the chance of collecting land pollution from sources such as stormwater drains and boat ramps.

Figure 129.3 shows a suitable container for collection and has the advantage of a lid to prevent spillage on the journey back to school.

Marine organisms live in a generally unchanging environment containing anaerobic and aerobic bacteria which help clean the sea water. (**Aerobic bacteria** are those which need oxygen to survive whereas anaerobic bacteria do not require oxygen to live.)

However, from the moment natural sea water is taken from the ocean it begins to change its temperature, salinity and biological and chemical composition.

When collected water gets back to school, the closed environment of your aquarium will support only a small percentage of both types of bacteria and they need sufficient time to establish their own new equilibrium.



Figure 129.1 Freshwater aquariums



Figure 129.2 Saltwater aquarium



Figure 129.3 Container for carrying salt water back to school in a car

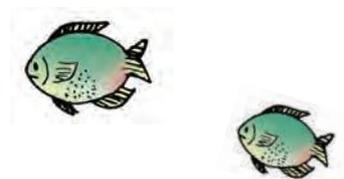




Figure 130.1 Conditioning water for a salt-water aquarium

This is achieved by **water conditioning**, the process where water is left in the dark for two weeks to allow anaerobic and aerobic bacteria to reach this equilibrium.

At least two weeks is recommended to condition your water. The holding area should be dust-free and clean (as shown in Figure 130.1) where you can provide oxygen from a pump.

## Aquarium design

A good aquarium will mimic the conditions found in nature. It will be a good ecosystem with a balance between producers, consumers and decomposers (refer back to Chapter 5). As you will be feeding the animals, less producers and more decomposers are usually present.

In designing an aquarium, you must consider the needs of the living plants and animals you keep. Plants need light, carbon dioxide and the right temperature to grow. Animals need oxygen, space, shelter as well as water uncontaminated by dissolved and solid nutrients. The aquarium should look good, require low maintenance and have the animals and plants that you wish to display clearly visible. These design features are summarised in Figure 130.3.



Figure 130.2 Commercial aquarium display

Needs of plants	Needs of animals	Needs of humans	Aquarium design to supply needs
Light	_____	_____	Fluorescent light with grow tube
CO <sub>2</sub> for photosynthesis	_____	_____	Good aeration
Temperature	_____	_____	Heater or cooler as required
_____	O <sub>2</sub> for respiration	_____	Good aeration
_____	Temperature	_____	Heater or cooler as required
_____	Space	_____	2 litres of water per 1 cm of fish
_____	Dissolved nutrient removal	_____	Biofiltrations
_____	Solid waste removal	_____	Particle filter
_____	Shelter	_____	Objects in the aquarium - rocks, corals, tubes
_____	_____	Looks good	Variety of animals and plants
_____	_____	Visible display	Made of transparent material - glass or perspex
_____	_____	Low maintenance	Automatic aeration or filtration of solids and removal of dissolved wastes

Figure 130.3 Aquarium design needs

# Aquarium construction

## A. Using readily available kits

Visit an aquarium shop (Figure 131.1) and start with a few fish and a simple system like the aquarium kit shown below (Figure 131.3).

This contains a basic tank, an under-gravel filter and a basic aquarium pump and tube. Set up your aquarium as follows.

1. Clean the tank out and rinse it thoroughly. Do this to remove any dirt and other fine materials such as glue and glass chips left over from the manufacturing process.
2. Assemble the side uplifts by sliding the connections into the base of the under-gravel filter (Figure 131.2).
3. Now place the under-gravel filter assembly on the bottom of the aquarium so that the airlift tube is in one of the corners.
4. Cover the under-gravel filter assembly with about 5 cm of washed gravel that is too coarse to fall through the slits in the filter.
5. Place rocks and ornaments as desired.
6. Place a plate on top of the gravel and pour water slowly into the dish. Adding the water to the tank this way avoids stirring up the gravel.
7. Attach the airline tube, start the pump and adjust the flow.
8. Place the top on the tank and, after 24 hours, add your fish.



Figure 131.1 An aquarium shop

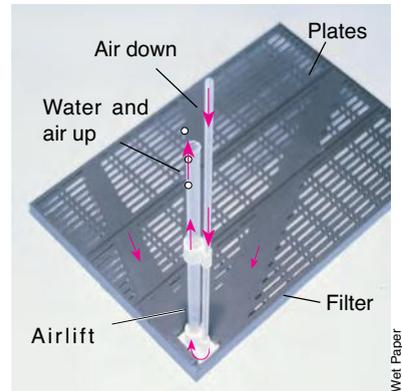


Figure 131.2 Under-gravel filter



Figure 131.3 Basic aquarium kit

## Diving deeper



1. Arrange for a school visit by a local aquarium shop owner to give a talk on how to set up and maintain an aquarium.
2. Arrange for a glass cutter to come to school and show students how glass is cut.

The person could help cut the glass then for a school project aquarium described over.

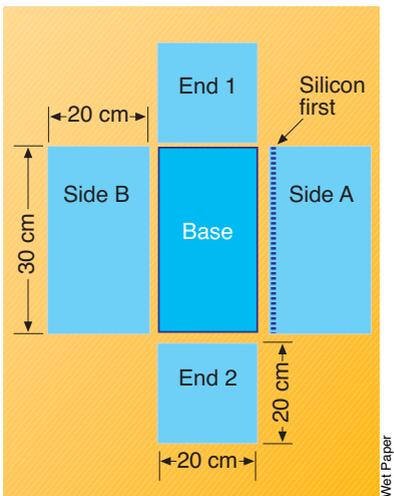


Figure 132.1 Approximate glass sizes for an aquarium

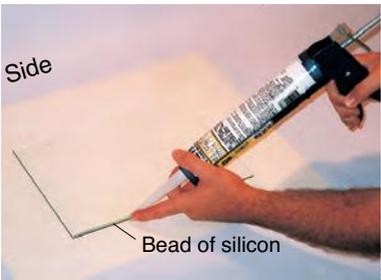
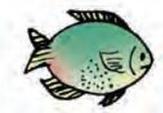


Figure 132.2 Run glue along one side.



Figure 132.3 Use bottles to support the glass.



## B. Making your own aquarium

This section describes how to construct small project and permanent aquariums. The small project aquarium is designed to be pulled apart and stored for next year's class.

The aquarium shop can supply you with a removable under-gravel filter, some fish and lots of advice.

Glass is most often used because it is cheap, easy to work with and lets lots of light into the water to increase photosynthesis.

The permanent aquarium can be any size and has a built-in under-gravel filter made from glass. For this aquarium, you can cut your own glass and set up your own under-gravel filter.

### Materials

In this aquarium, get your glass pre-cut in pieces from an aquarium shop (Figure 132.1). It is very important to match the size of the under-gravel filter system with the **base size** when you order your glass. Your industrial arts section can help you with a silicon gun and dispenser tube with a cap.

This cap is cut to allow the silicon to come out in a bead of glue (Figure 132.2). The diameter of this bead is determined by where the tube's cap is cut and can be as thick or thin as required.

As a guide, the bead should be the thickness of the glass that it is coming into contact with.

You will also need some old newspapers, a roll of masking tape, two 1 litre bottles and a flat surface to work on. This construction method will need two people.

### Construction steps

1. Fill the two bottles with water.
2. Spread the newspaper out on a flat surface.
3. Lay the sheets of pre-cut glass on the newspaper and write the words 'base, side A, side B, end 1, end 2' on the sheets of glass as shown in Figure 132.1.
4. Take one side. Run a bead of silicon the thickness of the glass along the entire lower length (Figure 132.2).
5. Carefully move the glued section towards the edge of the base so that it just touches the base's edge.
  - a. Place a bottle behind the side so that the glass can rest against it .
  - b. Repeat this on the other glass side using the other bottle (Figure 132.3).

6. Run a bead of silicon along three sides of end 1 (Figure 133.1).
7. Now comes the tricky part where you have to glue two sides together.
  - a. Place four pieces of masking tape at the edges you will be gluing, ready to hold the ends when finished.
  - b. Carefully lift up one of the sides and have your partner hold it in a vertical position.
  - c. Place your hand on the base. Carefully push in the bottom of the side that your partner is holding so that the glue makes a firm contact with the base.
8. Repeat this for the other side (Figure 133.2). Carefully remove your hand from the base and ask your partner to keep both sides in position.
9. Pick up the end by the un-glued edge and carefully bring the bottom bead of glue into the end of the base so that its lower edge makes contact with the base (Figure 133.3).
10. Use this contact point as a hinge to bring the other two glued edges into contact with the sides. Now tape the pieces in position (Figure 133.4).
11. Repeat for other end, again using the tape to hold pieces in place. Leave for 24 hours to set before testing with water.
12. Make sure you place a piece of high density foam under the aquarium before you fill it. If there are any leaks, patch them up with additional silicon. Your aquarium is now ready for use as shown in Figure 133.5.

All you have to do is to add the under-gravel filter that should now fit neatly into the base, add water and follow the steps as described on page 131.

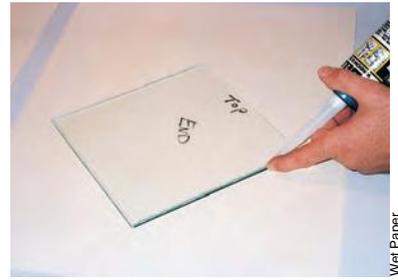


Figure 133.1 Prepare ends with glue.



Figure 133.2 Prepare the ends with masking tape.

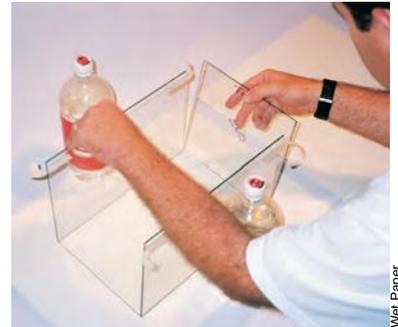


Figure 133.3 Position the end to the base.



Figure 133.4 Tape in the sides to hold the ends together.

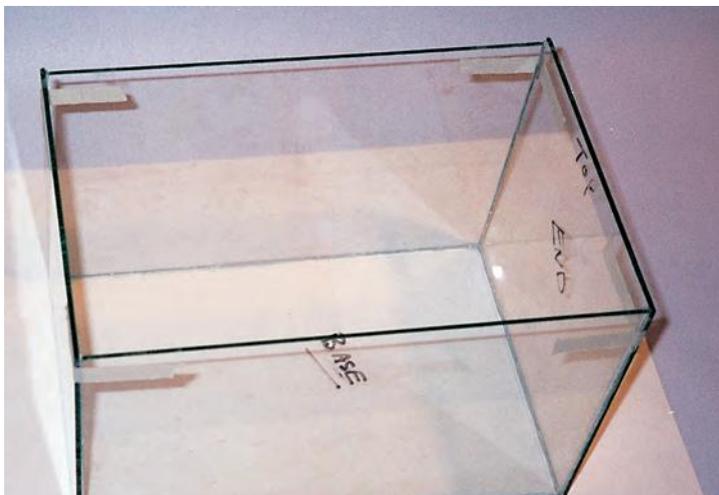


Figure 133.5 Finished aquarium



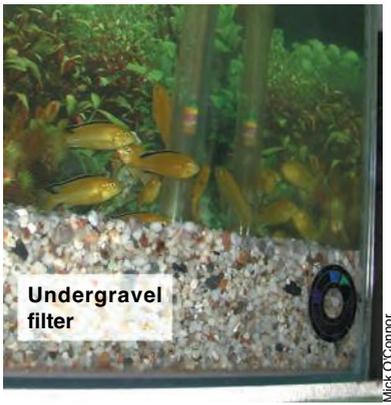


Figure 134.1 An undergravel filter

## Under-gravel filtration

An **under-gravel filter** is a tray of gravel or shell grit at the bottom of the aquarium linked to an uplift water system which sucks water from the tray. The air introduced into the **uplift tube** creates a vacuum which sucks aquarium water through the plates and along the channels. The under-gravel filter works on the principle of **displacement** by uplifting air as shown in the detail of Figures 134.2 and 134.3.

The tray with the shell grit or gravel is designed to provide a suitable environment for the growth of bacteria and other biological filtration organisms which will absorb the invisible wastes produced by fish and other marine organisms.

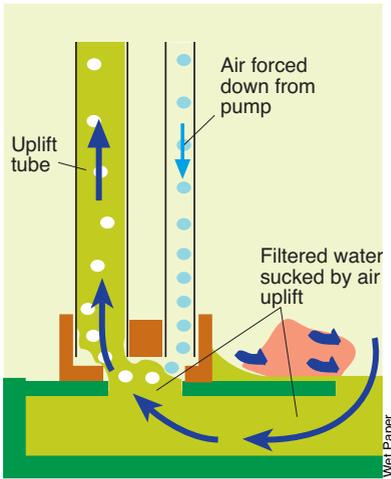


Figure 134.2 Air uplift principle

Biological **filtration** organisms are usually the algae, crustacea, worms and bacteria that grow in the under-gravel filter. As water passes over them, they take out the soluble animal wastes for food. The bacteria, algae and worms can be grown on plastic, gravel, glass beads or anything that will not release into the water substances that will poison your animals. As fish produce ammonia, the bacteria convert it into nitrite and then into nitrate. Nitrate is less harmful to fish than nitrite. Plants can use both nitrite and nitrate, however often nitrate builds up, and a 10% water change is needed when nitrate levels get past one part per million.

Another benefit of this filter is that any solids in the water are drawn into the gravel and remain there either until they break down or become part of the living filter. The under-gravel filter has no moving parts so it cannot wear out. However it needs to be cleaned to remove debris that accumulates in the filter tubes.

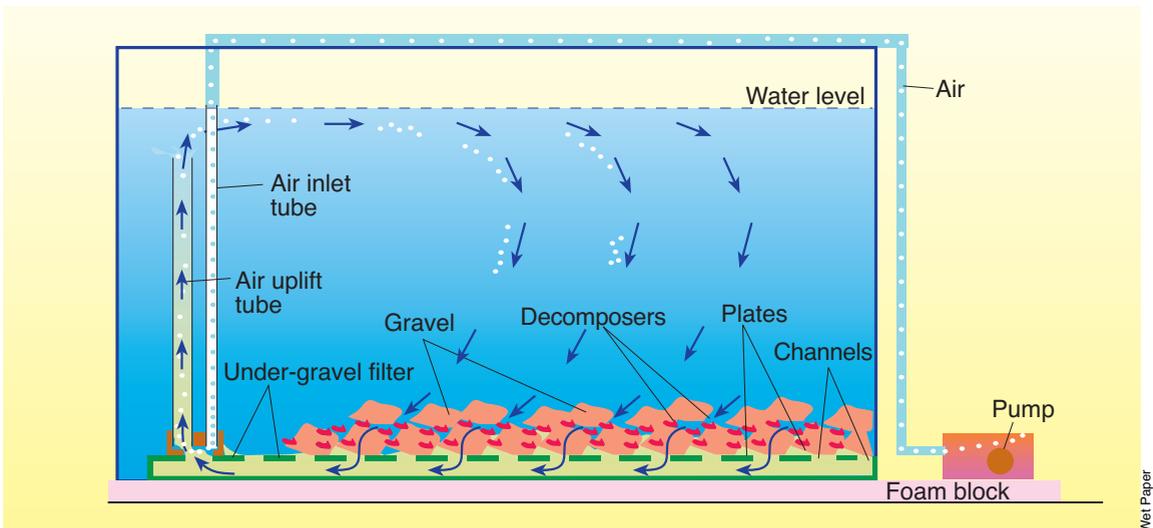


Figure 134.3 The principle of the under-gravel filtration and water circulation system

The best way to do this is to move the fish, remove the water and gravel to another tank and then wash out the filter. Remember to keep the gravel because it contains your microorganisms and do not use disinfectants or cleaners because **residual** chemicals can pollute your tank.

### Trickle filters

An alternative to the under-gravel filter is the **trickle filter** a filter containing biological filtration organisms outside the aquarium. Water is pumped up into the filter above the tank and allowed to gravity feed back into the aquarium (Figure 135.1). The box of the filter can contain expensive **bioballs** or inexpensive materials such as the plastic tops off drink bottles. These materials provide places for the cleaning bacteria to grow and provide a greater surface area for algae, bacteria and worms. These filters have the added advantage that they are easy to wash and sterilise if a disease sets in. Whatever you use, you can be sure that with a biological filter your water will remain crystal clear.

## C. Larger aquariums

Larger aquariums are usually homemade for storage or viewing of fish and other invertebrate life. They can be made of a variety of materials but be wary of metals which are often poisonous to fish. Plastic, glass, perspex and glazed pottery can be used. Concrete painted with pool paint also makes an excellent storage tank (Figure 135.2). Larger aquariums as shown in Figure 135.3 are useful for displays in larger areas such as building foyers. A glass aquarium built to hold between 70 litres and 90 litres of water is useful because it holds enough water to absorb liquid wastes and at the same time contain a gravel bed biological filter.



Mick O'Connor

Figure 135.1 Trickle filter and grow out tank



Ballina State High School

Figure 135.2 Bigger aquarium lined with pool paint



Wet Paper

Figure 135.3 A display aquarium

## Additional equipment

### Air supply

When water stands still, the air goes out of it. Water plants and animals need air dissolved in the water so they can breathe. In nature, wind, waves, waterfalls and currents all put air into, or **aerate**, the water. In aquariums, air pumps are needed to dissolve oxygen for animals. An air supply must move water about the aquarium, particularly down through the gravel and back up to the surface where it helps replace waste gases with oxygen. Simple air pumps, like the one in Figure 136.1, have a rubber **diaphragm** which moves backwards and forwards to pump the air.

Plastic tubing takes the air through valves into the tank where air stones make small bubbles which allow the air to dissolve in the water faster (Figure 136.3). Choose one size of tubing and stick to it for all your needs; 4 millimetre internal diameter is a standard size. Air stones will eventually block but are essential for good air uplifts. You can make an air supply system for a number of aquariums with polypipe fittings as shown in Figure 136.2 and inexpensive plastic tubing available from most hardware stores.

### Lights and heater or cooler

Your aquarium should be 98% covered at all times to cut down evaporation, to prevent material falling in and to stop fish from jumping out. A light and reflector to direct the light down into the tank is essential if the tank is to be placed indoors. Gro-lux fluorescent lights turned on for between 10–12 hours per day are usually enough for this size aquarium. Constant water temperature suited to the animals you have in your aquarium is important. Variations in water temperature can kill all tank life, not just the fish. You will need to check which temperature range your tank should have once you have decided which fish you will grow.

Tropical aquarium water temperatures are usually between 23°C and 28°C. Temperate tank temperatures range from 14°C–23°C. The size and type of heater or cooler is again determined by your tank and the type of organisms you want to keep. Get advice from local aquarists on what best suits your fish. To cool your water, you could try using an old refrigerator cooling element (Figure 136.4).

### Before you put your water in

A glass aquarium will crack if filled with water while it is sitting on an uneven surface.



Figure 136.1 Air supply mechanism



Figure 136.2 Air supply fittings

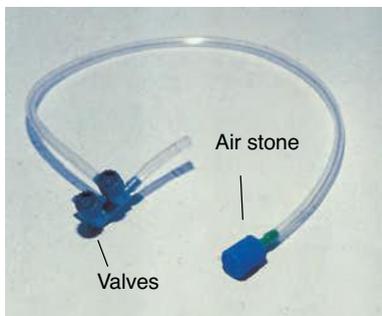


Figure 136.3 Air control mechanisms



Figure 136.4 Homemade aquarium cooler

A base of 10 millimetre medium to heavy density polystyrene will prevent this happening. Newspaper, carpet or similar materials can also be used.

If your aquarium has a steel stand, see if you can have it galvanised to prevent rust forming.

## Workplace health and safety

Keep all pumps and electrical equipment away from water and have elements such as the one shown in Figure 136.4 tested and tagged once a year to see they remain earthed.

## Stocking aquariums

1 centimetre of fish to every 2 litres of water

### Freshwater aquariums

Remember that you are trying to set up a balanced system. It is too easy to put in too many animals.

There is no hard and fast rule but, as a guide, put in 1 centimetre of fish to every 2 litres of water. Remember that overcrowding causes stress, waste build-up, and the possibility of disease spreading among your animals.

The types of plants and animals used will depend on how you are setting up your aquarium. Again, you should try for a system similar to a natural habitat, for example, a freshwater stream or an estuarine community. This will allow you to select animals and plants that are suited to each other, enabling a system to be set up fairly rapidly within the tank.

Freshwater crayfish make excellent animals to keep because you can watch the breeding cycle and study how the animals grow. They are very hardy and you can pick them up quite easily and take them out of the tank for short periods of time. Small fish such as guppies and freshwater plants like *Elodea* are also easy to keep.

### Marine aquariums

Start by adding a limited number of 'as small as possible' specimens, and keep a close eye on them for a week or so. If any die, remove them quickly before they can foul the water or spread disease.

Consider using a separate quarantine tank for any newcomers which can then be transferred to the main tank after a week or so of settling in. Keep a notebook alongside the aquarium and record any new additions, deaths, environmental changes such as temperature and other observations.

**Diving deeper**



3. Use the library to research the aquatic or marine community found in your area. Identify the producers and consumers and make a list of the organisms from each community you could use in an aquarium.
4. Fish produce different wastes to birds and mammals. Use the library to research the difference in nitrogen-containing wastes produced by fish and how the wastes and the method the fish use to get rid of them differs from that of birds and mammals.
5. Read some of the books available on looking after aquariums, fish care and fish diseases. Get them from the library, and from your local State Fisheries Departments.
6. Experiment with different homes for aquarium animals. For example crayfish like plastic tubes as shown below.



Figure 137.1 Crayfish hides

Simone Baker



Figure 138.1 Aquarium fish



Figure 138.2 Anemone and Clownfish



Figure 138.3 Barramundi in aquaculture tank



Figure 138.4 Scorpionfish

Marine aquariums that have become fully balanced, like the one on page 135 shown in Figure 135.3, are fully self-contained and require little maintenance.

However, to acquire enough knowledge to set up a successful tank on this scale takes many years of experience.

## Marine plants

Which plants you put in your aquarium will depend on the temperature of the water. Marine plants seem to prefer temperatures below 20°C. In southern states, you can have green algae such as Sea lettuce but this needs tungsten light to maximise growth.

Marine angiosperms such as eelgrass, tapeweed and wireweed are generally more difficult to keep alive and do not have a variety of plants and animals growing on them.

By adding such plants to the aquarium if only for a day or two, you will allow smaller organisms in the plants to colonise the tank as they move out in search of new homes.

## Marine animals

Anemones and Clownfish (Figure 138.2) can be purchased from an aquarium shop. These can be easily introduced onto rocks in your aquarium. Be very very careful with poisonous fish such as the Scorpionfish shown in Figure 138.4.

Sponges, however, are very hard to keep, die readily and produce a slime that will rapidly ruin an aquarium.

Shrimps are good aquarium cleaners and make excellent food for other fish. Brine shrimp can be raised from eggs bought from an aquarium shop. Crabs also help to keep the aquarium clean, but avoid large specimens as they create havoc with the aquarium landscaping and climb out readily.

Echinoderms, sea urchins and even brittle stars can be kept but take care because they seem to die unpredictably and will readily foul a tank after they die.

Sea urchins are a reliable indicator of the health of a marine aquarium. If they do poorly (drop spines) something is wrong, even when other organisms appear to be doing well. Brittle stars happily eat chopped fish but prefer to hide away from light.

Sea cucumbers are sand filterers and so need detritus (decaying matter) in fine sand to swallow. (They have difficulty swallowing coarser sand.) Feather stars can be kept quite successfully if the water is cold, of high quality and contains plankton. However, dead stars discolour the water rapidly.

Most varieties of worms do well in the aquarium by feeding on detritus, although filter feeders such as Feather-duster worms will need an occasional feed of plankton (such as freshly hatched brine shrimp or a change of about 25% of the water). Worms are very useful decomposer organisms.

Hardy species of fish to try first are small mullet, blennies, gobies, leather-jackets, trumpeters, hardyheads, zebras, cobblers (watch out for their poisonous dorsal spines), angelfish and putters.

Pipe fish, seahorses, shore eels and other small species will eat brine shrimp and tubifex worms in place of their normal diet of plankton. Bream are a useful fish to add bacteria in a new filter system but remember that any large, active organism will place demands on a filter system.

## Looking after your aquarium

If your under-gravel filter is working well and you have the right amount of plants and animals, your aquarium should need little looking after.

Your fish are good indicators —if they are healthy and feeding well, things are usually quite normal. However, you need to check the temperature daily with a thermometer and at the same time make sure the air stones are working and the water is lifting well out of the airlifts.

This will ensure good water circulation and aeration. If algae grow on the glass, clean it off with a plastic washing up brush (which you do not use for anything else!). Remember you must wash your hands and rinse them well in clean water, as you do with anything else you put in the aquarium. Detergents are deadly!

Probably the biggest cause of problems in small aquariums is overfeeding. Avoid the 'kindness' trap of thinking you are doing your fish a good turn by piling in the food. Much of it will probably fall to the bottom and form a home for oxygen-guzzling decomposer organisms. Feed enough for your animals to eat as you watch and retrieve uneaten food.

## Which aquarium should I set up?

This is entirely your choice. Generally marine fish are more colourful than freshwater fish but harder to keep. Salt is also very corrosive and the upkeep on fittings is high. Freshwater organisms are very hardy and their aquariums are easier to maintain and their equipment lasts longer.

Most experts recommend a freshwater aquarium as the first aquarium for beginners before they progress to marine tanks.



Figure 139.1 Feeding Barramundi in a school aquarium



1. What is an aquarium ?
2. What are two things that animals produce that can affect water quality?
3. Why must town water be checked before using it in an aquarium?
4. What happens to the dissolved oxygen as water is boiled?
5. What does the term '*water conditioning*' refer to and for how many weeks should water be conditioned?
6. What is an under-gravel filter and what should it contain?
7. How does an air uplift tube work?
8. What are some common micro-organisms found in the under-gravel filter of a marine aquarium?
9. What is a trickle filter and how is different from an under-gravel filter?





10. What is biological filtration and how does it work to remove harmful substances from your aquarium?
11. Why is glass the most common material used to make aquariums?
12. Why are metals avoided in aquarium construction?
13. Why are sea urchins a reliable indicator on the health of your aquarium?
14. What should you check daily in your aquarium?
15. How can chlorine be removed?
16. What type of glue is recommended to join glass sheets for aquariums? Why?
17. Why are the channels necessary under the gravel bed filter?
18. Why are nitrates important to plants?



## Key words

Aerate, aerobic bacteria, aquarium, base size, bioballs, diaphragm, displacement, filtration, residual, trickle filter, under-gravel filter, uplift tube, water conditioning.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. An [1] \_\_\_\_\_ is a place where freshwater and salt-water animals and plants are kept, away from their natural [2] \_\_\_\_\_. A good aquarium should copy the natural conditions of the [3] \_\_\_\_\_ plants and animals as closely as possible.
- b. Aquariums cannot be filled with water straight out of the [4] \_\_\_\_\_. Check your town water before you fill your aquarium. It will contain [5] \_\_\_\_\_ and possibly, during winter, a long-term active chlorine [6] \_\_\_\_\_ called chloramine.
- c. In designing an aquarium, you must consider the [7] \_\_\_\_\_ of the living plants and animals you keep. Plants need light, [8] \_\_\_\_\_ and the right temperature to grow. Animals need oxygen, [9] \_\_\_\_\_, shelter as well as water uncontaminated by dissolved and solid [10] \_\_\_\_\_. The aquarium should look good, require low [11] \_\_\_\_\_ and have the animals and plants that you wish to display clearly [12] \_\_\_\_\_.
- d. An [13] \_\_\_\_\_ \_\_\_\_\_ is a tray of gravel or shell grit at the bottom of the aquarium linked to an uplift water system which sucks water from the tray. The air introduced into the [14] \_\_\_\_\_ \_\_\_\_\_ creates a vacuum which sucks aquarium water through the plates and along the channels.
- e. Larger aquariums are usually [15] \_\_\_\_\_ for storage or viewing of fish and other [16] \_\_\_\_\_ life. They can be made of a variety of materials but be wary of metals which are often [17] \_\_\_\_\_ to fish.
- f. In aquariums, air [18] \_\_\_\_\_ are needed to [19] \_\_\_\_\_ oxygen for animals. An air supply must move water about the aquarium, [20] \_\_\_\_\_ down through the gravel and back up to the surface where it helps replace [21] \_\_\_\_\_ with oxygen.
- g. Freshwater [22] \_\_\_\_\_ make excellent animals to keep because you can watch the [23] \_\_\_\_\_ cycle and study how the animals grow.

# Chapter 12 Underwater farming



**Web reference and subscription**  
[www.austasiaaquaculture.com.au](http://www.austasiaaquaculture.com.au)

Over 75% of the Earth's surface is covered by water yet almost all of the farming is carried out by humans on land. Within the next 40 years, the human population on planet Earth will double and underwater farming will go a long way to feed the extra 5 billion people.

In the pollution-free waters of our southern coasts, marine science and industry have combined to build huge underwater farms like the **fish pens** in Figure 141.1. Further north in warmer, saltier waters, oysters are grown on **racks** as shown in Figure 141.2. These are examples of underwater farming which have attracted large amounts of Australian and New Zealand investment.

To work as an underwater farmer, you will need a commercial coxswain ticket as well as understanding fisheries legislation, management and marine biology issues.

## Food from the sea

### Improving technology

Improving fishing technology can increase the number of fish caught. An example of improved fishing technology is using computer-driven sonar nets to find large schools of fish. Other methods include bigger fishing operations with mother ships containing on-board fish factories spending months at sea to increase the fishing harvest.

The technology brings many benefits but introduces new problems such as **overfishing**.

### Fertilising the water

**Upwellings** are places where currents bring up large amounts of **nutrients** from the deeper layers in the sea (Figure 141.3).

Many of the world's most productive fisheries are found in upwelling areas, for example, 22% of all fish caught in the oceans are taken off Peru in only 0.1% of the ocean's surface (see Figure 142.1 over). Just 1% of the total catch comes from the 90% of the oceans where there is no upwelling.

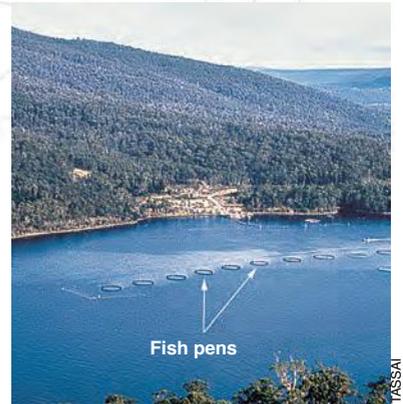


Figure 141.1 Salmon pens in Tasmania



Figure 141.2 Oyster farm New South Wales

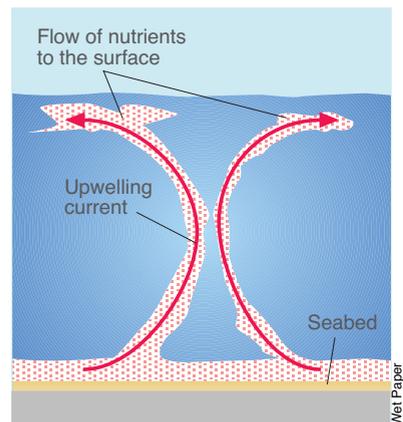


Figure 141.3 Upwelling currents



Figure 142.1 Upwellings off Peru



Figure 142.2 Aquaculture research facility Cairns

There is a theory that we could increase nutrient levels in the ocean by fertilising open waters, productivity could be increased.

Some scientists have considered installing nuclear reactors on the seabed to drive nutrients upwards. The artificial upwellings could bring to the surface organic materials that had settled to the bottom of the ocean. Artificial upwellings have been created using pumps to lift debris from the seabed, but so far they have not been economical.

## Aquaculture

Aquaculture is the farming of plants and animals that live in fresh or saltwater. Like all farming, it involves breeding and growing these plants and animals under controlled conditions to achieve higher production rates than would occur in the wild.

Aquatic species are farmed for food because they are generally higher in protein, have higher reproduction rates, higher food conversion ratios, and have less wastage than their terrestrial counterparts. Some are also farmed for unique products that are not found in land plants and animals.

Aquatic organisms may be farmed as:

- Water-based systems (sea cages and pens, inshore/offshore).
- Land-based systems (rainfed ponds, irrigated or flow-through systems, tanks and raceways).
- Recycling systems (high control enclosed systems, more open pond based recirculation).
- Integrated farming systems (eg livestock-fish, agriculture and fish dual use aquaculture and irrigation ponds).

Aquaculture can be compared with the water equivalent of land based agriculture as shown in Figure 142.3.

Agriculture	Aquaculture
Land based	Water based
Relatively easy on solid land	Relatively hard in liquid water
Stable non-moving medium	Unstable moving medium
Uses domesticated plants and animals	Stock is usually wild or bred from wild stock
Little chance of waste and food contaminating the living area	Waste and food are placed into the living area often causing contamination
Extensive variety of plants and animals used	Limited variety of plants and animals used
Containment, feeding, protection from predators and disease is relatively straightforward	Containment, feeding, protection from predators and disease is relatively complicated and sometimes almost impossible

After O'Connor 2008

Figure 142.3 Agriculture/aquaculture comparison

There are two types of aquaculture systems that are presently used as successful methods of farming aquatic animals for food.

These are extensive and intensive aquaculture systems which can operate in an open or closed water environment.

## Extensive systems - mostly natural waters

Natural water bodies such as rivers stocked for recreational fishing, farm dams to which fish or crustaceans have been added, large earthen ponds built for farming fish or crustaceans and stick and tray culture of oysters in natural waterways (Figure 143.1) are examples of extensive aquaculture systems.

Extensive aquaculture systems have aquatic animals which are grown in large tanks (Figure 143.2) and released into dams. These dams are stocked at relatively low densities and much of the feeding is partly or completely based on the natural food generated in the pond itself.

There is generally little to no artificial food supplied. The Barramundi caught in the lake near Proserpine in Figure 143.3 must rely on other fish in the lake for food.

In other cases the water is fertilised to promote algal growth. The algae may serve as food for the culture animals or other animals (eg zooplankton) on which the culture animals feed. This technique is used by fish farmers. There is a subsequent increase in the numbers of minute animals which feed on the algae. When hatched **fish fry** are introduced into the pond they begin feeding immediately on the zooplankton.

Another feature of extensive systems is that a large water surface area is required, but not necessarily a large continuous supply of water. It needs only enough water to fill and maintain the water level in the dams and ponds.

A newly constructed dam may be filled during the first wet season, allowed to mature and then stocked with fish. Providing that there are not too many fish in the dam, it may be several months before more water needs to be added.

However, earthen ponds require more attention. Some may just need to be topped up regularly while others may require continuous water exchange.

### Problems

There are a number of problems associated with extensive systems. These include:

- dependence on the local climate and water quality,
- a low level of control over the environment and production,
- low production efficiencies.

### Simplified definitions\*

**Extensive aquaculture** is farming mostly in natural water bodies.

Eg: Oysters, mussels

**Intensive aquaculture** is farming mostly in artificial ponds, dams or cages.

\*If you study aquaculture systems further you will learn that there are many variations to these terms.

**\*Download the Australian Prawn Farming Manual - An excellent free publication**

*aciar.gov.au October 2006*



Figure 143.1 Extensive oyster farm in natural waterway



Figure 143.2 Larval cultures of barramundi fish stocks prior to release



Figure 143.3 Extensive system in lakes



1. Name the four methods that could be used to increase the harvest of the sea. Which method do you think has the greatest potential?
2. What is aquaculture?
3. What is the difference between *extensive* and *intensive* aquaculture systems?
4. What fish is grown in the Pearl River Delta region in South China?
5. What is a fish pen and how is different from an oyster rack?
6. What fish are farmed in the Philippines? Draw a pie graph to show the percentage major species cultured in the country includes.

## Intensive systems - mostly caged waters

Intensive aquaculture systems have aquatic animals stocked at high densities in small ponds, raceways, tanks, troughs, cages or dams and can be found in both artificial and natural waterways. These systems are more suitable for expensive species such as salmon, crayfish and trout.

### Features

A major feature of intensive systems is that the feeding is done regularly and is based largely on artificial feed such as specially formulated diets in pellet form.

The amount of food given must be watched very carefully. Insufficient food may result in poor growth, increases in disease and cannibalism, and the death of many animals. Excess food also causes a number of problems such as rotting uneaten food. The rotting process involves the activities of fungi and bacteria which are decomposers and remove a lot of oxygen from the water. The resulting low oxygen concentrations is likely to cause the death of the cultured animals or at least stress them. Stressed animals tend to grow more slowly and have an increased susceptibility to disease.

Another feature of intensive systems is that fresh water must be flushed regularly through the holding facilities to remove or dilute the accumulated wastes. Animals produce wastes high in nitrogen. Some of these can be very toxic (particularly ammonia) and must be diluted or removed from the system regularly. Therefore a good supply of clean water or a very efficient filtering mechanism is essential in intensive aquaculture operations.

In intensive systems there is a high level of control over the environment, high production efficiencies, and less dependence on the local climate and water quality. However, these advantages come at high costs.



Figure 144.1 Indonesian fishmarket



Figure 144.2 Chinese fishmarket

## Traditional Asian systems

The growing of aquatic organisms has been practised in Asia for many centuries, particularly in China. Their methods were low-cost and extensive and most of the produce was used by the farmers' households and their local communities. Indonesia and India were also pioneers in fish culture.

In Asia inland or freshwater aquaculture is the major source of fin fishes for local consumption. It is characterised by low-input culture techniques and extensive or semi-intensive stocking.



Figure 145.1 Intensive Indonesian milkfish and prawn farm

Inland fishponds are operated mostly by small farmers as part of their simple farming systems. Freshwater cage or pen culture seldom reaches a commercial scale. China is the world leader in freshwater aquaculture with the fastest-growing component of China's freshwater aquaculture being pond fish culture.

Inland aquaculture in Asia is dominated by integrated farming of finfish, livestock, rice, fruit trees and vegetables. Tilapia and carp are the most popular fish produced in integrated farming. This type of farming increases the production of the farms, makes better use of farm resources, creates employment and allows agricultural wastes to be disposed of. In the Pearl River Delta region in South China a dike-pond system is used integrating the production of Chinese carp, sugar cane, and mulberry leaf silkworms. The farmers in India have adopted an integrated system of rice-fish culture and fish-livestock-crop farming. This provides an efficient way of producing most of the food needs of farm families, increasing their incomes and making use of livestock waste. Rice-fish farming which is found in almost all provinces of Indonesia is the most common type of farming, followed by cattle-fish.

Aquaculture is the leading fish producing sector in the Philippines, contributing 34% to total fish production in 1998 (Figure 145.2). They produced milkfish and tilapia, and seaweeds, respectively. Major species cultured in the country includes: seaweeds (68%), milkfish (16%), tilapia (8%), shrimps or prawn (4%) and others (4%). Farmers with small landholdings in Indonesia culture fish with rice, vegetables, chicken, duck, sheep, and cattle.

In the milkfish farm in Figure 145.1 prawns are grown by the farmer. On a 0.6-0.7 hectare area he stocked 30 000 *milkfish* fingerlings and 15 000 wild prawn fry. At five months of culture, he was able to get 350 kilos of prawns and profit on his business well before the fish were harvested.

All images on this page courtesy Southeast Asian Fisheries Development Centre (SEAFDEC)



Figure 145.2 Philippines aquaculture



Figure 145.3 Indonesian aquaculture

- A — mudcrab culture in pens
- B — the seaweed *Kappaphycus*;
- C — tilapia;
- D — hanging culture method for oysters and mussels

# Oyster case study

Oysters are an example of an **extensive system** of aquaculture and are one of the invertebrates most suited to aquaculture. In 195 BC, Sergius Ovata first cultivated oysters in Lake Lucinius, near Rome, and was reported to have made a fortune because the Romans ate a lot of oysters.

## Biology

**Oysters** have a soft body which is covered with a hard outer shell. They breathe through gills and have a strong adductor muscle to keep the shell together (Figure 146.1). They are **hermaphrodites** or bisexual and eggs and sperm are released into the water where they fertilise each other (Figure 146.4). After about 24 hours, they form a larval stage called a "trochophore" which is free swimming.

In about a week the second or "veliger" larval stage forms which starts to look for a place to settle. By 2-3 weeks, the veliger attach themselves to a hard surface and are now called "spat". (They got this name because people originally believed that the adult oyster simply spat out its young). Spat usually, if not always, start life as males, and then may change to a female.

When the gonads of adult oysters are ripe, they are full and white (Figure 146.2), giving the oyster its prime condition.

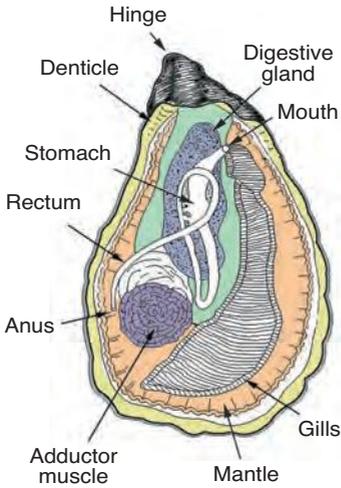


Figure 146.1 Oyster anatomy  
Wet Paper



Figure 146.2 Adult oyster  
Ruth Fairley



Figure 146.3 Oyster spat  
Ruth Fairley

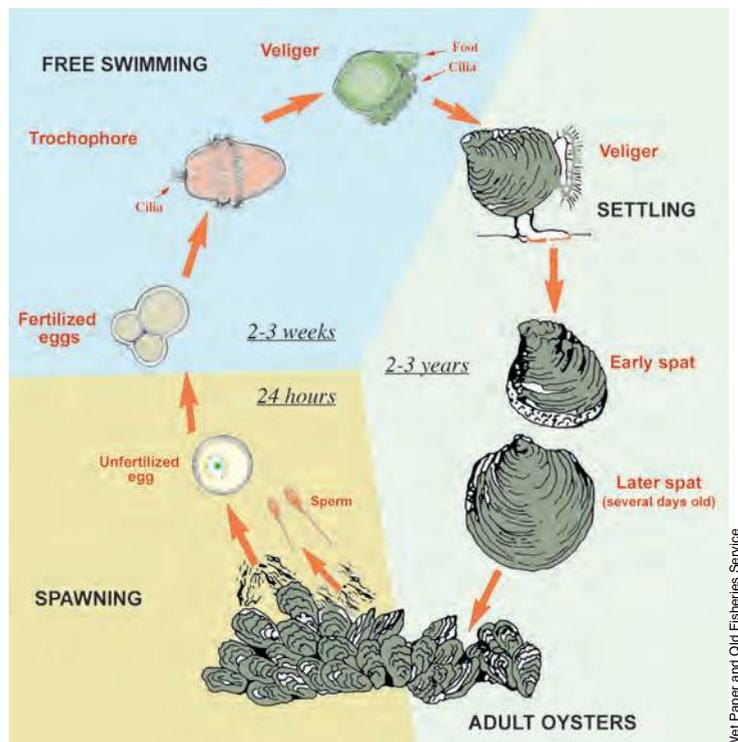


Figure 146.4 Oyster life cycle  
Wet Paper and Old Fisheries Service

## Oyster dissection

[www.msg.umd.edu/programs/education/interactive\\_lessons](http://www.msg.umd.edu/programs/education/interactive_lessons)

After spawning the gonad becomes shrunken and watery, lowering the quality.

Oysters take about 3-4 years to grow to a marketable size, during which time they develop their protective shells. The oyster feeds through its gills (Figure 146.1), taking micro-organisms out of the water and feeding on them. For this reason, pollution can greatly affect the oyster. When it is out of the water, oysters close their valves and in cool conditions can survive for up to two weeks in prime condition.

### Farming

Most oyster farms operate by collecting spats and putting them onto manufactured racks or bags to grow. The racks are painted with tar to prevent woodworms eating them away. They are left in this stage for about 6-12 months, after which they can be culled by hitting the stick with a hammer to shake off the oysters.

The oysters are then put loose in trays for about 9 months or more to fatten. After this they are purified, sorted and then sold. By the time they are sold the oysters will be 3 to 4 years old. Often, clumps of oysters on rocks are placed in these areas and the oysters allowed to mature. This is a traditional aboriginal method of growing oysters. Other methods to grow oysters include rafts, tumblers (Figure 147.2).

### Processing and marketing

In most states it is mandatory to purify oyster for 36 hours. The aim of this is to remove most of the micro-organisms from the oysters. It can be done in a shallow rectangular tank, filled with sterilised estuarine water. This is sterilised using high intensity ultra violet light, killing all micro organisms, but still leaving the water salty. The water is then circulated through the tank and UV light source.

Oysters are graded by hand either plate, bistro or bottle and wholesaled by the dozen. "Bistro" oysters now have their own niche in the oyster market and are sold to bars as a cheap oyster, affordable for the public.

Oysters are mostly sold directly to restaurants, but the profit restaurateurs make can be as high as 300%. This price discrepancy annoys many oyster farmers, who consider they do not get enough return for their 3 to 4 years of work.

### Disease and environmental hazards

Mudworms, parasites, floods, heat and general pollution are the main threats to the oyster industry. The need for high water quality is vital. Oyster leases are controlled by state government regulations and licences are required in most states.



Figure 147.1 Extensive aquaculture, SA



Figure 147.2 Oyster bags on a line



Figure 147.3 Oyster spats on a rack



Figure 147.4 Oyster trays and tumblers

# Salmon case study

The text on the next two pages has been supplied by Tassal Ltd [www.tassal.com.au](http://www.tassal.com.au)

Salmon are an example of an intensive system of aquaculture. The four phases of salmon aquaculture in fresh water, brackish water and marine are shown in Figure 149.1.

## Freshwater stage

As salmon approach maturity, at the end of summer, previously selected brood stock are transferred from sea farms to the hatchery, where they complete their natural maturation process in fresh-water. During May, when the fish are 'ripe', eggs and milt (fish semen) is collected from females and males respectively.

A single female will typically provide 5 000 to 10 000 eggs, depending on her size (Figure 148.2). A male can provide sufficient milt to fertilise hundreds of thousands of eggs, but in a typical hatchery situation, the milt from three males is pooled to then fertilise the eggs from females.

The eggs are fertilised by mixing them gently with milt in a bowl (Figure 148.2), they are then rinsed, counted in bulk, and stocked in incubators which receive a constant flow of clean water, heated to about 10°C (Figure 148.3).

During the subsequent six weeks or so, the fertilised eggs develop embryos which eventually hatch complete with eyes, fins and a large yolk-sac attached to the belly. These fish, now called **sac-fry**, spend several more weeks hiding in the artificial substrate provided, much as they would in gravel in nature, using up the yolk to grow.

Between September and November, as they reach about 4 centimetres in length, the fry are gradually moved to outdoor production tanks. Over the spring and summer period the fish continue to grow, soon developing the "finger mark" pattern of coloration along each flank (called parr-marks) which characterise juvenile salmon in fresh-water.

Internal physiological changes are also occurring, the most important being that special salt secreting cells in the gills and the kidneys increase in number and in activity. The fish are turning into **smolts** (Figure 149.3), a change which will allow them to not only survive but to thrive in seawater.

By mid September, some fifteen months after they were hatched these smolts, averaging about 75 grams in weight are ready to go to sea. They are transferred in purpose-built tankers with special oxygenating systems, and their condition is monitored during the journey by experienced personnel.



Figure 148.1 Adult salmon

Wet Paper



Figure 148.2 Mixing eggs and sperm

Ruth Farley



Figure 148.3 Hatchery

Bob Moriatt



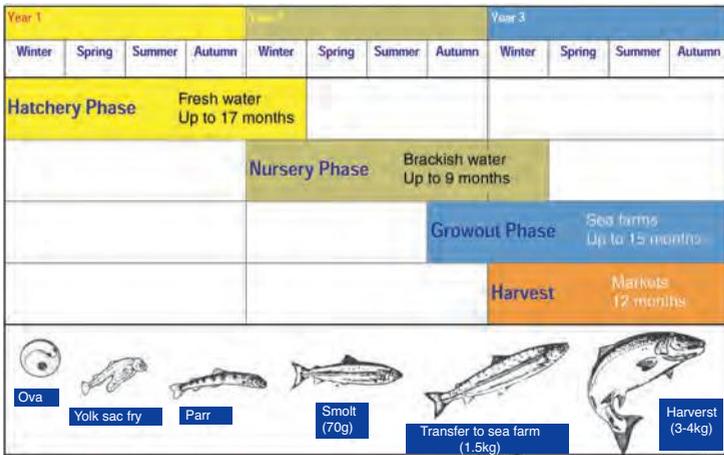


Figure 149.1 Salmon life cycle

**Brackish and marine stage**

Tassal’s annual intake of around one million smolt is transferred between April and December to brackish water sites in the Huon River and the Tasman Peninsula. The brackish Huon sites also provide ideal conditions in which the young smolt grow rapidly, with high survival rates.

Frequent downstream flushes of fresh rainwater and a good natural rate of water flow in the river also aid in carrying the fish through their critical first summer. Careful management and regular checks on the fish population ensure an optimum nurturing environment in which the young salmon develop.

After six to nine months at the nursery sites in the Huon River, the salmon are transferred to the Dover farm (Figures 149.5 - 149.6) for grading and ongrowing to harvest size in pens. Most pens currently in use are 80 metres in circumference, each containing around 15 000 salmon.

The area of each site varies and accordingly the number of pens per site differs. The number of pens at any site at any given time will change as fish are harvested and as new seasons fish are introduced.

**Stockfeed**

Salmon feed is largely comprised of fishmeal, cereal products, fish-oil, and vitamin and mineral premixes, commercially manufactured to exacting standards. High quality fish meal is the main protein source.

The formulation and particle size of the feeds are varied as the fish grow, to ensure that both the health and nutrition needs of the fish are met throughout its lifecycle. For example the start feed in the hatchery is extremely fine, and feed used for ongrowing is in pellet form.

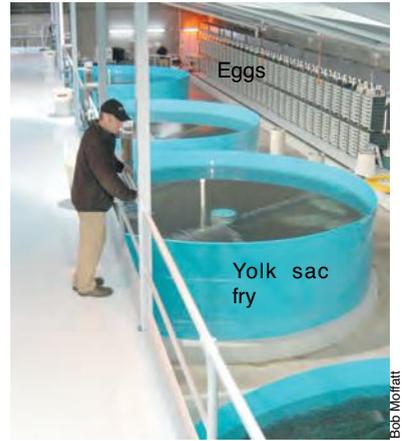


Figure 149.2 Grow out tanks



Figure 149.3 Smolt



Figure 149.4 Monitoring feeding by underwater video camera



Figure 149.5 Holding pens



Figure 149.6 Checking size



Figure 150.1 Killing salmon



Figure 150.2 Transfer to factory



Figure 150.3 Gilling and gutting



Figure 150.4 HOGG salmon packing and distribution



Figure 150.5 Marketing overseas

## Harvesting

Pens ready for harvesting are towed to a harvesting platform. The live salmon are transferred from the sea cages to the harvest wharf using a low pressure pump system where they are put to sleep and killed (Figure 150.1). This method of transfer lowers the stress on the salmon compared to a traditional dip net method. Inside the processing facility the salmon are gilled and gutted (Figure 150.3) and inspected prior to the individual salmon being weight graded. After weighing and grading chilled salmon is held in an aerated ice slurry and packed into polystyrene cartons (Figure 150.4). The most common form of distribution are HOGG fish (Head On Gilled and Gutted).

## Value adding - smoking

Chilled salmon are hand filleted to ensure quality control. The fillets are then hand salted and cured over night. The smoking process utilises Tasmanian woods to create a rich and distinctive smoke flavour. Smoked fillets are rapidly cooled then sliced to produce a range of pack sizes 100 grams, 200 grams, 500 grams and traditional sliced sides.

## Sales, marketing and distribution

In Australia, salmon are sold in the wholesale, retail and food service markets in Australia and enjoys more than 50% market share. Wholesale provides the basis for business whilst retail supermarkets and food service categories are seen as major growth opportunities. Specific products are marketed in each of the market categories. **Sales and marketing** employees are located in four states to service wholesale, food service and distributors. Supermarket business is serviced by distributors and a national foodbroker network.

Specialized equipment (Figure 150.6) was developed for the safe packing and transport to ensure the salmon sold are of high quality.

## Export market

Major focus is on the Japanese market where fresh, head-on gilled and gutted salmon are airfreighted regularly to customers in the main auction markets of Japan, Indonesia, Singapore, Thailand, Hong Kong, Philippines, Taiwan and a number of smaller island outlets.



Figure 150.6 Pallet loading of salmon for air freight

# Polyculture

Many fish farms hold fish in an enclosure for their total life cycle. These fish are bred and allowed to develop in the enclosure. This method has only been developed recently for marine species because previously we knew little about egg production or the feeding of larvae. Early attempts at rearing larvae had poor results because of disease and lack of suitable food. These problems have now been overcome or, at least, controlled.

**Polyculture** is a new development though it was used by the ancient Chinese. A polyculture farm can have shellfish and crabs developing on the seabed, finned fish living in the water and water animals, such as ducks, being raised on the surface. This multiple cropping saves on material, space and labour costs (Figure 151.1).

## Seaweed farms

Algae are one of the most primitive life forms but still little is understood about this plant. Most seaweeds are just colonies of algae and there are thousands of types of algae from tiny diatoms to the giant kelps.

Most of the usable kelps are only found on rocky shores which are difficult to harvest. To farm this seaweed, a method of growing it in an area where it can be easily harvested, must be developed. Most seaweed farms have remained the same for decades. They consist of a network of ropes 100 metres long, netted together across the ocean surface.

Seaweed spores are trapped in the rope's fibres and develop into new individual plants (Figure 151.3). Some modern farms use synthetic horizontal beds to increase the cropping areas and lower the maintenance and costs while making mechanical harvesting possible. Seaweed grows very fast and most species can produce up to three crops a year. For example, the *Macrocystis* species is the fastest-growing plant in the world and farmers have to make sure it receives a constant supply of nutrients to maintain its growth rate. Many of these farms process human wastes from sewerage plants because of the high nutrient content in wastewater.

Marine science and technology have been used to develop new varieties of seaweed, for example, developing different strains of seaweed with desired properties. Genetic manipulation has produced new strains that reproduce faster and contain more food. One problem is that farmers have to ensure that the natural oceanic consumers of seaweed do not harvest the crop before they do.



Figure 151.1 Fish and redclaw polyculture farm

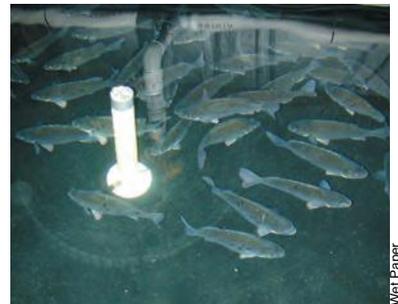


Figure 151.2 Fish from farm dam above

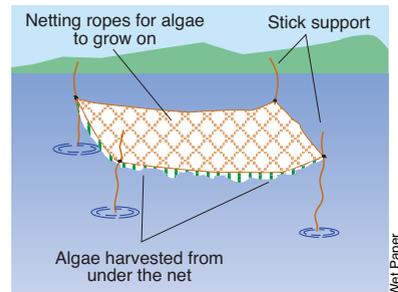


Figure 151.3 A seaweed farm with netted ropes to which algae attach



Figure 151.4 Indonesian seaweed farm

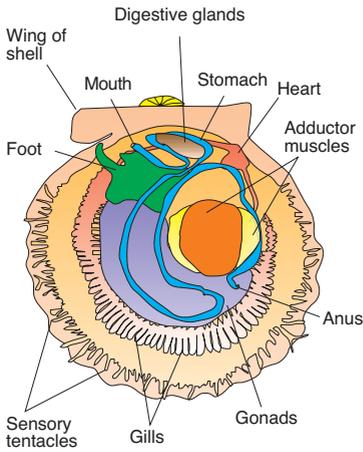


Figure 152.1 Scallop internal anatomy  
Bob Moffatt

## Diving deeper



1. Arrange an excursion to a local aquaculture farm.
2. Research aquaculture methods to raise any one of the following marine organisms:
  - barramundi, oysters, mussels, scallops, seaweed, salmon, tuna, pearls, crayfish, prawns.
3. See your school's vocational education coordinator to arrange a structured work placement or work experience on an aquaculture farm.
4. Obtain a label from a box of seafood and write an explanation for each part of information explaining how it helps the fish shop owner.
5. Complete a rich task on a seafood export.

## Invertebrate farms

Invertebrates, such as oysters, mussels, crayfish and prawns have been farmed for many years. These farms are becoming more important because they are more energy efficient and have greater productivity than fish farms. Invertebrates are mostly first order consumers which feed on plant material and so use only a small amount of energy to produce food. Invertebrates have a high **fecundity** rate, that is the females produce a high number of eggs each breeding season.

### Crayfish

Refer Chapter 13.

Freshwater crayfish occur naturally throughout Australia. Commercial marron production is largely based in its natural habitat in south-west Western Australia and there is an expanding base of production in South Australia. Commercial redclaw production is mainly confined to coastal regions of Queensland. Yabbies are produced commercially throughout NSW, Victoria, SA and WA.

### Scallops

Scallops have an excellent aquaculture potential. Scallop meat (the adductor muscle of the scallop) is a common seafood sold in fish and chip shops. Scallops sold in the South Pacific are trawled from the seabed by commercial fishing boats.

However, the scallop can be induced to spawn in artificial conditions by increasing the water temperature. The scallop aquaculture industry is in its infancy with farms being established along our southern coastline. Imported scallops from farms in Asia are larger but lack the flavour of locally farmed Tasmanian scallops.

### Crabs

Mud crabs have been farmed in Asia for many years, but are only just being developed commercially in some countries. There is a very good market for the product but some characteristics of the crabs do not lend themselves to farming. Mud crabs are very territorial and will fight when crowded together. They are also cannibals and many of the young are destroyed by the adults.

Another difficulty with farming mud crabs is that they burrow under the mud during the day and feed at night. This causes problems with the structure of the ponds (they burrow into the dam wall) and makes the crabs difficult to harvest.



## Pearls

Some oysters are used as miniature factories for growing pearls.

Five species of oysters naturally produce pearls when grains of sand or other foreign material get inside the shell and irritate the oyster. The oyster responds by producing substances made from calcium carbonate to surround the object. Pearl formation is also triggered by tiny parasitic worms which may burrow into the shell. Oysters can be manipulated to produce a greater number and more perfectly shaped pearls than occur naturally. These are called cultured pearls (see Figures 153.1 and 153.2).

## Mussels

Mussels are another invertebrate that are particularly suitable for marine farming because they are highly productive, grow well and have a high protein content in their meat. Some mussels are grown on ropes hung from pontoons. The larvae settle on the ropes where they mature. Mussels are different from oysters in that they are not permanently attached to the substrate. They can, if conditions are unfavourable, detach themselves and swim to a new position by expelling jets of water. Like oysters, mussels are filter feeding plankton eaters and so are susceptible to concentrating bacteria such as *E.coli* in their tissues. This health threat can have a devastating effect on product sales.

## Prawns

Prawns have been farmed for a long time in Asia. Farms are now being set up in northern Australia and all over the world. Prawns have a high breeding rate, good growth rate and a great market potential. Prawn larvae are kept for three weeks in a controlled indoor environment before they are released into grow-out ponds. The female prawn has to lose her shell before she can mate but at this time prawns are most susceptible to predators and disease. As well as raising their own breeding larvae, farms can be stocked by collecting larvae and juveniles from the wild to be reared in protected ponds.

## Clam farms

Clam meat is highly prized on the open market where it is regarded as a great delicacy and can command prices of up to \$150/kg in Hong Kong. Clams grow at a surprisingly fast rate. They can reach the size of a 20 cent piece in six months. The young clams are then placed back into the wild where they can reach market size in 5–10 years. Scientists have estimated that clam farms could produce up to 6000 tonnes/square kilometer per year. Experimental clam farms have also been established on the Great Barrier Reef and the South Pacific (Figure 153.3).



Figure 153.1 Pearls



Figure 153.2 Seeding pearl shell



Figure 153.3 Clam farm Vanuatu



7. What is rice-fish culture and fish-livestock-crop farming?
8. Why is oyster farming an extensive aquaculture system?
9. Draw a diagram of an oyster life cycle.
10. What are spat?



11. How are oysters marketed to restaurants?
12. What problems do oyster farmers face in farming their product?
13. What is a suspension culture and how is it helpful to oysters?
14. Why are oyster racks painted with tar?
15. How are mussels grown?
16. How does a pearl form?
17. What does the term 'moulting' refer to?
18. What is the fastest-growing plant in the world?
19. Why is it difficult to harvest seaweed and oysters from the wild? How has this been overcome by seaweed and oyster farmers?
20. What happens in a salmon hatchery?
22. How are salmon harvested?
23. What are HOGG salmon?
24. What does the term *value adding* mean and give one example.
25. Why are the young of oysters called spats?
26. What is an intensive farming system? How has this led to a pollution problem?
27. How long are imported aquarium fish kept in quarantine? Why might this be a problem?
28. List five employment opportunities in the aquaculture industry.



## Problems in underwater farming

Setting up underwater farms may cause environmental problems so they need to be carefully managed and monitored. Some of the problems that need to be overcome involve pollution, reclamation of wetlands, disease and introduced species.

If you are using red claw in school projects don't dump them in the local stream when finished.

### Pollution

Many underwater farms are developing intensive systems where large numbers of animals are kept in small ponds or in sea pens. These farms need to feed their animals regularly but any excess food can cause problems when it gets into the natural environment. Animal waste contains high amounts of nitrogen which can be toxic (particularly ammonia). Using sea pens and draining aquaculture ponds can cause damage to benthic animals because the overflow water contains large amounts of animal waste which pollutes local waterways. Other chemicals such as disinfectants, insecticides and fertilisers can also be released by the farms into the surrounding environment. Mud crabs and prawns prefer to live in estuaries. If ponds are built in these areas, they may cause environmental problems because these ponds or cages can alter the water flow and cause sedimentation. Estuaries are the nurseries of the sea and interfering with these areas can affect the life cycle of many other animals.

### Disease and introduced species

Disease is a major concern of the underwater farmer since the farm is so crowded with animals. If one animal becomes sick, the disease can spread rapidly to the other stock. Most animals are prone to parasites, bacteria, fungus and viruses. Since the farm may import food and stock from other areas and even from overseas, the chance of disease is increased.

A **marine pest** is an introduced species of plant or animal that seriously affects the survival of native animals and plants unique to a region. The pest can be introduced from another country or be a naturally occurring organism that increases in numbers. For example, the algae in Figure 155.1 was introduced into the southern ocean off Tasmania by an overseas ship, reproduced rapidly and now concentrates in local mussels and oysters.

When people eat the seafood, the **toxin** produced by the algae makes them ill and gives the oyster an undeserved bad reputation.

Fish shops then have difficulty selling mussels and oysters which impacts on the whole shell fishing industry. The algae produce spores that live in soft silty seabeds for many years and are a very hardy species and therefore pose a big problem. Other examples are the Japanese sea star in Figure 155.2 and the Japanese seaweed which both came from the Northern Hemisphere in the ballast water of ships. The sea star was first recorded in Tasmania in 1986 and the larvae may yet be carried across the Tasman Sea and Bass Strait to the mainland of Australia and New Zealand.

## **Employment opportunities**

University graduates have considerable employment opportunities in the broader area of applied aquatic biology and can be employed as technicians, farm managers, policy makers and advisors, aquaculture consultants and research workers (Figures 155.2 and 155.3).

Aquaculture technicians are required to:

- breed and raise marine organisms such as fish, eels, crustaceans, shellfish, pearl-producing shellfish, algae, crocodiles and turtles in artificial conditions;
- identify common diseases in fish and shellfish, and take the necessary steps to prevent problems which may occur in intensive farming;
- carry out experiments using chemical and biological substances to control predators, parasites and micro-organisms;
- monitor the environment using oxygen meters, salinity meters, pH (acidity) meters and water chemistry analysis kits;
- maintain live feed and algae cultures;
- keep records of breeding and treatment programs and
- develop and implement systems of profitable farm management.

## **The future of aquaculture**

Aquaculture can help solve the problems of feeding the world's increasing population and the over-exploitation of existing fisheries while expanding a new area of industry.

We need to increase the percentage of food produced by aquaculture. Although the ocean covers 71% of the world's surface, it does not produce 71% of the world's food. The land produces nearly 5000 million tonnes of food worldwide every year but just 90 million tonnes comes from the ocean. Could this mean that the full potential of the oceans as a food source has not been realised?



Figure 155.1 Introduced algae



Figure 155.2 Aquaculture farm manager



Figure 155.3 Employment in seafood handling industry

## Diving deeper



6. Complete a chart on the life cycle of an aquacultured animal or plant.
7. Research the export of live fish to Asian markets. Find out how valuable individual marine organisms are and what methods are used to ensure that the highest quality of product reaches the market.
8. Find out how seafood is used in sushi.

### Projects

Aquaculture is an ideal school project subject. The tanks shown in the figure below were built as part of school projects (See also pages 374 - 376).

Projects can cover anything from commercial operations to scientific study and be as short as a week or as long a year.

Everything from studies in anatomy to breeding cycles, conditions of growth and new and innovative water filtration techniques can be studied where experiments can be controlled under laboratory conditions.

School aquaculture projects teach you how technology, advertising, commerce, social studies and science can combine to produce a viable economic venture.

However if you use an aquarium for research, never tip water out into a local stream because you could introduce non-native species or unwanted pollution into a stream.



Ballina SHS

Many world fisheries are poorly managed with little thought for conserving diminishing fish stocks. The only thought on the minds of some fishermen is for immediate high returns. A fishing vessel cannot go out all the time to catch fish. It may sit at the wharf for weeks at a time when the weather is rough. Every day the fishing vessel stays home represents a day's lost income. In contrast, a pond containing prawns or fish can be harvested at any time so the farmer can plan and manage the business more predictably.

## Key words

See pages 374 - 375 for Aquaculture project ideas

Aquaculture, fecundity, fish pens, grow-out farms, harvesting, hatcheries, hermaphrodites, holding pens, juveniles, moulting, nutrients, polyculture, racks, sac-fry, smolt, spat, toxin, upwellings, value adding.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. The earliest marine [1] \_\_\_\_\_, oyster farms in Asia, were established over 2000 years ago where [2] \_\_\_\_\_ were raised in much the same way as they are today. Oyster farms were also established in Europe in ancient times. The great scientist [3] \_\_\_\_\_ noted the cultivation of oysters in Greece. Romans also had oyster farms.
- b. As salmon approach [4] \_\_\_\_\_, at the end of summer, previously selected brood [5] \_\_\_\_\_ are transferred from sea farms to the hatchery, where they complete their natural [6] \_\_\_\_\_ process in fresh-water.
- c. Chilled salmon are hand filleted to ensures [7] \_\_\_\_\_ control. The fillets are then hand salted and cured over night. The smoking process utilises Tasmanian woods to create a rich and [8] \_\_\_\_\_ smoke flavour.
- d. Pens ready for harvesting are towed to a [9] \_\_\_\_\_ platform. The live salmon are transferred from the sea cages to the harvest wharf using a [10] \_\_\_\_\_ pump system where they are put to sleep and killed.
- e. [11] \_\_\_\_\_ employees are located in four states to service wholesale, food service and [12] \_\_\_\_\_.
- f. University [13] \_\_\_\_\_ have considerable employment opportunities in the broader area of applied [14] \_\_\_\_\_ [15] \_\_\_\_\_ and can be employed as technicians, farm managers, policy makers and advisors, aquaculture consultants and [16] \_\_\_\_\_ workers.

# Chapter 13 Crayfish



### Web reference

[www.fish.wa.gov.au/fishtales/yabby](http://www.fish.wa.gov.au/fishtales/yabby), [www.dpi.nsw.gov.au/fisheries](http://www.dpi.nsw.gov.au/fisheries)

Australian **yabbies** (crayfish) are famous - we have the greatest variety of **crayfish** found anywhere in the southern hemisphere and we have the three largest crayfish found anywhere in the world!

Crayfish are prized food for fish, birds and humans. Some species have great potential as a source for human food - these species have high reproduction rates, they grow relatively quickly, they are easy to raise, they are high in protein and they taste superb.

They can be raised in farms almost anywhere in Australia if the correct species is used. At the moment only three species are farmed in Australia and they are all from the one genus *Cherax* - **blue claw** (Figure 157.1), **red claw** (Figure 157.2) and **marron** (Figure 157.3).

Marron are farmed in Western and South Australia, red claw are a tropical cray and are farmed mainly in Queensland and blue claw or the common yabby is farmed in its normal area - the Murray Darling basin. Permits are required to farm all yabbies.

Crayfish have always fascinated humans with their ability to live in water and walk on land for short periods allowing them to migrate into farm dams and streams.

## Studying crayfish

Any biological study of crayfish should include anatomy and physiology. Anatomy looks at structure both internal and external while physiology deals with how these structures work to make the organism function. It is convenient to study each system within the crayfish separately.

### General characteristics of crayfish

Crayfish belong to the phylum Arthropoda - the arthropods. The name means jointed legs and the phylum includes the crustaceans, insects and spiders. Crustaceans are the lobsters, crayfish, prawns and crabs.



Figure 157.1 Blueclaw



Figure 157.2 Redclaw



Figure 157.3 Marron

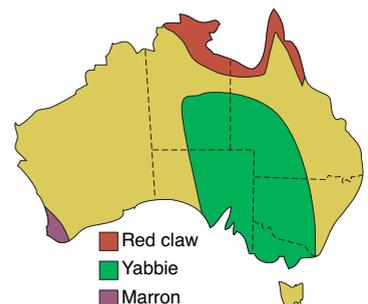


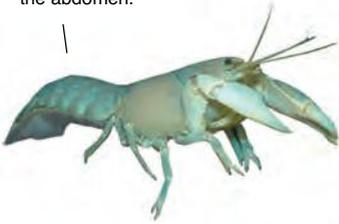
Figure 157.4 Distribution of yabbies  
Wet Paper

### Did you know

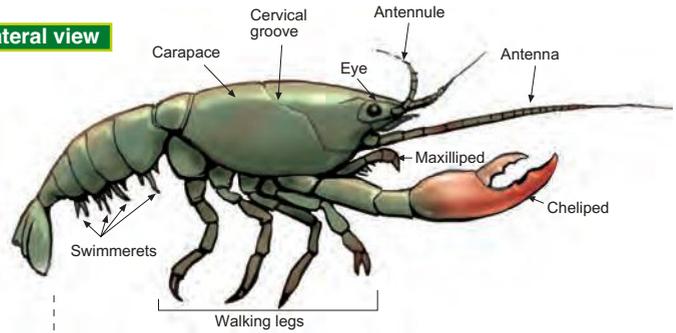
Chemical co-ordination using hormones affects the whole body. It controls growth, moulting and sexual maturation and reproduction.

Hormones are produced by the X-organ located in each eyestalk and are secreted into the blood. The blood then takes these chemicals to all cells in the body.

The part of a crayfish that we eat is the muscle in the abdomen.



### Lateral view



### Dorsal view

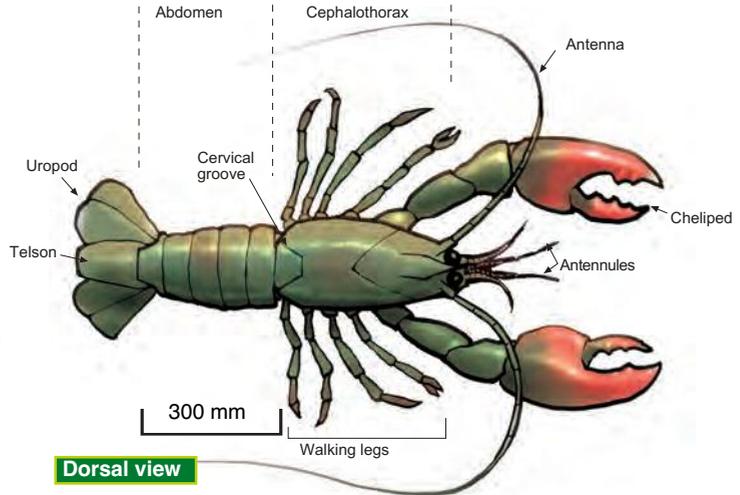


Figure 158.1 Yabby external features  
Bob Moffatt, Illustrations Kerry Kitzelman

## Skeletal and muscular systems

Support and movement is made possible by the skeletal and muscular systems. Those animals that have skeletons either have the skeleton on the outside of their bodies (**exoskeletons**) or like us on the inside of their bodies (**endoskeletons**). Endoskeletons grow continuously with the animal, exoskeletons do not, and pose problems for animals that have them.

The skeleton is used to support the body, to provide an attachment for the muscles to pull against and to protect the internal organs. The tough external skeleton of a crayfish is divided into **head, thorax** and **abdomen**. The whole body is divided into segments.

Each segment has one set of paired limbs or appendages.

- the head has six pairs;
- thorax has eight; and
- the abdomen has six.

The head and thorax are fused into a single inflexible carapace.

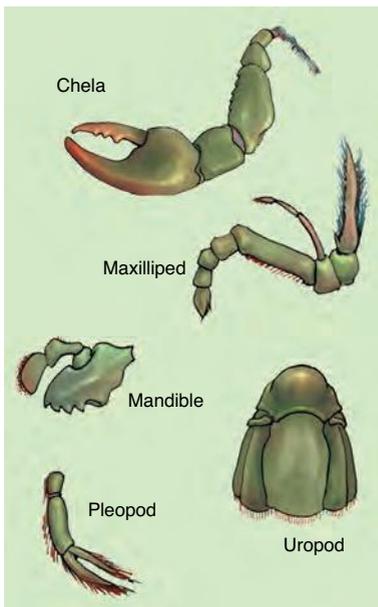


Figure 158.2 Appendages  
Kerry Kitzelman

The first pair of limbs in the head are the antennules used for balance, touch, taste, smell and checking the quality of the water. The next pair the antenna are touch, taste and smell sensors.

After these are the mouthparts. The mandible is used for biting and tearing food and it secretes a lubricating fluid.

The next five pairs of limbs are used for feeding. They hold, position and move food around the mandible before it is taken in through the mouth as well as cleaning and protecting the mouth.

The next pair form the nippers used for fighting, holding, and as a counterweight to balance the muscular abdomen.

The next four limbs are walking limbs. Unlike a prawn that swims, crayfish are bottom dwellers that walk. The remaining six limbs of the abdomen are used for swimming and carrying the eggs in a female. The last one forms the tail. With so many limbs the chance of damage and loss is high - the crayfish is able to regenerate damaged limbs.

## Movement

The abdomen has flexible segments each having its own piece of overlapping exoskeleton. This allows the segments to move independently up and down but not sideways.

## Digestive system

The **digestive system** consists of mouthparts, oesophagus, stomach, digestive gland and intestine.

Crayfish are detritivores - they eat organisms that break down dead and decaying matter as well as the matter itself. They take hold of the food using the chelae (nippers) at the end of their limbs and move it towards their mouthparts. The mandibles cut and grind the food into small enough particles to be ingested through the mouth. The food then passes through the short oesophagus to the stomach.

The stomach has two areas - the first part for grinding and the second part for filtering. The first part called the **gastric mill**, and three plates grind the food into particles small enough to be digested. Anything that cannot be digested, such as sand, is regurgitated from the body via the oesophagus and mouth.

The food then passes into the second section of the stomach which filters the mashed food. The liquids and very small particles of food pass through a series of filters and are directed to the digestive gland where enzymes are added to break down the food. Nutrients are absorbed by the digestive gland after digestion occurs.

Coarse particles that are unable to pass through the filters are directed into the intestine to be passed out through the anus as faeces.

Unlike the human system, the intestine in a crayfish does not secrete digestive enzymes nor does it absorb nutrients or water.



Figure 159.1 Yabby defences

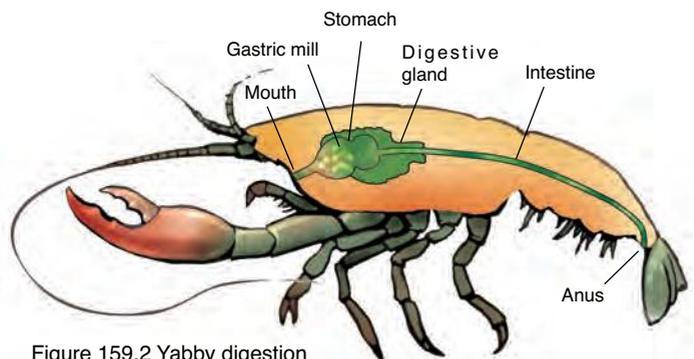


Figure 159.2 Yabby digestion  
Kerry Kitzelman

## Circulatory system

**Circulation** systems continually send blood through pipes in a circle. The blood is pumped out to cells where it delivers oxygen and nutrients and picks up wastes transporting them to cleaning stations before sending out the clean blood again. The human circulation system is a closed system - the blood stays within arteries veins and capillaries and our blood is red due to the oxygen carrier haemoglobin. Crayfish blood is pale blue having a different oxygen carrier, haemocyanin, and their blood does not stay within vessels. It bathes all tissues in their bodies.

The crayfish circulatory system is an open system - blood is pumped from a single chambered heart to all areas of the body along arteries.

- The blood pours out into spaces in the crayfish's tissues called sinuses, and bathes the internal organs, providing them with oxygen and nutrients. The blood drains into the ventral artery and is taken to the gills and green gland. It is re-oxygenated and carbon dioxide and wastes removed.
- When the blood returns to the heart it drains into a sac like bag which surrounds the heart, the pericardium.
  - The blood then enters the heart through six openings or valves called ostia.

Circulation occurs as the blood is pumped from the heart along the main arteries through a system of valves in the ostia and sinuses that force the blood to flow in one direction only.

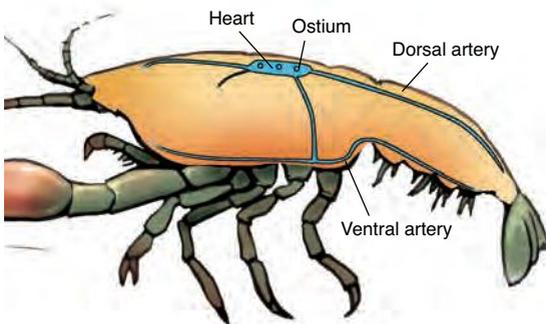


Figure 160.2 Circulation  
Kerry Kitzelman

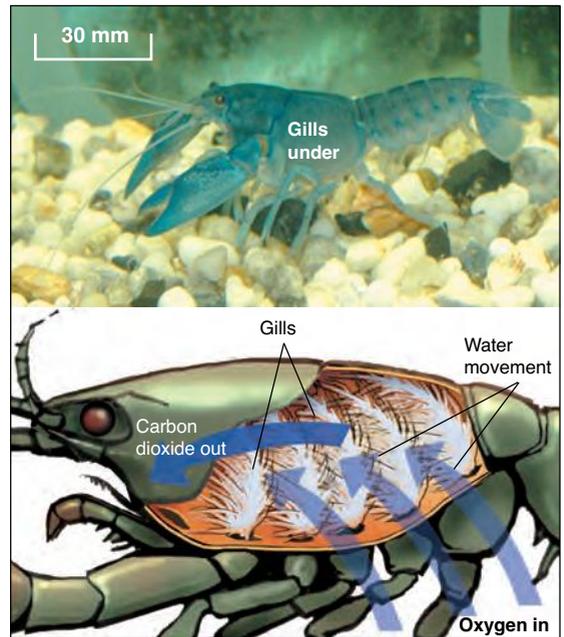


Figure 160.1 Gas exchange  
Kerry Kitzelman

### Gas exchange

Carbon dioxide is removed by the gills at the same time as oxygen is obtained from the surrounding water.

The gills are made of bony or cartilaginous arches to which pairs of filaments rich in blood vessels are attached.

- The filaments are thin structures with a large surface area to allow efficient gas exchange between the water and the crayfish blood.
- The gills are inside along each side of the body under the carapace.
- Water is pumped up between the legs and out the front past the mouth over the gills by moving the legs and beating some of the mouth parts.
  - As it passes the legs the setae filter the water before it reaches the gills to remove any large particles which could damage the gills.
- The gills need water to keep the filaments separated.
  - When the cray leaves the water it keeps the filaments wet, but they will eventually dry collapsing on top of one another and the cray will die.

## Excretory system

The **excretory** system is responsible for the removal of cellular wastes from the body. These are the wastes from chemical reactions in the cells including carbon dioxide. The main excretory organs are the antennal gland (also called the green gland) and the gills.

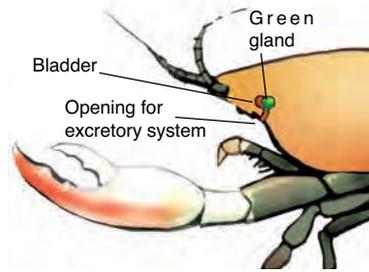
Crayfish do not have kidneys to extract wastes from the blood, they have an antennal gland. Wastes produced in cells travel into the blood and are brought to the **green gland**. The green gland filters mineral waste from the blood and water. The minerals and water are stored in a small storage bladder attached to the gland before being urinated out of the body through an opening in the exoskeleton near the base of the antennae. The crayfish releases this waste solution, similar to our urine, into the water from this opening.

Like our kidneys the green gland helps a crayfish regulate the water balance within its body. Crayfish continually absorb fresh water by osmosis and must continually excrete it as urine.

## Nervous system - co-ordination

All parts of any animal must work in harmony - they must act correctly at the right time to make the animal work as one. This planning and control is called co-ordination and is carried out by the **nervous** and **hormonal** system.

The crayfish nervous system is composed of a brain and nerves (Figure 161.2). The brain is small, and like ours, is found in the head. Two large nerves connected to it pass either side of



**Did you know**  
Nitrogenous wastes from the breakdown of protein are not removed by the green gland but are excreted through the gills, mainly as ammonia.

Figure 161.1 Excretion  
Kerry Kitzelman

the **oesophagus** before joining on the ventral (underside) of the body and down to the tail. Nerve bundles or ganglia are found along the length of this ventral nerve cord, one in each segment, with fine nerves coming from them into surrounding tissue.

They are like 'mini brains' controlling the many operations within that segment, particularly the muscles that move the paired appendages. These 'minibrains' allow the cray to co-ordinate the movement of a large number of limbs, even when these limbs are performing different actions like feeding, walking and swimming.

The ventral **nerve cord** brings messages back to the brain from receptors located all around the body. Receptors include the compound eyes, the two pairs of antennae, antennules and setae. Messages from the brain are sent back around the body along this same ventral nerve cord, similar to our spinal cord.

Unlike our spinal cord the main nerve cord of a crayfish is not protected by a backbone, it lies in muscle tissue and the exoskeleton protects the lot.

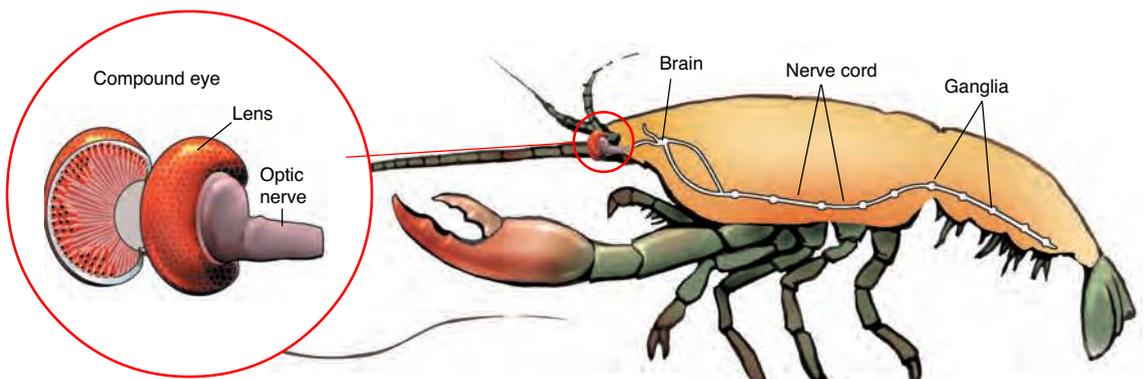


Figure 161.2 Nervous system  
Kerry Kitzelman

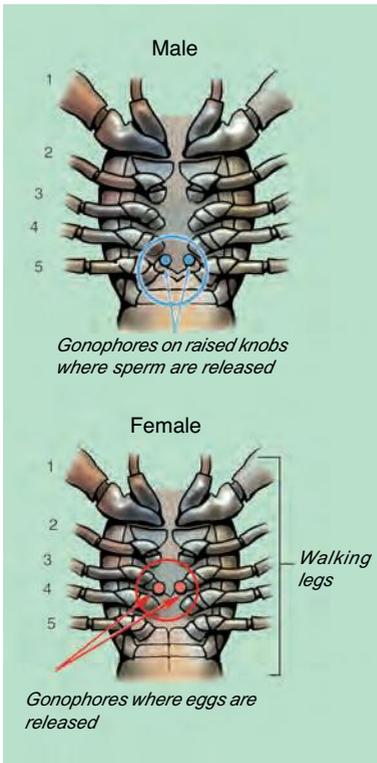


Figure 162.1 Yabby sexing  
Kerry Kitzelman

### Sexing a yabby

1. Take the yabby holding it around the cephalothorax to avoid being bitten.
2. Turn your hand over so you can see the underside.
3. Look for the reproductive organs.
4. Determine and record the sex using the figures above.

## Reproductive system

Crayfish have separate sexes. The female has two ovaries that produce eggs (ova), and a male has two testes that produce sperm.

In a mature male ready to breed, the testes are milky white and have a tube (the sperm duct) connecting them to the base of the last pair of walking legs. The ovaries in a mature female ready to breed, are full of yellowish-brown eggs and have a short tube (oviduct) connecting them to the base of the second pair of walking legs. The female will lay between 100 and 1000 eggs with the average count being 400-600.

To mate, the crayfish face each other, and the male deposits a gel containing sperm on the female close to the opening of her oviducts. Using her limbs she works the eggs through the gel to fertilise them and then moves them back and attaches them to the setae on the swimmeretes. The female will use her swimmerets to move fresh oxygenated water over the eggs while they develop. They will remain on her until they hatch into larvae. The larvae will remain attached to the setae using a small hook until they resemble miniature adults, and are able to swim free. The sex of crayfish can be determined quite easily by looking for the openings to the reproductive organs on the underside of the cray. These reproductive organs in the male crayfish are short projections on the bases of the last pair of walking legs (Figure 162.1). In the female the opening of the oviduct can be seen as small oval shapes on the second pair of walking legs.

### Moulting and growth

When the animal grows into the space between its body and its skeleton, a new larger skeleton must be made and the animal must get out of its old skeleton and make a new one. This is called **moulting**.

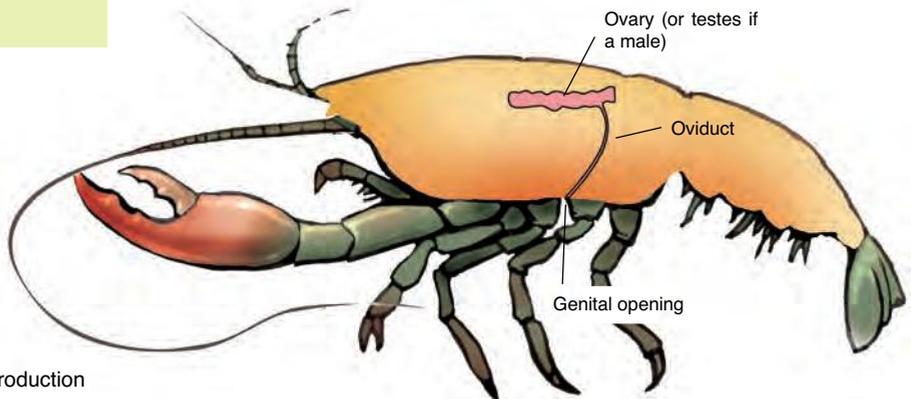


Figure 162.2 Yabby reproduction  
Kerry Kitzelman

# Aquaculture projects

Marron, yabby, koonac and gilgies are all freshwater crayfish that can be kept in an aquarium. Marron and yabbies are easy to buy, most aquarium stores will sell them.

All freshwater crayfish will uproot and eat plants in an aquarium as they like hiding there from predators. So they should be provided with grow out tubes, like the ones shown in Figure 169.1 Chapter 14, to give them alternate places to hide.

Figure 163.1 shows a grow out pond if you want to run a small school commercial venture, but this will need careful planning for space, security and filtration. Figure 163.3 shows a school who was successful in a government sustainability grant.

## A useful web site

[www.fish.wa.gov.au/fishtailes/yabby](http://www.fish.wa.gov.au/fishtailes/yabby)

See pages 374 - 375 for other project ideas

Setting up a freshwater crayfish aquarium is easy and this Western Australian Government web site has all the details.

## Diving deeper



1. Make a scale model yabby and paint it or make a puppet yabby.
2. Make a yabby container out of old industrial plastic containers. Rig up a filtration system and rack for your class.
3. Set up an aquarium and raise some yabbies.
4. Make a grow out tank or apply for a government grant to set up an aquaculture room.



Figure 163.1 Redclaw tanks



Figure 163.2 Students measuring yabby



Figure 163.3 Apply for a Government grant to set up a fish/redclaw/vegetable garden sustainability project.



1. Name three types of crayfish found in Australia.
2. Draw fully labelled lateral and dorsal colour diagrams of a crayfish.
3. What is an exoskeleton?
4. Draw up a table of the appendages of a crayfish and their use. Make a drawing for each appendage.
5. Describe how a crayfish gets oxygen into its blood.
6. Draw a diagram to show the difference between a male and female crayfish.
7. Describe how a crayfish reproduces.
8. What is moulting and why is it necessary?
9. Draw a map of the distribution of crayfish in Australia.
10. Make an enlarged copy of Figure 164.1 and create a fully labelled wall poster.

## Key words

Abdomen, antennae, blue claw, circulation, digestion, endoskeleton, excretory, exoskeleton, green gland, hormone, mandible, moulting, nerve cord, oesophagus, pleopod, reproduction, uropod, walking legs, yabby.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Crayfish are prized food for [1] \_\_\_\_\_, [2] \_\_\_\_\_ and [3] \_\_\_\_\_. Some species have great [4] \_\_\_\_\_ as a source for human food - these species have high [5] \_\_\_\_\_ rates, they grow relatively quickly, they are easy to raise, they are high in [6] \_\_\_\_\_ and they taste superb.
- b. Those animals that have skeletons either have the skeleton on the outside of their bodies ([7] \_\_\_\_\_) or like us on the inside of their bodies ([8] \_\_\_\_\_).
- c. The [9] \_\_\_\_\_ system consists of mouthparts, oesophagus, stomach, digestive gland and [10] \_\_\_\_\_.
- d. The part of a crayfish that we eat is the [11] \_\_\_\_\_ in the abdomen.
- e. Carbon [12] \_\_\_\_\_ is removed by the [13] \_\_\_\_\_ at the same time as oxygen is obtained from the surrounding water.
- f. The [14] \_\_\_\_\_ system is responsible for the removal of cellular wastes from the body. These are the [15] \_\_\_\_\_ from chemical [16] \_\_\_\_\_ in the cells including carbon dioxide.
- g. Wastes produced in cells travel into the blood and are brought to the [17] \_\_\_\_\_. The green gland filters mineral waste from the blood and water.

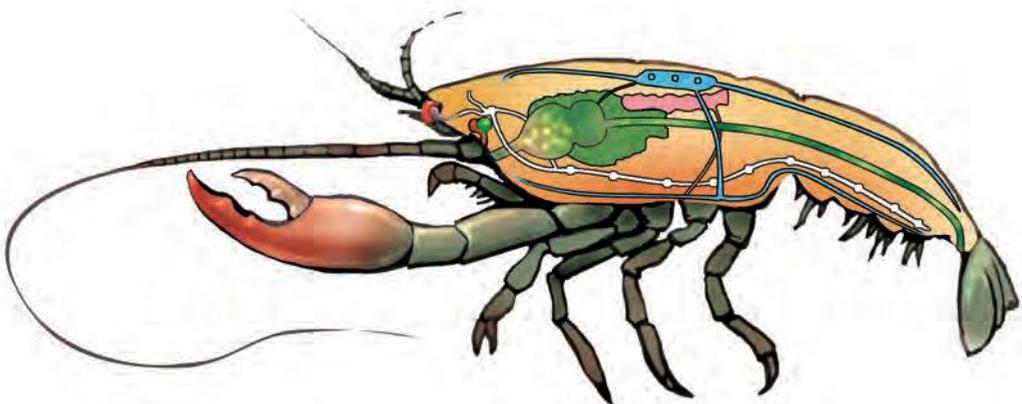


Figure 164.1 Make fully labelled wall poster of this diagram  
Kerry Kitzelman

# Chapter 14 Aquaculture farm designs



TASSAL

Simone Baker

## Web references

[www.csiro.gov.au](http://www.csiro.gov.au), [www.aims.gov.au](http://www.aims.gov.au), [www.dpi.nsw.gov.au/fisheries/aquaculture](http://www.dpi.nsw.gov.au/fisheries/aquaculture)

## Aquaculture farm designs

Before establishing an aquaculture facility there are many factors that must be considered if the facility is to become an **efficient** and **economic** operation.

Its success is dependant on some of these factors —

- Site selection;
- Proximity to markets;
- Availability of labour, equipment and materials;
- Design and construction of the facilities such as the earthen ponds, hatchery, stockfeed, value adding.

However the single most important part of any business is the **business plan** which indicates when the farm will break even and begin to show a profit. You can learn about business plans in small business courses at school.

### Site

Sites can be expensive and depending on size, may be affordable family operations as in the red claw farm situated in existing cane fields as shown in Figures 165.1 and 165.2. Others may be large operations which require companies or groups of people to run them such as the **tuna farms** in Figures 165.3 and 165.4 or the salmon farms as discussed in Chapter 12.

Extensive tuna farms catch wild tuna in the Great Australian Bight and tow them in cages to Port Lincoln. Brave seamen battle huge seas in expensive boats to get the fish back to the lease (Figure 165.3). The fish then have to be fed daily at sea for months before they are harvested. Ships come from Japan and the fish are killed at sea under strict supervision of the buyer.

The intensive red claw farm in Mackay is a family operation. The farm has existing machinery and infrastructure with water, power, telephone and internet all on site. The site is close to market and the red claw can be harvested easily and driven to market in a old four wheel drive. The tuna farmer however gets much more for a tuna than the farmer for red claw.



Figure 165.1 Grow out ponds - North Queensland

Old Fisheries



Figure 165.2 Red claw farm - Mackay

Wet Paper



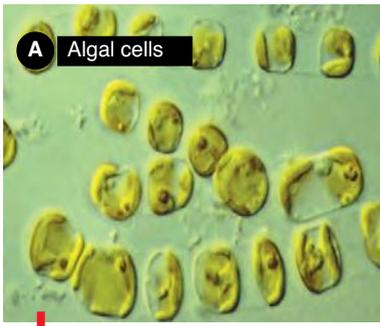
Figure 165.3 Tuna farm leases - SA

Wet Paper



Figure 165.4 Tuna farm and supply boat

Wet Paper



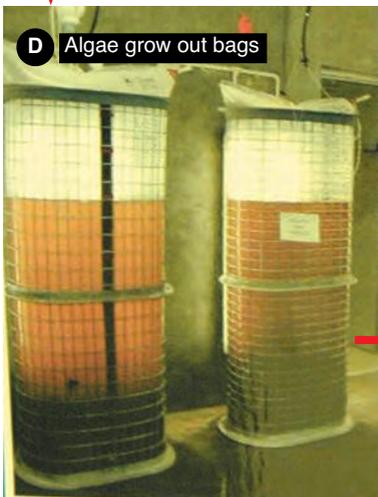
CSIRO Marine Labs



Wet Paper



Wet Paper



Wet Paper

## Hatchery production of 'seed'

**Hatcheries** are an essential part of modern intensive aquaculture. Most marine species have complex reproductive cycles, and multiple larval stages each requiring a range of habitats and food types. Producing the young (or 'seed') for aquaculture is often difficult, requiring detailed research and specialist laboratories. Parents or *broodstock* may be caught from the wild, and induced to spawn by artificially elevating temperatures, varying light cycles, or use of artificial hormones.

**Hatcheries** are places where eggs and sperm are mixed to make larval fish. Once the fish reach a certain size they are moved to grow out ponds where they reach a size that can be **harvested** for sale.

### Barramundi

Fertilised eggs are removed from broodstock tanks and placed into 1000 litre tanks with flow through water. The eggs hatch after 14-17 hours and the larvae are fed on rotifers and brine shrimp (Figure 166.2). After about 21 days the larvae are weaned onto a suitable dry pellet food.

### Stockfood

During their time at the hatchery, the larvae need to be fed and in many cases specialized algae is grown to feed specialized zooplankton.

*Algae* --> *Rotifers* ----> *Brine shrimp* ----> *Laval fish* --> *Fingerlings*.

The algae are grown in special culture flasks before being transferred to **carbays** (Figure 166.1C). This algae is then stored in large bags (Figure 166.1D), because large amounts are required for rotifers (Figure 166.1E) and brine shrimp. These animals are used as food in the first-feeding of marine larval finfish and crustaceans.

### Salmon

Salmon hatcheries are also a closed system and have been discussed on page 148.



Figure 166.1 Algae production

Figure 166.2 Zooplankton production

## Silver perch

**Silver perch** are a fish that can be raised a different way. Sperm and eggs are mixed in the hatchery and while the larvae are feeding off their yolk sac, they are transported to a pond that is full of microscopic food.

A few weeks before transfer, the farmer fertilized the pond with mixtures of super phosphate, sulphate of ammonia, potash and either poultry manure or lucerne hay. This causes naturally occurring algae and zooplankton to bloom providing the young silver perch with a food source.

During the fingerling phase the silver perch are initially fed three to five times per day with a crumble of protein. However during the grow out phase farmers either let them fend for themselves or feed the growing fish with pellets.

## Aquaculture foods

Every species has its particular dietary requirements, but it is often not possible (or profitable) to feed them a natural diet in aquaculture, so most foods are artificially produced. Manufactured food pellets are made with the required proportions of protein, (from fish meal and cheaper soya beans) fats, (from fish and vegetable oils) carbohydrates, (from bran or flour) and micro nutrients such as trace metals and vitamins. Pellets are produced in appropriate shapes and sizes for each species and growth stage. Micro-pellets (milligrams in weight) are made for plankton-feeding oysters. Large pellets are made for carnivorous fish. Depending on the feeding habits of the animal, the pellets are made to float, or slowly or quickly sink. Dry pellets are easier to store, and easy to supply in measured doses. Stock are fed at appropriate times of the day by hand or mechanically. Large fish farms have mechanical pellet broadcasters which blow the food throughout the ponds.

Food is generally the most expensive component of intensive aquaculture. The daily food bill on a tuna feed lot in South Australia, or salmon farm in Tasmania may be over \$15 000. The aquaculture of carnivorous fish such as tuna and Barramundi involves large amounts of valuable fish protein or baitfish. Most fish feed contains large amounts of high-protein fish meal. Fish meal is manufactured mainly from small baitfish such as herrings, anchovies and pilchards, and generally comes from South America and Asia.

It is expensive, (over \$1 500 /tonne) and in high demand for aquaculture. Environmentalists are concerned about depletion of baitfish and effects on the food chain. There is also a moral argument that it is a waste to feed high value protein to other fish when many people are starving.



Figure 167.1 Sperm collection



Figure 167.2 Stockfeed pellets



Figure 167.3 Pellet broadcasting

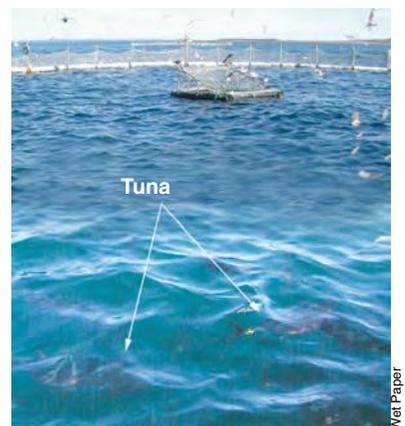


Figure 167.4 Port Lincoln Tuna



Figure 168.1 Cage design

TASSAL



Figure 168.2 Salmon cage

Wet Paper



Figure 168.3 Pond design

Wet Paper

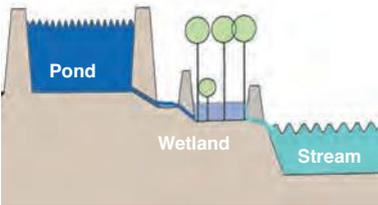


Figure 168.4 Barramundi pond design

Wet Paper

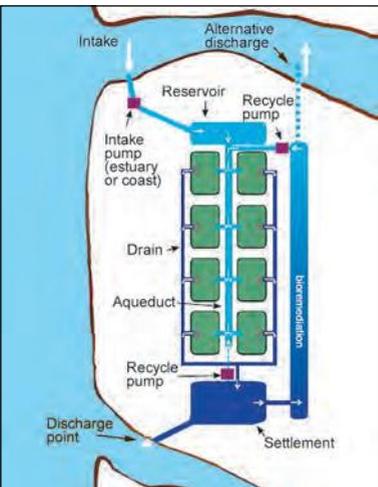


Figure 168.5 Prawn farm pond design

Old Fisheries

## Ocean rearing techniques

The young or 'seed' from hatcheries are reared or grown out to market size using a variety of techniques. Mussels are made to settle on rope which is encased in mesh tubes like nylon stockings, and hung from rafts for grow out.

Fish may be reared in floating cages or pens, to keep them in, and their predators out. Ocean cages for salmon and tuna are typically large, 30-50 metres in diameter, and 20 metres deep. They are supported by a floatation collar made from poly pipe.

## Pond design and construction

Most fish and crustaceans are reared in large ponds on land. These are typically excavated in low-lying coastal areas, near a ready supply of water. The earth excavated to make the pond is used to make the pond walls. Walls are made with wide bases and tapering tops for stability and to resist water pressure.

Barramundi and prawn ponds are typically 30-100 metres long, by 10-30 metres wide, and 1-1.5 metres deep. Ideally, the earth should be clay to prevent water seepage, otherwise clay or plastic liners are used to seal the ponds. Earthen ponds are designed to be drained, with a deeper area or depression like a bath tub, so the water can be drained and the crop easily harvested. Prawn farms\*, as shown in Figure 168.5, are based on a similar principal. \* See [www.aciar.gov.au](http://www.aciar.gov.au) for a free prawn farming manual.

Water is pumped or channelled from a dam, river or the sea. Each pond in a farm should have an independent water supply to prevent spread of any diseases. To avoid costly pumping, freshwater farms often gravity feed water from an elevated reservoir. Saltwater farms may use tidal circulation.

Ponds must be well oxygenated, particularly during the night when algae also respire, and the CO<sub>2</sub> builds up. Electrical spray pumps and paddle wheels are often used to circulate and reoxygenate water.

Aquafarms are highly reliant on expensive diesel fuel and electricity, and energy is generally their second greatest cost.

Discharged waters are generally stored in a settling pond for later discharge or recirculation.



Figure 168.6 Waste settling pond from red claw farm

Wet Paper

# Grow out

As the name suggests this is the place where the fish or crustaceans are allowed to grow bigger ready for harvesting.

## Redclaw

Redclaw (a type of crayfish) grows rapidly in a wide range of temperatures, eats a variety of foods, tolerates a wide range of salinity, can be stimulated to reproduce throughout the year and does well under crowded conditions (Figure 169.1).

The redclaw goes through a series of moults in order to grow and mate. **Moulting** occurs when the outside shell is shed and replaced by the soft shell underneath. Each soft shell can increase in size which allows the redclaw to grow.

In redclaw farms, juveniles are transferred to nursery tanks where they grow to about 56 centimetres before being transferred to the larger grow out ponds. An average sized pond is about 20 metres x 50 metres.

Redclaw eat a variety of commercially prepared foods including marron and yabbies. Their feeding rates depend on each animal's size and temperature because young crayfish eat more food per unit of body weight than older ones and they eat more in warm weather. On average, each redclaw eats about 2% of its total body weight every day. At the age of six months, a redclaw weighs about 50 grams.

# Harvesting

This is when the fish are killed and prepared for market. Some methods include:

- a light shining at the end of a trough which encourages the red claw to run up the chute for harvesting (Figure 169.4);
- draining or netting ponds; or
- vacuuming up.

The harvesting process should produce seafood of the highest quality so that it can be sold fresh or be smoked or prepared to allow for value adding. The smoking of salmon is a value adding stage.

Most seafood once harvested needs to be chilled for transport and distribution. This requires supplies of ice, and machinery to make ice is often part of the farm design.

An exception to the rule are some oysters which can be bagged and transported to markets. Once opened however, they have to be chilled.



Figure 169.1 Red claw grow out tubes

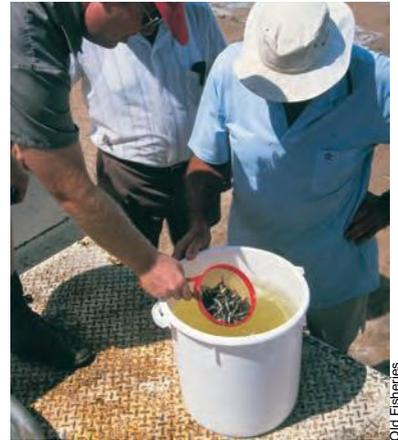


Figure 169.2 Fingerlings



Figure 169.3 Grow out nets



Figure 169.4 Red claw harvesting chute

# Marketing and distribution

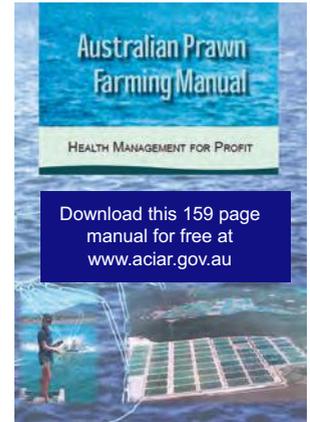
It is often said in business that the “middle man” makes all the money, but without marketing and distribution, the farmer is lost. Direct marketing is where the farmer supplies direct but this requires specialized systems. The salmon distribution label (Figure 170.2) has been specially designed to allow the freight companies that handle the fish to reach the fish shop in the shortest time. Sales representatives would have contacted the fish shop and secured the order.

The order is filled at the factory and the label identifies the order. Payment for the order is done by an account set up by the company.



Ruth Farley

Figure 170.1 Live salmon



## Economics

### Introduction

The current world demand for seafood is placing increasing pressure on the world's wild fisheries with a majority of the major commercial species being classified as being either fully or over exploited. It is only a matter of time before commercial fishing will no longer be able to provide the world's demand for seafood.

Aquaculture provides the world with one solution for a sustainable method of satisfying the world's demand for seafood. Although aquaculture as an industry is socially desirable to supplement capture fisheries, replace imports and generate exports, the main goal of an individual aquaculture farm is to make money and be commercially viable.

High prices for aquatic products such as salmon, trout, barramundi, and mud crabs attract investment in aquaculture projects. This is the driving force behind most Australian aquaculture. Even if there is high demand and high prices the single most important step in the establishment of an aquaculture venture is the selection of a suitable site to minimise costs over the long term.

### Costs associated with an aquaculture venture

Site selection, planning and design are critical to the profitability of an aquaculture operation. Sound planning and design minimises costs associated with construction and management of the ponds as these costs eventually affect the cost of fish production which in turn affects the profit of the operation.



Wet Paper

Figure 170.2 Box label



Wet Paper

Figure 170.3 Distribution by the pallet





Simone Baker

Figure 172.1 Barramundi grower

The table below calculates gross income based on estimated selling prices per kilogram of live fish at the farm gate at different production levels.

Gross Income at Different Selling Prices				
Selling Price (\$/kg) (\$)	Annual Production (tonnes)			
	40 (\$)	50 (\$)	70 (\$)	80 (\$)
10.00	400 000	500 000	700 000	800 000
9.00	360 000	450 000	630 000	720 000
8.00	320 000	400 000	560 000	640 000
7.00	280 000	350 000	490 000	560 000
6.00	240 000	300 000	420 000	480 000

## Diving deeper



- Prepare a project report on Silver Perch under the following headings
  - Introduction, distribution, habitat, general biology, culturing Silver Perch, die, husbandry & health status, aquaculture potential
  - Use the following web page as a guide  
[www.fish.wa.gov.au/aqua/broc/aqwa/perch](http://www.fish.wa.gov.au/aqua/broc/aqwa/perch)
- Compare the value adding methods of some common products. For example compare a Dunlop tennis shoe with a Niki or green and cooked prawns.

### Project

*Crayfish are an ideal marine animal to study for a school term project because raising them brings together the marine studies skills of aquarium construction and sea water management.*

*Ref page 163*

As the table indicates the gross income of an aquaculture enterprise does not accurately reflect the true profitability and sustainability of the farm's operations. Although the gross income figures above may look impressive they do not take into account the minimum acceptable return on the initial capital investment for the venture, nor the annual operating costs incurred in earning the income. Without these figures the aquaculture enterprise may in fact be operating at a loss or at best minimal profitability and would not be economically sustainable over the long term.

### Profit levels

The main goal for establishing an aquaculture facility is to make a profit. The profit level should reflect the required rate of return that an investor wants to make on the initial capital outlay for the facility over a specific time frame.

For an aquaculture farm to be profitable the amount of income the farmer gets by selling the farmed species must be greater than the operating costs incurred in producing it. Therefore the level of profit is determined by the selling price (within an acceptable range for the farmed species) less operating costs.

With aquaculture it is very difficult to assess the profitability of a business when the selling price for most fish is uncertain and sensitive to market acceptance.

Although the selling price of seafood products tend to be uncertain, the farm manager can aim to increase the profitability of the aquaculture facility over time in 2 ways by lowering the costs of production per unit.

- The profitability of the aquaculture farm can increase dramatically as the number of organisms farmed increases.

For example if a farm that produces fifty tonne of fish is able to viably increase stocking rates to eighty tonne of fish, the costs of fish fry and food increase but the other costs will remain the same.

2. By aiming to sell at a higher price, the profitability of the aquaculture farm increases as the selling price of the seafood product increases. For example for fifty tonne of fish at \$9.16 and \$6.80 per kilogram of live fish will return a gross income of \$458 000 and \$340 000 respectively with costs remaining much the same. This may be able to be achieved by producing better quality or bigger sized fish or by increasing sales to different markets.

## Diseases

There are a number of ways to prevent diseases in aquaculture facilities.

### Avoid stress

Appropriate growing conditions that do not stress the fish are essential for successful culture. While species can tolerate sub-optimal conditions for short periods (eg for prawns, short periods of low temperature, dissolved oxygen levels or salinity levels), they will become stressed and more susceptible to disease. Many of the potential disease parasites, viruses and bacteria occur naturally in the environments and may be present in the ponds or tanks. The natural defence systems of healthy fish will ward off infection. However once a fish becomes stressed, opportunity for the disease to cause infection increases via the lowering of the immune systems. The stress may also occur during handling (eg grading, harvesting, transferring between ponds, transport to market), from predators (such as cormorants), drug treatments, poor water quality, undernourishment or overcrowding.

Prevention of stress is fundamental to maintaining disease free stock. Good husbandry techniques for disease prevention include:

1. maintenance of appropriate water quality standards;
2. maintenance of optimum stocking rates to prevent overcrowding;
3. quarantine management for new stock before introduction into the ponds;
4. development of feeding regimes to maintain water quality;
5. regular inspection of fish to monitor health and implement disease management protocols if necessary.



Figure 173.1 Checking for disease



Figure 173.2 Recording growth rates



Figure 173.3 Monitoring bacteria in water



Figure 174.1 Small farm pump system

Wet Paper

## Disease management protocols

Some diseases are not naturally occurring and every effort should be taken to ensure that these are not introduced onto the farm from hatcheries, other farms or the wider environment. Many of the disease outbreaks (if caught early) are easily treatable, with little or no effect on the productivity of the crop. However some fish diseases are difficult to treat and cause widespread mortality in the aquaculture facilities as well as in the wild.

Disease in hatcheries can be a particular problem, both in terms of losses in the hatcheries but also through putting at risk customer farms or native fish stocks (through restocking programs).

### Good practice for disease management

1. Upon the first signs of disease outbreak, specimens should be removed and analysed for disease symptoms, and water quality should be checked. If no obvious manageable causes are found then a qualified veterinarian should be consulted immediately.
2. Appropriate training for all staff on health management and disease recognition. Key personnel should have specialised training in the recognition and diagnosis of common fish diseases. These personnel should be made aware of the importance of keeping up-to-date with the latest disease identification and management.
3. Appropriate equipment on site to assist in the accurate diagnosis of diseases including a microscope and testing kits.
4. Appropriate protocols to prevent the inadvertent introduction of disease onto the farm from stock movement, employees, visitors or equipment.
5. Appropriate protocols to deal with disease notification and management should an outbreak occur.



Figure 174.2 Staff training

Wet Paper



Figure 174.3 Water quality monitoring

Wet Paper

### Preventative measures

There are a number of steps that can be taken to reduce the risk of disease, these include:

1. Ensuring stock introduced onto the farm is disease free using quarantine procedures when introducing stock;
2. Maintaining water quality;
3. Handling fish as little as possible and with care;
4. Monitoring animals regularly so that diseases are detected and treated at an early stage;
5. Feeding the animals an appropriate diet;



Figure 174.4 Aeration

Simone Baker

6. Limiting cross contamination from ponds with diseased animals;
7. Disinfecting ponds after harvesting diseased animals; and
8. Allowing time to dry ponds after harvesting and before stocking.

## Key words

Algae, aquaculture, broodstock, brine shrimp, business plan, disease, economic, efficient, fingerlings, fixed costs, gross income, grow out, harvesting, hatcheries, laval fish, marketing, moulting, profit levels, Redclaw, rotifers, Silver Perch, stockfood, stress, tuna, variable costs.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Before establishing an aquaculture facility there are many factors that must be considered if the facility is to become an [1] \_\_\_\_\_ and [2] \_\_\_\_\_ operation.
- b. [3] \_\_\_\_\_ are an essential part of modern intensive aquaculture. Most marine species have complex [4] \_\_\_\_\_ cycles, and multiple larval stages each requiring a range of [5] \_\_\_\_\_ and food types.
- c. The algae are grown in special culture flasks before being transferred to [6] \_\_\_\_\_. Large amounts are required for the brine [7] \_\_\_\_\_ and [8] \_\_\_\_\_ which are used in the first-feeding of marine larval finfish and crustaceans. This [9] \_\_\_\_\_ is stored in large bags.
- d. Fish may be reared in floating [10] \_\_\_\_\_ or pens, to keep them in, and their [11] \_\_\_\_\_ out. Ocean cages for [12] \_\_\_\_\_ and tuna are typically large, 30-50 m in diameter, and 20 m deep. They are supported by a floatation [13] \_\_\_\_\_ made from 'poly pipe'.
- e. [14] \_\_\_\_\_ occurs when the outside shell is shed and replaced by the soft shell underneath. Each soft shell can increase in size which allows the redclaw to [15] \_\_\_\_\_.
- f. A [16] \_\_\_\_\_ cost is a cost that stays the same in its amount over a period of time despite wide changes in the [17] \_\_\_\_\_ levels or level of activity.
- g. Many of the [18] \_\_\_\_\_ outbreaks (if caught early) are easily treatable, with little or no effect on the productivity of the crop. However some fish diseases are difficult to [19] \_\_\_\_\_ and cause widespread [20] \_\_\_\_\_ in the aquaculture facilities as well as in the wild.



1. Describe four factors essential for aquaculture farm design.
2. Why is tuna farming so expensive?
3. Give an example of an inexpensive (under \$100,000) aquafarm.
4. Why do algae need to be cultured in such high numbers for feeding rotifers?
5. Describe how barramundi are fed in the early stages of their life.
6. Silver perch food is manufactured by fertilizing ponds. Describe how this is done.
7. What does the term *grow out* refer to?
8. What types of feeds are used for carnivorous farmed fish?
9. What is an ocean cage and draw a fully labelled diagram to illustrate your answer.
10. Why is water from a barramundi pond drained through a wetland during harvesting?
11. Write a definition for the term *harvesting*.
12. Draw a table to show the difference between fixed and variable costs in aquaculture.
13. List three ways diseases can be controlled in farmed fish.
14. Describe two ways profitability can be increased in aquaculture.

# Chapter 15 Food from the sea



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[www.csiro.gov.au](http://www.csiro.gov.au), [www.dfat.gov.au](http://www.dfat.gov.au),  
[www.fish.wa.gov.au](http://www.fish.wa.gov.au), [www.dpi.nsw.gov.au/fisheries](http://www.dpi.nsw.gov.au/fisheries)  
[www.dpi.qld.gov.au](http://www.dpi.qld.gov.au), [www.dpiw.tas.gov.au](http://www.dpiw.tas.gov.au)



Figure 176.1 Squid kebabs



Figure 176.2 Bugs



Figure 176.3 Fishhooks made from bone and shell

Eating food from the sea is part of most human cultures. Our country is made up of people from many different **ethnic backgrounds** - a mix that has changed our seafood eating habits. An important aspect of seafood marketing is understanding how people eat and buy their food.

Most seafood is good for you. Fish oils, for example, can help to prevent heart disease. Fish generally is low in fat and high in protein and contains Omega 3. Much of the world depends on food from the sea for its protein.

## Many cultures

Many people in traditional cultures divide the year according to the food available. For example, during the **Mirdawarr** (the end of the wet season) fish, shellfish and mud crabs are an important part of the diet of people who live in the coastal forest in Arnhem Land. Turtles are easier to catch later in the year in the season known as Dharratharramirri when the turtles come nearer the coast to shelter from strong winds. As the season progresses into white man's spring and summer, known to Aboriginal people as **Rrarranhdharr Dhuludur**, waters in Torres Strait and the Timor Sea become calmer and fishing is easier.

Fish can be caught in a variety of traditional ways. **Hooks** are made from bone or the rim of a shell (Figure 176.3). Simpler hooks known as **gorges** can be made from straight pieces of bone pointed at both ends, tied to a string, baited with a worm or small fish, then thrown into the water.

## Indo-Pacific cultures

**Pacific Island** people traditionally cook fish by making a fire in a pit, heating large stones in it and putting the fish on top covered with grass and leaves. Sand is then placed on top and the fish baked slowly. An Australian **Aboriginal** favourite is barramundi wrapped in the leaves of the wild ginger plant and baked in the hot ashes of the camp fire.

The word **barramundi** is an Aboriginal word which means 'river fish with large scales'. This fish enters the estuaries and rivers to breed and it became a seasonal delicacy.

Traditional Aborigines from Western Australia gathered marron and scampi; oysters (see Figure 177.1) provided a rich source of protein to people along the north-west coast.

Other favourite seafood included the **trepang**, (sea cucumber or beche-de-mer) which was considered a delicacy, especially among the traders and explorers from Asia. Further north, the Torres Strait islanders ate the giant clam and collected rainwater in its shell.

## Mediterranean cultures

**Mediterranean** people greatly appreciate **seafood**. A frequent activity for migrants from this region living in the Mornington Peninsula in Victoria was to collect a bucket of cockles, soak them overnight in salt water and then cook them with olive oil, wine and herbs. Italians also eat tiny clams in a sauce with pasta.

**Europeans** are avid collectors of mussels (Figure 177.2) which can be eaten in a **Spanish** paella or steamed and sprinkled with finely chopped, fresh green herbs.

Traditionally, Mediterranean fishermen caught octopus and squid (Figure 177.3) by night and it became an important part of their diet, eaten in a variety of ways including being marinated and then cooked on a skewer, barbecued or casseroled.

Mediterranean cuisines regard squid highly, often cooking it in spaghetti marinara. Squid has become so popular today because of being introduced by migrants from this region. Calimari fritti (fried squid) has become a staple in many Italian restaurants.

## Asian cultures

The first significant wave of **Asian** migrants, mainly **Chinese**, arrived in the 1850s during the gold rushes. They brought with them many aspects of their culture including their cuisine.

Seafood is highly prized by coastal Asian people. The Australian and New Zealand abalone industry, which dates only from the 1960s, owes its success to the demands of the Chinese.

Trepang are slug-like creatures which can extend their elongated sausage-shaped bodies up to 60 centimetres in length. In Asian cooking, they are slit lengthways and the internal organs removed and the flesh boiled or smoked over a pit in ash then dried in the sun.



Figure 177.1 Oysters



Figure 177.2 Mussels



Figure 177.3 Baby octopus and squid



Figure 177.4 Snapper

## Diving deeper



1. Find out what happens to the seafood from your area.
  - Does it all stay in the local area or is some sent to other areas?
  - Where is this exported food sent to?
  - How much is sent overseas?
  - How much is sent to other parts of our country?
  - How is it sent?
2. What seafood recipes can you find?
  - Check in magazines or cookbooks.
  - How simple are these recipes?
  - Are they suitable for local fish?
3. Go out for dinner to a seafood restaurant and practise your table manners for eating seafood.
  - Find out how to eat prawns at the table.
  - Is the knife used to eat fish the same as the knife used to eat steak?
  - How are mussels and oysters eaten?
  - What cutlery is used for eating crabs?
4. Make a fishhook out of a shell or bone.



**Japanese** diners love fresh seafood and pay big prices for our tuna, prawns and other **shellfish**. **Taiwanese** fishermen collect the giant clam for the meat of its adductor muscle, which holds the animal closed. This is trimmed, then frozen or canned.

### British culture

The British had strong traditions of eating seaweeds. The **Scots** ate a seaweed called sea kale as a vegetable, and used it as the main ingredient in a soup cooked with potatoes, onion, milk and lemon juice. The **Welsh** used seaweed to make small flat cakes, cooked it for breakfast and spread it on toast. The English eat kippers and cockles (with salt, pepper and vinegar) and are famous for their fish and chips.

## Cooking seafood

Check out the National code of fishing practice

[www.recfishoz.com/about/code.html](http://www.recfishoz.com/about/code.html)

So, you've caught some fish or collected some other seafood. Perhaps you've been to the shop or market and bought some. What do you do with it now?

### Freshness

Seafood will deteriorate faster than just about any other food. Correct handling is vital. If you are going to eat the fish you catch rather than release, kill as quickly and painlessly as possible (see the recreational fishing web reference above).

Letting them go to sleep in a ice slurry is much better than spiking the brain with a sharp knife or skewer, by a blow to the head or by breaking the neck.

Fish with a high blood content, such as salmon, should be bled by cutting the throat. Once a fish has been killed, gut it as soon as possible and put it on ice. Sharks especially need to be bled and cleaned as soon as possible after capture.

Put prawns, crabs, lobsters and other crustaceans on ice as soon as they are caught unless they can be kept alive. Tie mud crabs carefully to prevent them damaging you or the rest of your catch. Before cooking, put 'live' crustaceans in a freezer for 45–60 minutes to kill them humanely.

You can keep shellfish such as oysters, cockles and mussels in cool, clean sea water to help clean them out, or put them straight onto ice.

When buying fish from a shop or market, it is important to check their condition. Fish should have clear, bright eyes which should not be sunken at all. The scales of the fish should glisten, and the gills should be a bright, healthy red.

All seafood should smell like the sea, but the smell should not be too strong. Filleted fish should be firm and springy to touch. There should certainly be no smell of ammonia or any bad or nasty smells. Frozen fish should have a use-by date: check it! Make sure that the freezer in which the frozen food is kept is at a temperature of  $-20^{\circ}\text{C}$  or colder and that there is no sign of thawing.

## Preparing seafood for cooking

### Scaling

You do not have to scale fish which are going to be **skinned**. Leave the scales on fish which you are going to freeze whole because this prevents freezer burn and the flesh drying out. Fish which are going to be cooked whole can generally have the scales left on. They will peel away easily when the fish has been cooked. Some fish are difficult to scale because their **scales** are too tough.

To scale a fish, hold it by the head (in your left hand if you are right-handed) and use a scaler or a blunt knife to scrape the scales off. Work from the tail to the head as shown in Figure 179.1. Run your finger nail over the fish afterwards to make sure that you have removed all the scales. Turn the fish over and do the same on the other side, then wash the fish.

### Gutting

Fish to be cooked whole must be gutted and gilled. **Gutting** involves cutting the fish open by simply running a sharp knife from the fish's vent to its gills and cutting or scraping the gills and guts from the fish. Scrape a sharp knife down the inside of the backbone to remove the blood often found there. Wash the cavity out with clean water, preferably clean sea water, before cooking it whole or cutting the head off and then cooking it.

### Slicing

Large fish such as big mullet (jewfish) or snapper are often best prepared by being cut into steaks or **cutlets**. The easiest way to do this is to gut the fish, freeze it whole, then cut it into slices (Figure 179.2).

You can do this with a butcher's bandsaw or with a clean garden bow saw with a coarse blade. You can cut unfrozen whole fish into cutlets but you will need a meat cleaver or saw to cut through the backbone. For many fish, the most convenient method of preparation is to take a fillet. You will need a sharp knife with a thin, flexible blade (Figure 179.3). The length of the filleting knife you use is determined by the size of the fish: a whiting is best filleted with a 10–15 centimetre blade, a Spanish mackerel with a 25–30 centimetre blade.



Figure 179.1 Scaling a fish



Figure 179.2 Mackerel cutlets



Figure 179.3 A filleting knife

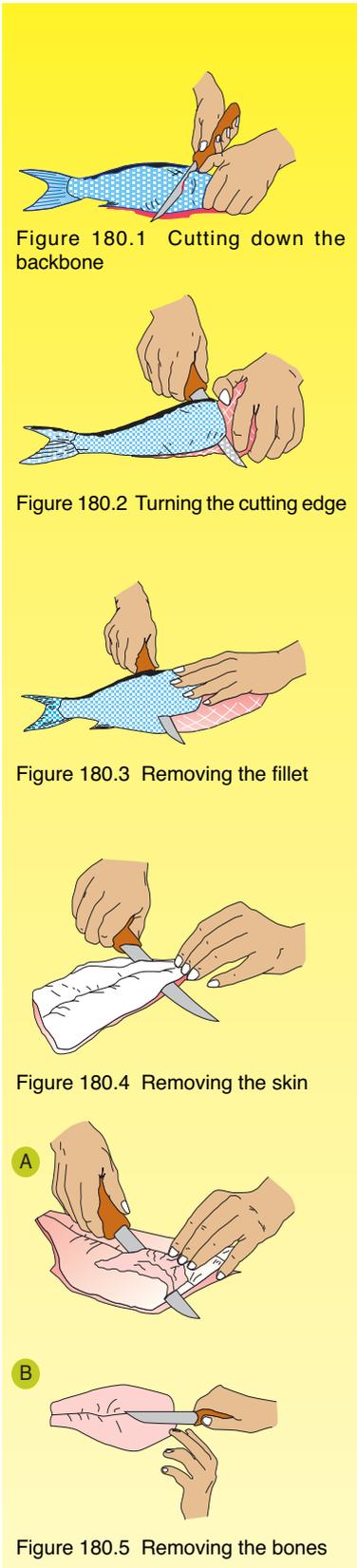


Figure 180.1 Cutting down the backbone



Figure 180.2 Turning the cutting edge



Figure 180.3 Removing the fillet

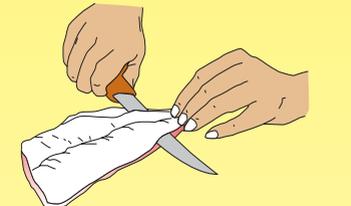


Figure 180.4 Removing the skin

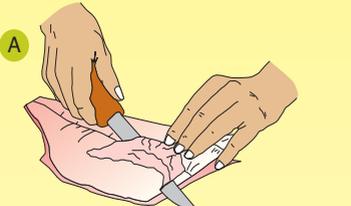


Figure 180.5 Removing the bones

## Filleting

To **fillet** a fish, hold the fish's head (in your left hand if you are right-handed) and, with the body of the fish laid on a flat surface, cut down behind the pectoral fin until you feel the backbone (Figure 180.1). Now turn the cutting edge of the blade away from you and, keeping the blade flat and your left hand on the fish's head, cut along the backbone until you are almost at the tail (Figure 180.2).

If you are not skinning the fillet, cut straight through and remove the flesh from the fish. If you are skinning the fillet, turn the fillet over and push the blade between skin and flesh. Keeping the knife blade still and flat to the table surface, pull the fillet and skin towards you with a sawing motion (Figure 180.4 and Figure 181.1). Turn the fish over and repeat on the other side. You can now carefully remove the ribs from the fillet by slicing around the whole rib cage and cutting it away. If you can feel any side bones with your fingers, cut a thin 'v' from the front of the fillet to remove them (Figure 180.5).

## Opening shellfish

Bivalves like mussels, oysters and cockles are best opened with a stout, short-bladed knife. Using good quality gloves, insert the blade between the two halves of the shell and twist, or slide the knife through the adductor muscle which holds the two halves of the shell together. Once opened, slice the meat from the shell.

To clean squid, octopus or cuttlefish, first cut open the body tube. This will let you remove the head and guts and any skin lining the inside of the body tube. Be careful of the ink sac! You will also need to remove the 'quill' or cuttlebone. Next, remove all of the outer skin and the swimming fins – these are usually too tough to eat. If you are going to eat the head, you must remove the beak with a sharp knife.

Squid and cuttlefish are ready to cook after these preparations but you will need to tenderise octopus by pounding.

## Peeling seafood

Prawns, crayfish and crabs are usually cleaned after they have been cooked. You can clean crayfish and lobsters by cutting through the shell along the underside of the tail.



Figure 180.6 Shucking an oyster

Take care to cut the shell without damaging the meat. Break the shell apart and remove the meat. You will need to make a shallow cut down the back of the tail section to remove the vein. Twist the legs off and extract the meat by breaking the shell with your hands or a nutcracker. To clean a crab, lay it on its back and twist off the legs as for crayfish. Pull back the flap on the underside of the crab and remove the top part of the shell. Remove the stomach and gills and wash the inside. Remove the meat from the shell.

Prawns (shrimp) and yabbies can be cleaned by first twisting off their heads. Pull back the legs, removing the centre section of the shell in the same motion. Now squeeze the tail segment and gently pull out the flesh and the vein (Figure 181.2).

## Cooking safely

Hot oil will cook you too! Be careful — don't splash oil around. Make sure that any food that you put into the oil is absolutely dry. If the food is wet, there could be an explosion when you put the food in the pan, scattering hot oil over you and the kitchen.

It does not take long to fry fish. Cook squid strips or rings for no more than 15–20 seconds, small fish fingers or prawns for 60 seconds and larger fillets for 90–120 seconds. A whole, largish fish should take only 4–6 minutes. Put the fish into the oil gently and turn it when you are a little less than halfway through your cooking time. At the end of your cooking time, remove the fish from the oil and put it onto paper towelling on a plate or grill to drain.

## Some cooking methods

### Basic principles

Seafood should never be over-cooked because it ruins the flavour. Indeed, much seafood is wonderful eaten raw. When cooking thick fillets or thick whole fish, cut through to the backbone in several places. This allows heat to penetrate more quickly and prevents the outside being over-cooked while the inside is underdone.

### Barbecuing

Fresh seafood is a great barbecue alternative to the traditional chops and sausages. Fish fillets or cutlets can be put straight on to a lightly oiled barbecue plate. They will take about 4–6 minutes to cook on each side.

Turn them once, taking care not to break the flesh. Add a squeeze of lemon, and salt and pepper to taste. Serve with a green salad.



Figure 181.1 Removing the fillet

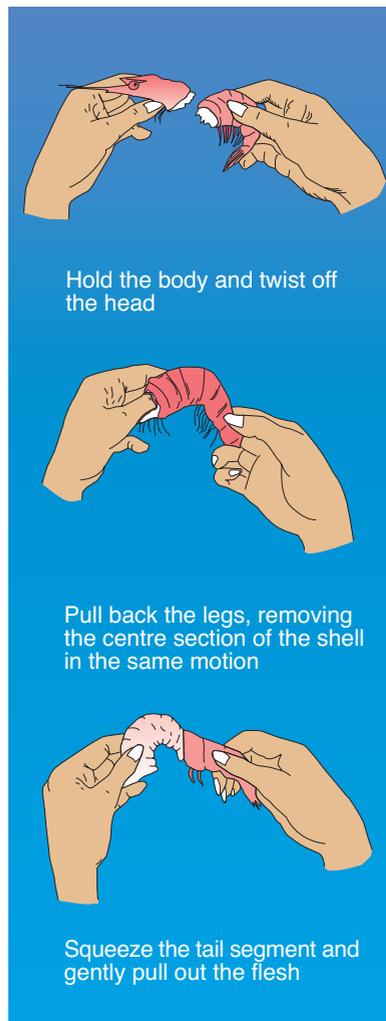


Figure 181.2 Peeling a prawn

*Seafood should never be over-cooked because it ruins the flavour.*





## Questions

Use your textbook to find the answers

1. What does the word 'multicultural' mean?
2. What is the difference between a *hangi* and a *luau*?
3. How are trepang cooked?
4. What does gutting involve?
5. What are the characteristics of a good filleting knife?
6. Describe how to scale a fish.
7. Describe how to fillet a fish.
8. Why should fish be cooked quickly?
9. What does bleeding a fish involve?
10. Describe how to peel a prawn.
11. What is a fish cutlet?
12. Which fish are best suited to making fish cutlets?
13. What dangers are associated with seafood cooking?
14. Describe how to bake a fish.
15. What does the word 'battering' refer to?
16. How are oysters traditionally eaten?
17. Identify one interesting fact from the web site on fishing code of practice.
18. Name any three uses of seaweed.



*Seafood to be fried in butter can be lightly dipped in flour to which has been added a little salt and pepper.*

You can also cook squid this way, but don't over-cook it. Cook squid only long enough for it to get hot all the way through.

### Frying

Seafood to be fried can be lightly dipped in flour to which has been added a little salt and pepper. You could also try crumbing or battering. The best fish to fry are those without too much dark meat. For best results cut away any dark meat before cooking.

When frying fish, put a centimetre of olive oil in a frying pan. Your oil must be very hot before you start. Check the temperature by putting in a small piece of potato. If the oil is the right temperature, the potato will crackle and sizzle. You should aim to maintain this temperature so do not try to cook too much at one time or the oil temperature will drop and your food will be soggy. Have some paper towel handy to put your fried seafood onto. It will help absorb the excess oil.

### Crumbing

To crumb fish or prawns, first beat one egg into a cup of milk. Dust your seafood with flour, then dip it into the egg and milk mixture, then into the breadcrumbs. The easiest way to do this is to put the crumbs into a plastic bag, add the seafood and shake.

### Battering

Make a simple batter with one cup of plain flour, a pinch of salt, some fresh black pepper and 2 tablespoons of lemon juice or vinegar. Slowly add water, mixing as you add, until you have made a thin batter. It must be smooth and runny. Dry the fish thoroughly, dust lightly with flour, dip into the batter, lift each piece slowly so that excess batter can run off, then carefully add to your hot oil.

### Baking

Fillets can also be baked. The big advantage of baking fish is that it is more difficult to over-cook your meal. You can use an oven dish or (for easier cleaning up) aluminium foil parcels. Simply wrap the fish in the foil to make a tight parcel. The foil stops the fish from drying out and keeps the flavour in. Leaving the scales on fish which is to be baked can be a good idea. The scales will lift off easily after the fish is cooked. To check that a baked fish is cooked, poke a skewer through it. If the fish is properly cooked, the skewer will go in and out easily. The 'extras' that you bake with the fish are the interesting part.



Figure 182.1 Pan frying fish

Bill Thompson



Figure 182.2 Battering

Paula Morfitt



Figure 183.1 Seafood meal prepared by students for staff.

As a start, white wine with a little salt and pepper tastes good. Other extras could include garlic, ginger, soy sauce, chilli and so on. Some wonderful concoctions include all manner of fruits, spices and nuts. Other seafood such as crabs and prawns may be baked with fish.

## Seaweed

If you have been to a Japanese or Korean restaurant, you may have noticed the nori wrapped around sushi. Nori is thin dried seaweed. Nori farming is a very old form of aquaculture in Japan. Seaweed is used for many other foods though you probably did not notice the seaweed extract in your flavoured milk, ice-cream, pudding or cheese. (Not to mention the seaweed in cosmetics, linoleum or car polish). Alginates, extracted from kelp, are used as thickeners in many products. They are also used to make the agar used for culturing bacteria in the laboratory.

## Other foods

Oysters are traditionally eaten raw. There is a debate about whether they should be chewed or not. Please yourself. If you do not like the thought of eating raw oysters there are a number of popular recipes which cook them.

Not very many years ago, squid was not a popular seafood and many of us would not have dreamed of eating raw fish. However these are now very popular in many parts of our country.

Other seafood previously regarded as unusual will be more in demand in the future for various reasons.

Firstly, many traditional foods are already heavily exploited and there is a danger that further demand will cause these foods to become scarce and expensive.

This has already happened with southern rock lobster (crayfish) and abalone whose scarcity has put them beyond the price of most people so that most of our production of these foods is exported.

## Diving deeper



5. As an alternative to plain fish, a marinade will add a zing to barbecued fish. Try this one:
  - a. Combine a cup of pure olive oil, a large squeeze of lemon or lime juice, a large pinch of salt, some freshly ground black pepper and a teaspoon of soy sauce.
  - b. Place dried fish fillets or cutlets in the marinade for an hour or so, then barbecue.
6. Try this recipe for raw fish.
  - a. Use a skinned fillet of fish. Remove any red meat and large bones. Cut the fish into finger-sized portions. Pat the fish dry with a paper towel.
  - b. In a bowl, place 2 cups of white vinegar, a bay leaf, a tablespoon of soy sauce and some freshly ground pepper. Add the fish and leave for 1–2 hours. Then eat it raw. If you find the vinegar taste is too strong, dilute it with water up to a 50/50 mix.
7. Before you cut up your squid, locate the pen and the ink sac and write your name in squid ink (Figure 183.2)



Figure 183.2 Write your name in squid ink

## Diving deeper



7. Visit your local fish shop, fish market, or supermarket and research the answers to these questions.
- What types of seafood are available?
  - How are they prepared for sale?
  - How are they presented for sale?
  - What is the most expensive seafood available?
  - What is the cheapest seafood available?
  - What exotic, non-local seafood is for sale?
  - What local seafood is for sale?

8. Try this recipe for oysters.

Cut rashers of bacon into strips long and wide enough to wrap around your oysters.

Sprinkle the oysters with some lemon juice, freshly ground black pepper, a little salt and some finely chopped parsley.

Wrap the oysters in the bacon and push a toothpick through to hold in position.

Place in the refrigerator for 30 minutes then place under a hot griller until the bacon is crispy.

Eat immediately.

9. What other recipes can you find for cooking seafood? Invite a representative from your local seafood marketing authority to come to class.



A second reason for our expanding demand for seafood is the increasing **multiculturalism** of our society. As different cultures exert an influence on us, so the foods that are part of these cultures become part of our culture.

## Key words

Aboriginal, Asian, barramundi, Chinese, cutlets, ethnic backgrounds, Europeans, fillet, gutting, gorges, hangi, Hawaiian, hooks, Japanese, luau, Maori, Mediterranean, Mirdawarr, multiculturalism, Pacific Island, Rrarranhdharr Dhuludur, scales, Scots, seafood, shellfish, skinned, Spanish, Taiwanese, trepang, Welsh.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- Our country is made up of people from many different [1] \_\_\_\_ a mix that has changed our seafood eating [2] \_\_\_\_.
- The word [3] \_\_\_\_ is an [4] \_\_\_\_ word which means ‘river fish with large [5] \_\_\_\_’.
- To [6] \_\_\_\_ a fish, hold the fish’s head (in your left hand if you are right-handed).
- Simply [7] \_\_\_\_ the flesh of [8] \_\_\_\_ from the shell and cut away the non-edible portions cut away with a sharp [9] \_\_\_\_.
- Snapper are often best prepared by cutting into steaks or [10] \_\_\_\_.
- Fish to be cooked [11] \_\_\_\_ must be [12] \_\_\_\_ and gilled.
- To clean squid, octopus or cuttlefish you first cut open the [13] \_\_\_\_ tube.  
This will let you remove the head and [14] \_\_\_\_ and any skin lining the inside of the body tube.
- Seafood should never be [15] \_\_\_\_ - \_\_\_\_ because it ruins its flavour.
- When [16] \_\_\_\_ fish, put a centimetre of olive oil in a frying pan. Your oil must be very hot before you start.  
Check the temperature by putting in a small piece of [17] \_\_\_\_.
- [18] \_\_\_\_ (shrimp) and yabbies can be cleaned by first twisting off their heads. Pull back the [19] \_\_\_\_, removing the centre section of the [20] \_\_\_\_ in the same motion.
- [21] \_\_\_\_ farming is a very old form of [22] \_\_\_\_ in Japan.



**Search engine references**  
 AUSMEPA, fishing, aquaculture, offshore oil and gas, shipbuilding, shipping transport services, tourism and recreation

The surfboard in Chapter 10 was manufactured in Australia in factories using raw materials such as fibre glass, resins and labour (Figure 185.1). The fibre glass was imported from Canada and the resin made in Australia. Factories involved include where the blanks were made (Figure 185.2), where the surfboards were made (Chapter 10), and warehouse storage. These are located on industrial sites zoned for industries that involve fibreglass and flammable liquids. Insurance rates are high and workers in the factory have strict workplace health and safety requirements. Factories have to be well ventilated and strict environmental controls mean no chemicals or fumes are to enter the environment.

Wages are controlled by workplace agreements and in many cases unions bargain for entitlements where chemicals and harsh working conditions apply. Once the surfboards have been made, they are sold in retail outlets as shown in Figure 185.3. The surfboard **manufacturer** sets a price to the **retailer** taking into account the production costs. The retailer buys the surfboards at a **wholesale** price but must add expenses such as rent, electricity, advertising, insurance and labour. The surfboard manufacturing industry is one very small marine industry and has a flow on effect into the surf clothing industry.

## Seven types of industry

The National Oceans Office has estimated that the value of marine industries is predicted to be worth over \$70 billion by 2020 - almost 10% of Australian GDP\*. Seven different types of marine industry discussed in this chapter include

- Fishing*
- Aquaculture*
- Offshore oil and gas*
- Shipbuilding*
- Commercial shipping*
- Supporting and 'high technology' industries and services*
- Tourism and recreation*

GDP\* stands for gross domestic product and is an indication of Australia's productivity

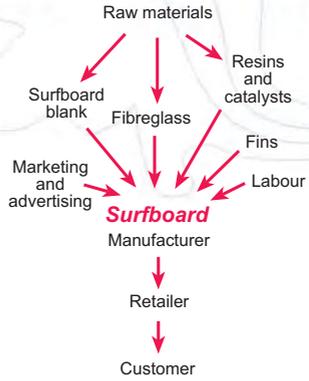


Figure 185.1 Manufacturing flow chart



Figure 185.2 Burfords blanks



Figure 185.3 Surf retail outlet



Bob Moffatt

Figure 186.1 Fishing trawler

# Commercial fishing

The commercial sector of the fishing industry comprises wild-catch, aquaculture, processing, storing, transporting, marketing and selling activities. Fishing is also discussed in Chapter 9.

## Wild catch\*

### Prawns

An example of wild catch fishing is the prawning industry where trawlers (Figure 186.1) drag nets over the ocean floor and haul their catch on board using ropes and winches.

The catch is sorted (Figure 186.2) and in many cases cooked on board. Prawns are then frozen and either exported (Figure 186.3) or sold locally to restaurants where a seafood lunch can cost between \$30-\$60 a plate (Figure 186.4).



Old Fisheries

Figure 186.2 Sorting the catch

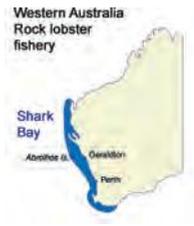
### Western rock lobster

Ref: [www.fish.wa.gov.au](http://www.fish.wa.gov.au)

According to the Western Australian Government, the western rock lobster fishery is the most valuable single-species fishery in Australia and usually represents about 20% of the total value of Australia's fisheries. It was also one of the first fisheries in the world to be certified as ecologically sustainable by the Marine Stewardship Council.

Also called 'crayfish' or 'spiny lobsters', rock lobsters are exported mainly to South East Asia, USA and Europe, commanding high prices.

The area where fish are caught is called the **fishery** and most lobsters are caught up to 60 kilometres off the coast between Augusta and Shark Bay.



Bob Moffatt

Figure 186.3 Wholesale shrimp

Other types of wild catch fishing are shown in the table below and have been discussed in Chapter 9 .



Murray Waite and Assoc

Figure 186.4 Value adding

Main Australian commercial wild-catch fishery types*	
Fishery type (major method)	Target species
Finfish trawling / danish seining	Multi-species
Prawn / scallop trawling	Single species and/or groups of species
Scallop dredging	Single species
Purse seining	Single species and/or groups of species
Net hauling	Multi-species or single species
Meshing	Multi-species
Line fishing	Single species or multi-species
Trapping	Multi-species
Potting	Largely single species (e.g. lobsters, crabs)
Hand gathering	Usually single species (e.g. abalone)

Source: WA Fisheries

\* See Chapter 9 for examples

Commercial fishing is a very large business that supports many people's livelihoods and lifestyles. Australian seafood is an important part of our international image as a clean and environmentally responsible country. Many rural and regional communities depend partly, substantially or even wholly for their economic viability on prosperous commercial fishing enterprises.

Commercial fishing is Australia's fourth most valuable food-based primary industry - after beef, wheat and milk. In 2002-2003 it produced about 249 000 tonnes of produce, worth nearly \$2.3 billion or about 6% of the gross value of all farm and fisheries production.

## Aquaculture

**Aquaculture** - the farming of freshwater or marine species, in future years will be a major supply of seafood. The days when trawlers dredge seafood from the seafloor is limited as the call for ecological sustainable development gets louder.

Aquaculture is one of Australia's fastest-growing primary industries in is estimated to be worth over one billion dollars by 2020 and was discussed in detail in Chapters 12, 13 and 14.

Main aquaculture industries include crocodiles, pearls, rock oysters, sea urchins, crayfish, scallops, sea horses, abalone, giant clams, seahorses, squid, prawns, crabs, salmon, silver perch, bass, barramundi and bluefin tuna.

Environmental issues associated with aquaculture include local water quality and how to minimise the flow of nutrients into local creeks and waterways. In New South Wales there is a zero release policy for water used in aquaculture farms. This means water has to be cleaned on site or treated before discharge.

## Oysters

**Oyster farming** is Australia largest aquaculture industry. For example, South Australia's oyster aquaculture industry was valued at \$16.1 million in 2004, with value added and flow-on benefit to the economy of over \$33 million through support industries.

Some oysters are grown in bags that are hung off lines in intertidal areas as shown in Figure 187.1. Others are suspended on racks and trays depending on local conditions.

The majority of oysters are sold whole, with both sides of the shell still intact. They are they shucked (opened) and sold as shown in Figure 187.3. Some value-adding techniques exist such as growers providing half-shell product, pickled, smoked, oyster shooters, kilpatrick and even oyster shashliks.



Figure 187.1 Oyster bag and line SA

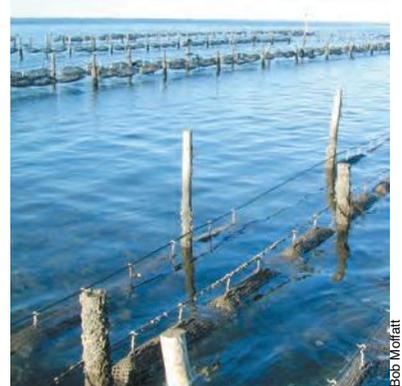


Figure 187.2 Oyster farming is Australia's largest aquaculture industry.



Figure 187.3 Oysters

## Diving deeper



1. Select a local marine retail outlet and list the broad categories of manufactured items they sell - clothing, fishing, snorkelling etc.
2. Find out where the goods are manufactured and the types of materials used in the manufacturing process.



Figure 188.1 The Mackerel platform in Victoria (Photo courtesy Esso Australia Pty Ltd)

## Diving deeper



3. Research information on Esso Australia's web site [www.essoaustralia.com.au](http://www.essoaustralia.com.au)
4. Research one of the following oilfields in the Timor Sea:
  - Jabiru
  - Challis
  - Elang/Kakatua
  - Laminaria/Corallina
  - Buffalo

# Offshore oil and gas

Information supplied courtesy Northern Territory Gov Website and Esso Australia Web site

Australia produces 9% of the world production of liquid nitrogen gas of 82 million tonnes. By year 2005, Western Australia and Victoria could be producing one-quarter.

## Bass Strait

Between 1965 - 1967 an Esso/BHP joint venture drilled Australia's first offshore well and discovered oil and gas in Bass Strait. The Mackerel platform in Figure 188.1 has been producing oil and gas from Bass Strait for over 20 years.

These discoveries have led to significant changes to Australia's industry and economy. Massive infrastructure costing more than \$12.5 billion has been built to develop, produce and process the crude oil and gas, which is used to power industry, fuel vehicles, heat homes and manufacture products in Australia and overseas.

There are now 21 offshore platforms and installations in Bass Strait which use a network of 600 kilometres of underwater pipelines to keep the oil and gas flowing, 24 hours a day.

## North west shelf

Marine gas sources in Western Australia are in the North West Shelf and Timor Sea with reserves to maintain current production for 30 years. Exploration began in the early 1960s but was suspended in 1975 due to the unresolved border between Australia and Indonesia. Signing of Timor Gap Zone of Cooperation Treaty in 1992 restarted operations.

Between 1999 and 2004 there have been over 16 oil and gas discoveries and US\$1.5 billion is committed to bring gas onshore via a 503 kilometre pipeline to a plant at Wickham Point in Darwin Harbour (Figure 188.2).

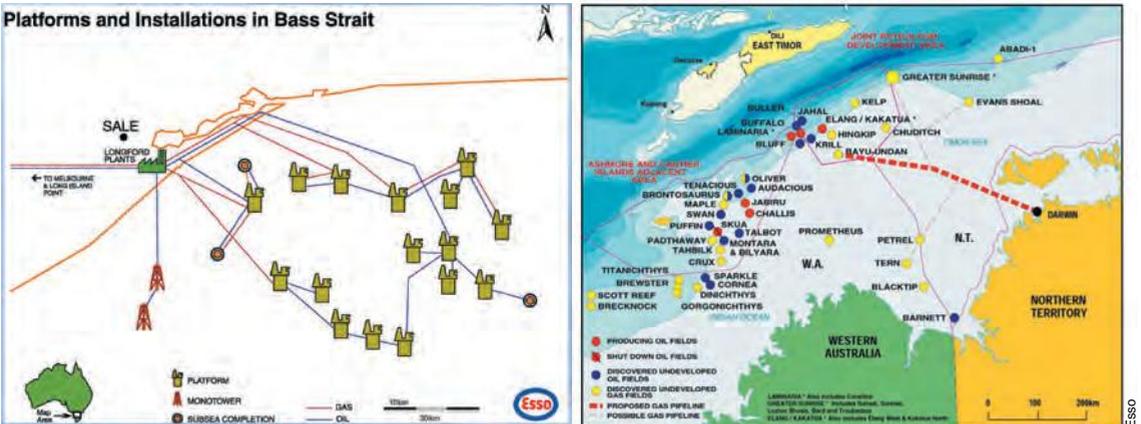


Figure 188.2 Bass Strait and Timor Sea oil and gas maps (Courtesy Northern Territory Gov and Esso Australia)



# Commercial shipping

## Ports

A port is a place sheltered from the open sea where ships can load and unload cargo. Major ports allow for a large number of ships for loading, unloading, discharging, handling and storing facilities. Exports include dairy products, grains, oils and fats and manufactured goods. Imports include cars and mineral fuels (crude oil). Other smaller vessels also use ports.

## Types of shipping

### Bulk carriers

These ships have huge compartments inside called holds (Figure 190.1). Cement powder, coal, iron ore and wheat, are solids but can change their shape and are moved in and out of the holds using different methods.

### Tankers

These ships are designed to transport bulk quantities of mineral oils, either crude oils or the refined product. They can carry single cargoes of 100 000+ tonnes. The liquids are pumped in and out of compartments in the hold via the pipe-work seen on the deck.

### Roll on roll off

Cars, trucks, mining equipment and agricultural machinery can be driven straight on and off the dock.

### Container ships

Containers are carried on the decks of large ships (Figure 190.5) and unloaded by special cranes (Figure 190.4). Some containers called reefers have built-in refrigeration units and are used to transport fruit and vegetables, dairy products and meat.

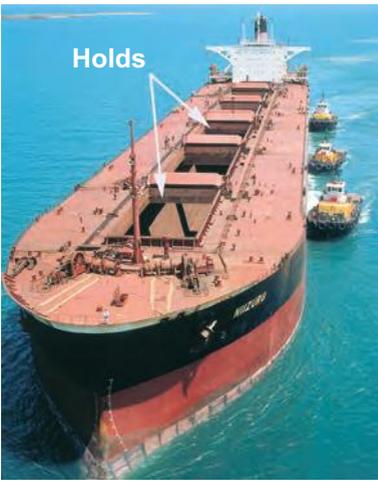


Figure 190.1 Bulk carrier



Figure 190.2 Oil tanker and ballast water



Figure 190.3 Ore loading terminal



Figure 190.4 Container terminal crane



Figure 190.5 Container ship

# Supporting industries and services

This covers a broad selection of industries such as marine instrumentation, engineering design and environmental management. It also covers service industries such as marinas, artificial reefs, ports, transport, catering and hospitality.

## Existing industries

Safety, maintenance and repair, communications, marinas are just a few examples of industries that support small and large ships.

Fire fighting equipment will have to be manufactured (Figure 191.5A) and maintained, sailing equipment and ropes will need to be replaced (Figure 191.5C) or marine communications gear to take advantage of digital networks (Figure 191.5D) will have to be purchased.

## Air, road and rail

Exports and imports have to be moved to wholesale or retail distribution points. For example the salmon that were harvested in Chapter 12 are flown to interstate markets in chilled boxes (Figure 191.4)

## Flow on effect

Where one industry develops others soon follow. This is called the flow on effect. For example the ferries in Figures 191.1 - 191.3 will need servicing, electrical work, training of crew, painting. Nearby shops will sell newspapers, drinks, food and employ staff.

## Emerging industries

Emerging industries include businesses based on marine biotechnology, alternative energy and seabed minerals. Aquaculture is one industry that will benefit from new technologies. The use of teraflex bags (Figure 191.4B) in the construction of artificial reefs introduces new materials into related industries.



Figure 191.1 Passenger ferry



Figure 191.2 Car ferry



Figure 191.3 Island ferry



Figure 191.4 Salmon for export



Figure 191.5 Some related marine industries  
Bob Moffatt and Marine Safety Queensland



Figure 192.1 Wineglass Bay, Tasmania



Figure 192.2 Feeding Dolphins, Monkey Mia, Western Australia



Figure 192.3 Whale watching at Hervey Bay - a tourist town



Figure 192.4 Snorkelling reef platform off Mackay

# Tourism

**Tourism** is what happens when people leave their permanent residences and workplaces and go to temporary destinations where they usually participate in a range of leisure activities.

## Tourism requirements

The tourism industry depends on its environment, local attractions and facilities.

- Good weather plays an important role in that environment for successful marine tourism. Snorkelling and scuba diving need good visibility, boating needs calm seas and surfing needs rough seas.
- Many tourism destinations need the presence of an attractive type of marine species to attract tourists. Whales, penguins and dolphins are just a few examples of how a marine species can attract tourists.
- Some people are attracted by the natural beauty of an area, such as a reef or the coastline, especially if it is not easy to get to.
- Camping out by the sea has been a significant part of our cultural tourism heritage.
- A number of tourist attractions with a marine theme have been built to cater for this short-break package tourism market.
- Some people are interested in going to areas to see relics of marine activities from the past. Pacific Island and Aboriginal people also have special **Dreamtime** places which are of great cultural significance.
- **Maritime museums** in Australia and New Zealand also play a vital role in preserving maritime history of all cultures.

## Tourist activities

Whale watching has become an industry along our coastline. It is based on the annual migration of whales, particularly humpback whales, as they move north from their summer feeding grounds in the Antarctic to tropical waters to breed and then move back south with their babies at the end of spring.

A visit to the Great Barrier or Ningaloo Reefs is considered an essential part of any trip to tropical Australian waters. Thousands of people visit the reefs every year, with some staying on one of the many coastal or island resorts. Transport to the reef is by car, plane, helicopter or by high speed **catamarans** like the one shown in Figure 193.1. Once at the reef, the passengers may disembark onto **floating platforms** (Figure 192.4) located on the reef, or onto a coral cay.

The natural environment is the main attraction for divers. The attraction may be a beautiful section of coral reef, underwater structures or different types of animals such as the fish life, sharks or seals.

There are diving centres throughout Australia, and many have their own dive boats and dive masters to show tourist sports divers the location.

There is nothing better than just messing about in boats and many tourist attractions provide sailing, canoeing or power boating facilities. Some related tourist activities are jet skiing, banana boat or rubber tube rides and paraflying.

Fishing is a very popular sport where tourists have a wide range of experiences available. Some people simply fish from the beach or a jetty.

**Charter boats** are available at most marine destinations, and are taken out by individuals or small groups, generally with a guide. Smaller boats can be hired to fish and large sea-going charter boats are hired by people after reef or pelagic fish.

Marine aquariums allow all types of tourists to see underwater life. The use of **acrylic** plastic, as shown in Figure 193.2, allows people to be transported under the sea to experience a different perspective on marine life.

In some areas of Australia, such as Monkey Mia (Figure 192.2), Western Australia or Tangalooma, Queensland, dolphins have befriended humans and regularly make contact with us.

## Tourist venues

A tourist **venue** is a place where tourist activities occur. Tourist **resorts** are venues where accommodation and activities are combined with attractive surroundings and good service. Many cities and towns are set up specifically to cater for tourist operations.

## Importance of tourism

Large cruise ships (Figure 193.4) now visit Australia with over 22 000 passengers cruising in any one season. With a stop over in any one port worth over a million dollars to the local economy it is not surprising that cruising is big business.

Tourism provides jobs and tourism needs to be valued as a resource. Tourists come from all parts of the world and from many different ethnic backgrounds. We need to understand their background and customs.

The old saying ‘money makes the world go round’ is especially relevant to tourism. The **restoration** of the *Pandora* or *Batavia* would not be possible if it were not for tourism.



Figure 193.1 Tourist boat returning from an offshore island



Figure 193.2 Marine aquarium with acrylic plastic

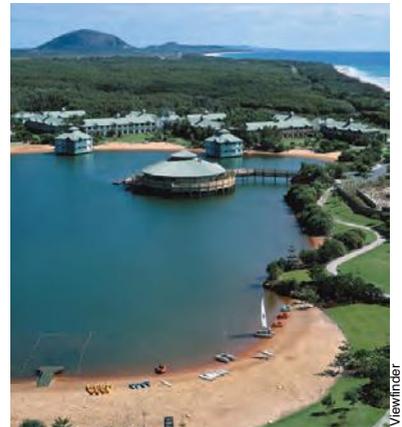


Figure 193.3 A tourist resort



Figure 193.4 Cruise ship

## Diving deeper



7. Conduct a survey of a local tourist destination in your area. Your friendly tourist operator will help you.
  - Find where the tourists come from (use post codes).
  - Record how they come to this location and how long they tend to stay.
8. Design an Australia- or New Zealand-wide itinerary for a person who wishes to visit:
  - the 10 best surfing beaches;
  - the 10 best dive sites; and
  - 10 varied and interesting tourist locations with a variety of leisure activities.
9. Research whale watching regulations, with particular regard to the distance that a plane can approach, how boats approach whales and not herding or separating whales.
10. Debate the marketing methods used for tourism.
11. Make a flow chart  
Choose two commodities traded at a port and draw up a flowchart to show point of origin (eg farm) through to final destination (eg ship to South-east Asia).  
Include the containers used for travel and storage and the modes of transport to and from the Port.
12. Design a floor plan for an underwater world type marine aquarium tourism venture.

## Management of marine parks

Tourism **taxes**, park entry fees and registrations of marine recreational equipment all go towards paying the wages of park managers, the upkeep of facilities such as boat ramps, walking tracks and to supporting marine research. If an area has a natural attraction, tourists are drawn to that area, which can impact on the quality of the environment. Other tourist facilities will generally follow later with further impact. Marine tourism must therefore be carefully managed so that the marine environment can be sustained for further tourism.

## Marine recreation industry

This huge industry covers everything from fishing, diving, surfing, boating, canoeing, kyaking, beach walking, jet skiing to name but a few. Every marine recreational activity will have accessories such as snorkels, lures, bait, leg ropes, sun hats and screens, wet suits, safety gear or even sun glasses.

### Flow on effects

Flow on effects can be jobs or materials created from a prime industry. For example recreational fishing creates jobs in boat sales, food supplies or even real estate rentals at popular fishing spots. Figure 194.1 shows some of the flow on effects of the surf industry. Can you make a list of the accessories and the associated industries for recreational fishing?



Figure 194.1 Manufactured flow on products from the surfboard manufacturing industry

Bob Morfitt

# Key words

Acrylic, bulk carrier, catamaran, charter boat, commercial fishing, container ship, dry dock, fishery, floating platforms, flow on effect, manufacturer, offshore oil and gas, port, retailer, resort, restoration, roll on roll off, ship building, shipping transport services, tanker, tourism, tour, wholesale, zoning.

# Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. The [1] \_\_\_\_\_ sector of the fishing industry comprises wild-catch, aquaculture, processing, storing, transporting, [2] \_\_\_\_\_ and selling activities.
- b. An example of [3] \_\_\_\_\_ catch fishing is the [4] \_\_\_\_\_ industry where trawlers drag nets over the ocean floor and haul their catch on board using ropes and winches.
- c. The area where fish are caught is called the [5] \_\_\_\_\_ and most [6] \_\_\_\_\_ are caught up to 60 kilometres off the coast between Augusta and Shark Bay.
- d. Marine [7] \_\_\_\_\_ sources in Western Australia are in the North West Shelf and Timor Sea with [8] \_\_\_\_\_ to maintain current production for 30 years.
- e. In Fremantle, Western Australia, a full-size replica of the Dutch ship [9] \_\_\_\_\_ was launched in January 1999. The Duyfken replica has been built as a project in experimental [10] \_\_\_\_\_ .
- f. Boats can be built and repaired in [11] \_\_\_\_\_ . They are then floated out to allow work to be completed while other ships are [12] \_\_\_\_\_ . Dry docks also repair [13] \_\_\_\_\_ and warships.
- g. [14] \_\_\_\_\_ are carried on the decks of large ships and unloaded by special [15] \_\_\_\_\_ .
- h. A [16] \_\_\_\_\_ is a place sheltered from the open sea where ships can load and unload cargo. Major ports allow for a large number of ships for [17] \_\_\_\_\_ , unloading, discharging, [18] \_\_\_\_\_ and storing facilities.
- i. Where one [19] \_\_\_\_\_ develops others soon follow. This is called the [20] \_\_\_\_\_ .
- j. [21] \_\_\_\_\_ are available at most marine destinations, and are taken out by individuals or small groups, generally with a guide. Smaller boats can be [22] \_\_\_\_\_ to fish for barramundi and large sea-going charter boats are hired by people after reef or [23] \_\_\_\_\_ fish.



- 1. List seven types of important marine industry.
- 2. Draw a diagram for a manufacturing flow chart.
- 3. How is offshore gas and oil exported from Australia?
- 4. What is the difference between a bulk carrier and a tanker?
- 5. Choose a marine industry and explain with an example, what a *flow on effect* is.
- 6. Define the meaning of the term '*tourism*'.
- 7. What is a wave piercer?
- 8. What is the whale watching industry based on? Give one example of how this industry generates jobs.
- 9. Name one marine industry and list 6 support industries?
- 10. What happens in dry docks?
- 11. Describe a day trip to a reef pontoon and how human impacts are reduced.
- 12. Why is tourism important to a local community?
- 13. Name two important shipwrecks that were restored through tourism dollars.
- 14. How are tourism taxes spent and what are their benefits?
- 15. Some tourist operations centre around the natural beauty of an area.  
Justify this marketing strategy.

# Chapter 17 Marine employment



## Web references

[www.ntis.gov.au](http://www.ntis.gov.au), <http://www.training.com.au>



Figure 196.1 Cruise boat coxswain



Figure 196.2 Sales rep in a surf shop



Figure 196.3 Oil rig engineer

Jobs in the marine industry are found on boats at sea, in shore-based operations or on inland farms. There are a lot more jobs on land than at sea but you still need an understanding of life at sea and the related marine environment wherever you work.

The best way to learn about marine employment is to gain experience in the marine industry. Then, if you like the field of work, organise through your school to learn about traineeships while you are still in full-time education.

This gives you the flexibility to either take up a career after studying at a tertiary institute or a career in a full-time job where you gain your qualifications while working.

## The world of work

Most schools offer **work experience** programs in which you spend a week at work. During this time you will experience the joys of waking up a bit earlier, getting yourself off to work by yourself and carrying out the routine tasks associated with most jobs. The world of work is fun because you get to work in a team, earn your own money and stand on your own two feet.

### What work experience is like

What's it like on work experience?

Take the example of getting some work experience on a cruise boat like the one shown in Figure 196.1. The first day you will probably just go out on the cruise, roll some napkins, help wash the boat and help the crew load and unload stores. In fact you may roll napkins, wash the boat and load the stores each day of your placement because this is what has to be done each day in order for the ship to operate. On board the ship you may also find a marine biologist with a university degree who also rolls napkins, washes the boat and loads stores.

These days, in a small business or in the close working conditions of a ship, everyone has to be **multiskilled**. This means that you are trained to do as many tasks as possible in the one job.

Marine biologists who work on cruise boats are multiskilled because they not only have to have a science degree, but also need to know how to tie a bowline, pour a standard drink, use a fire extinguisher and give first aid and resuscitation where necessary.

The **shipmaster** or **skipper** is in charge of the ship and may allow you to help with some navigation and explain to you what happens on board. You will learn to do team tasks like helping tie up the vessel or individual tasks like cleaning the ship's head (lavatory). If you are lucky you may get to drive the rubber ducks or serve the drinks (Figure 197.2).

Other days of your work experience may be spent on shore learning how bookings are made and how to take telephone messages, answer the phone and do the banking.

Work experience is a combination of fun and fear. You will find you are treated very differently from how you are treated in school because you are helping to earn your boss a profit and working in a team for a common purpose.

## In the workplace

Most research into what employers want from new employees reveals two essential elements — communication and a good attitude to work.

These are the building blocks of employment. So never be late, always try your hardest, communicate well and have a bright, happy, pleasant and productive attitude.

# Structured work placements

## Industry partnerships

Many schools have taken on a new and exciting role in **vocational education** in which students learn about the skills they need at work in specific areas. Because teachers are not expected to know about every job out there in the workplace, the scheme includes **industry partners**. Many schools that teach marine studies are now involved with these industry partners - a scheme that was supported by the Australian Student Traineeship Foundation or ASTF.

Figure 197.3 shows an industry partner with a marine studies teacher. The industry partner has a small fishing charter business and the teacher ran a marine studies course at school.

The industry partner wanted the students to have some basic marine skills before coming to work, for example, know how to tie knots, navigate, drive a boat, start and maintain the outboard motor, bait a line, gaff a fish and use a marine radio.



Figure 197.1 Skipper on a ship



Figure 197.2 Crusie attendant



Figure 197.3 Industry partner and school vocational education coordinator



Figure 198.1 Student learns how to use a marine radio.



Figure 198.2 Workplace assessor and trainee discuss radio logbook.



**Questions**  
Use your textbook to find the answers

1. What are two essential employee characteristics for successful work experience?
2. What is a structured work placement?
3. What does the word 'competencies' refer to? Give an example of one competency.
4. What goes into a logbook?
5. Who is a workplace assessor?
6. When does a person become competent in performing a skill? Give an example.
7. What are core course elements designed for? Give an example.

In **structured work placements**, the marine teacher runs classes in some of the basic marine skills at school. The students then spend time with the employer to learn skills that are more appropriately taught in the workplace and also practise skills taught in the classroom. For example, students learned the basics of how to use a marine radio at school (Figure 198.1) and then had the opportunity to get lots of practice at work (Figure 198.2).

## Getting a job

The value of the attainment of marine skills in a school–industry learning relationship is that students can gain qualifications that are **nationally recognised**. The types of skills that are to be learned are grouped into **competencies** which are recognised in all states by the marine industry.

For example one of the competencies required to operate a marine radio is to be able to switch on, tune and operate VHF, HF and 27MHz marine radio transceivers.

Once you achieve all other competencies needed in operating a marine radio (and there are over 20), you can take them to any employer anywhere in the country and he or she will know that you have been trained to use a marine radio to the industry standard.

## Becoming competent

In the world of work, you are rarely assessed on marks and percentages but on your competencies or on how you do the job. In the workplace, for example, you are not likely to be given a written exam on how to use a radio at the end of your day's training. Rather you will be expected to demonstrate that you are competent in what you have learned.

Training competencies are then recorded in your training **logbook** by a **workplace assessor** (Figure 198.2). This is a person in the workplace who has been trained to test your skills and has substantial experience in the particular industry in which they are assessing.

This often means that your logbook will show if you can perform a skill or you can't. In our radio example, you can show your competencies by being able to switch on, tune and operate VHF, HF and 27MHz marine radio transceivers as outlined above.

In the world of work everyone starts the same way at the bottom of the learning curve and knowing nothing. However, as your team work mates explain your new tasks you are expected to become competent in them.

This is why your **attitude** to learning has to be positive and your communication skills have to be sound so that you can feel confident in asking for help.

You will become competent when you can actually perform the task. For example, your skipper may ask you to get a weather report using the radio. If you are competent you will know when you can call, what radio and channel to select and how to make the call, write down the information and deliver it to the skipper in neat handwriting, and promptly!

## Getting more pay at work

If you work in a multiskilled work place, you could undergo training and you could find that you are paid according to your level of competence.

Under modern workplace agreements, you can gain pay rises in a number of ways. A group of workers can collectively bargain with their union for a better pay deal, or you as an individual can undertake training and negotiate a voluntary employer agreement that is related to your competencies.

To prove these competencies you can study to become a coxswain and then a shipmaster. Some modern workplaces allow you to do training on the job where you learn and be assessed by your workmates who train you in new competencies.

Many high schools now teach competencies. Technical colleges, private providers (people running private training businesses), colleges and universities offer a range of courses including, training in competencies which lead to higher level certificate courses.

## Marine traineeships

The best way to start your marine training is with introductory certificates in Maritime Services. This may take 1–2 years depending on whether you study part-time or full-time. Then you can decide which job you want. If you are really interested, your school vocational officer will help.

### Certificates

A certificate is made up of many course elements. Industry entry certificates are usually at Levels 1 and 2. A deckhand must complete many hours of work to get an introductory certificate in order to progress to the next level of coxswain.

A **coxswain** is a person who has achieved a higher qualification and who has many days experience at sea. They can be in charge of a vessel that takes paying passengers. You can also get a **restricted coxswain** to operate in a certain area and conditions.



Figure 199.1 Ships tug operator workplacement



Figure 199.2 Work experience student sorting oysters



Figure 199.3 Surfing instructors



Figure 199.4 Marine engineer



Figure 200.1 Shipmaster



Figure 200.2 Ship simulator

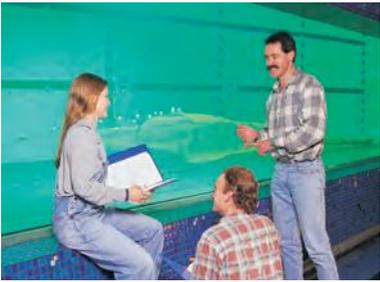


Figure 200.3 Flume tank used to study fishing methods



Figure 200.4 The engine room



Figure 200.5 Sea time on a tour boat

A deckhand can also progress to becoming a **marine engineer** who is responsible for the operation and maintenance of power-driven sea vessels including tankers, passenger liners, fishing trawlers, tugs and offshore drilling platforms or progress to a shipmaster (Figure 200.1) who takes the overall responsibility for all those who work and travel on the ship. It takes many years to become a shipmaster.

Courses in the maritime industry can be done through TAFE colleges, private providers, tertiary institutes or the Australian Maritime College (AMC). Facilities at the AMC allow ships officers to be trained on a simulator (Figure 200.2) or study fishing nets in flume tanks (Figure 200.3). Students who have successfully completed Year 10 will be eligible for most **certificate level** courses such as the Certificate in Fishing Operations, the externally delivered Certificate in Maritime Business and the Certificate in Small Craft Operations. AMC also offers courses in naval architecture for students wanting to learn about ship design (see Chapter 7). In the entry level certificate course in Maritime Operations there are two types of course element: core and elective.

### Core course elements

Everyone at sea needs to know how to use the radio, put out a fire in the galley and how to abandon ship. **Core course elements** (previously called modules) of a course are designed so that no matter where you work on a vessel, you are multiskilled in essential safety skills. Examples of these elements are **occupational health and safety**, practical mariners skills, radio operation, firefighting skills and first aid.

### Elective course elements

**These elements**, allow you to try out different aspects of a certificate level course. Students doing electives are shown in Figures 200.2 – 200.5. The students in the engine room are completing competencies in marine engineering on a tug. The student on the whale watching vessel is developing tourism competencies. The cruise attendant, who works for a dinner river cruise business, is taking a bar attendant course. Other elective elements include administration and front office, vessel handling, cargo operations and fishing.

### Sea time

The maritime industry recognises that experience at sea is fundamental to being a good employee. Every time you go to sea it's a good idea to ask the shipmaster to log time at sea.

This is usually recorded in a special seetime log book provided by your local government maritime office. Logged sea time is used as an entry into many maritime courses.

# Marine employment opportunities

You don't have to go to sea to work in the maritime industry and over 60% of jobs are shore based. The nice part of the industry is that every now and then you will get to go to sea and having your deckhand qualifications will be very useful.

## Tourism

The tourist industry has been our fastest growing industry since the early 1990s. Because of our vast coastline, natural attractions and reliable, warm, weather this rapid expansion has extended into the marine area. **Ecotourism**, based on 'look and leave it alone' ecological principles is the latest tourist boom industry.

Most popular marine tours involve pleasure boats (including cruise boats like that shown in Figure 201.1), snorkelling and diving tours, transport to the tour site (Figure 201.2), larger liner tours, sports fishing tours, whale and whale shark spotting and chartered sailing cruises. These tourism businesses provide a wide range of unskilled, semi-skilled and fully skilled employment opportunities for people with the requirements already discussed in this chapter, for example elements of shipboard safety and diving qualifications.

## Marine tourist centres

This chapter has so far discussed jobs at sea, however there are thousands of shore-based marine jobs.

Marine tourist attractions employ many staff in **interpretive** work. The staff member shown in Figure 201.4 works at Sea World and the photo shows her giving an entertaining, informative and enthusiastic commentary on sea lions to park guests. Some of the jobs at a typical marine tourist attraction centre, of which UnderWater World or Victor Harbor Whale Watching are examples, are listed below.

- **Managerial** - Usually one manager and an assistant manager control daily activities and coordinate staff.
- **Office and clerical** - Secretaries and receptionists handle large volumes of phone bookings and enquiries plus associated paperwork. Completion of a business course and good personal and computer skills are an advantage to getting a job in this area.
- **Technical** - Curators help maintain the health of all organisms in a centre by controlling their diets, monitoring water quality and quarantining endangered animals.



Figure 201.1 Expedition leader Antarctica



Figure 201.2 Marine tourism crew



Figure 201.3 Ferry skipper



Figure 201.4 Sea World Marine interpretation officer



Figure 202.1 Tour leader Kimberley region



8. What is sea time and how is it recorded?
9. What is a coxswain and what can they do?
10. What do most popular marine tours involve?
11. What are some of the typical jobs at a tourist attraction centre?
12. Name three qualifications that you can get at high school that are useful in getting a job.
13. Outline the role of armed services and employment opportunities it offers.
14. What job opportunities can be found in water sports?
15. Who do shipbuilders employ?
16. Outline the steps taken from being a school student to being a qualified marine fitter.
17. Describe the job of a marine engineer, and the qualifications needed to become one.
18. Describe how to become a marine studies teacher at a high school.
19. What is the difference between a bachelor's degree and a PhD?

To get these jobs you need a basic degree in marine biology plus boating and diving qualifications.

- **Trainers** - Training and managing the performance of the seals, dolphins and, possibly, killer whales is a highly specialised job that needs a range of qualifications including bachelor's degrees and extensive experience.
- **Tradespeople and/or technical assistants** - Centres usually need plumbers and fitters or people with maintenance skills to maintain aquariums and service vehicles.
- **Sales assistants** - These centres sell a full range of souvenirs including t-shirts, postcards and ornaments. Jobs are available here for people with good personal communication skills and usually involve shift or part-time work.
- **Catering** - Cooking, preparing and retailing snack foods, main meals and coffee and serving alcoholic drinks in licensed sections. You would need to complete a hospitality course and be available for shift work to find a job here.
- **Marinas** - Cleaning and servicing marine craft as well as making repairs and organising stores or trips away.
- **Front desk operations** - Admitting park guests, public relations duties, processing cash or credit cards.
- **Volunteers** - A whole range of opportunities exist here from feeding fish to helping with guided tours.

While you are at school, it's a good idea to apply to be a volunteer because that experience will serve you well if you do intend to work in this industry or a related one.

## Armed services

The Navy is the part of our armed forces that defends our coastline. It is a self-sufficient organisation responsible for training all its personnel, including tradespeople, and providing university degrees for its officers.

Joining the navy involves passing a medical, showing suitability in an interview, then completing an intense 3-month training course. After being accepted you must make a commitment to sign on for at least 6 years.



Figure 202.2 Find out more at [www.defencejobs.gov.au/navy](http://www.defencejobs.gov.au/navy)

## Fishing industry

In the past, the **commercial fishing industry** caught fish, prawns and lobsters for our tables. Today, because of the combined effects of increasing population and decreasing fish stocks, the industry is also moving into fish farming or aquaculture.

Most of the jobs in this industry have traditionally been gained through direct entry with no formal qualifications required. For example, people got jobs as general deckhands or untrained labour in fish markets and processing plants. Today, there is much more competition for jobs and any qualifications obtained are an advantage.

Many useful qualifications such as scuba certificates, radio and small craft proficiency and elements of shipboard safety certificates can be obtained from high school marine studies courses.

## Marine retailing and manufacturing

### Water sports

This area includes all the water sports of sailing and power boating, swimming and surfing, jet skiing, sailboarding, diving and fishing. Most of the manufacturers of equipment for these popular recreational activities are small businesses and there are a large number of them in Australia offering a diverse range of employment opportunities.

The makers of boats for jet skiing, sailing and power boating are part of the small boat building industry where many businesses consist of one or two tradespeople, two or three technical assistants, one or two owner-managers and possibly one office secretary. They find it difficult to spare the time to spend with **apprentices** and generally do not take them on without government assistance.

The jobs on the manufacturing side have traditionally been filled by untrained but talented enthusiasts with a vested interest in the industry.

### Retail shops

There are opportunities for untrained people to get jobs as technical assistants and sales people in retail and manufacturing areas. Surfboards and sailboards are now either manufactured by a few large companies and distributed to retail outlets for sale, or they are manufactured and sold by an individual retail surf shop. To work in these shops requires a good understanding of the needs of customers. For example to sell a set of fins for a surfboard requires a knowledge of the different fin types as well as how to remove and replace broken fins.



Figure 203.1 Deckhand

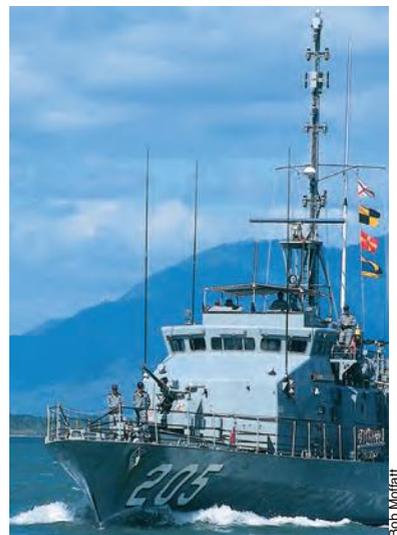


Figure 203.2 The Navy is the part of our armed forces that defends our coastline.



Figure 203.3 Retail salesman



Figure 204.1 Pro surfer

Bob Moffatt



Figure 204.2 A glasser in a surfboard manufacturing factory

Bob Moffatt



Figure 204.3 A divemaster safety checking a returning scuba diver

Alan Wolfe



Figure 204.4 Western Australian-made ferry

Alan Wolfe

The diving industry consists of a few large equipment manufacturers, mostly from the USA, with a large number of retail outlets or dive shops around Australia and New Zealand. Dive shops sell education courses and equipment packages. Jobs in the manufacturing side of diving - making air tanks, buoyancy vests and regulators - are filled by tradespeople such as gas fitters, machinists and technical designers.

On the retail side, a typical dive shop consists of between five and 10 staff, nearly all of them fully or partly qualified instructors who work on a multitasking basis in which they take turns to teach scuba courses, sell and maintain equipment, and organise and supervise dive trips.

To get a job in this area you should complete basic and advanced scuba certificates under instructors from the diving industry and then seek employment there.

Surfing (Figure 204.1 and 204.2) and diving (Figure 204.3) are good examples of people working in the marine industry for the lifestyle where the pursuit of wealth may not be as important.

The recreational fishing industry also revolves around a few manufacturers of equipment and accessories. Available jobs are mostly for unskilled people in the sales area. There are now, however, an increasing number of fishing and tackle shops putting together specialised equipment 'rigs' and organising extended fishing tours. This will open up job opportunities for semi-skilled fishing enthusiasts.

### Boat and shipbuilding

Boats and ships can be made from aluminium, wood, fibreglass, concrete, steel and, most recently, composites of high technical plastics such as kevlar.

Boat and shipbuilders or **shipwrights** usually specialise in a certain material in their construction processes. Most use only one or two materials. The jobs in this industry are mostly for welders, carpenters, machine fitters and electricians.

Examples of successful shipbuilders are Austal Ships in Western Australia and INCAT in Tasmania which are two of the world's biggest manufacturers and exporters of large passenger ferries. These ferries, mostly twin-hulled, 40 metre aluminium catamarans, can carry up to 300 passengers (Figure 204.4). Austal employs over 1000 people in a tiered management structure with many sections, under a chief executive officer. Staff come from a range of professional, skilled and general employees including accountants, naval architects, engineers, tradespeople, trainees and apprentices, sales persons, secretaries and clerks.



Figure 205.1 Austal is a large marine employer in Western Australia

### Case study

The best chance for school leavers to get jobs at companies like Austal is in the trades area. More than 500 people in this company are employed in the aluminium, electrical and engineering sections. This includes apprentices and trainees in the aluminium fabrication, marine fit-out, electrical, refrigeration, sheet metal and welding trades.

Most of Austal's technical staff are recruited directly from school after completing Year 10 with good passes in mathematics and English. Other trades such as electrical and refrigeration engineering need successful completion of Year 12. School reports are considered with particular attention paid to an applicant's record for absenteeism, behaviour and ability to work independently to full potential. Apprentices usually take three years to qualify in their respective trades, working typically four days a week with on-the-job training, plus one day a week in formal off-the-job training (for example TAFE).

### Marine science

There are few jobs as marine biologists. However marine science offers many careers in education, research and technology. The research field covers all the science disciplines of biology, chemistry, geology and physics plus related fields of engineering, geography and mathematics. Professionals in these fields are involved in research in fisheries, oceanography, archaeology and seafood technology. A great deal of fisheries research is currently going on into aquaculture with the breeding and growing of marine animals under controlled conditions. Up until 1990, oysters and yabbies were the only significant species under aquaculture (see Chapter 12).

Since 1990, many other species have been farmed successfully, especially the larger fish such as barramundi and tuna, and lobster. The bulk of the research concentrates on finding the best diets and conditions to grow the species to suitable sizes for sale.



Figure 205.2 Boat building business



Figure 205.3 Boat fabricator



Figure 205.4 Marine scientist



Figure 205.5 Marine scientist in the field

## Diving deeper



1. Select two of the following careers in the marine industry: passenger ferry deckhand, pleasure boat builder, ships' pilot or professional commercial diver. For each, find out and write:

- a job description describing the daily duties and responsibilities; and
- the qualifications and/or experience you will need to enter this career.

Hint: write to or phone the personnel officer of the organisation you have selected

2. Find out what the term '*flexible delivery*' means.
3. Obtain a letter from your work experience or school vocational education coordinator and go out and do some work experience.
4. Find out and list the steps to becoming a dive instructor.
5. Find out what certificate level courses are available in the marine studies field.



Figure 206.2 Beach litter control operator



Figure 206.1 Government marine technical officer

Research fields require administration and technical support to help collect and distribute data. There are a wide range of jobs for semi- and fully trained personnel including laboratory assistants, boat skippers, deckhands, computer programmers, office clerks, secretaries, marine park rangers and divers.

### Local government

Local authorities often employ lifeguards to patrol beaches. Lifeguard positions are usually filled from the ranks of the voluntary surf lifesaving movement. Other jobs at the local government level involve repairing navigation marks (Figure 206.1) or beach litter control (Figure 206.2), for which you would need to have a tractor licence, or jobs in water quality environmental monitoring where you would be responsible for controlling stormwater pollution on beaches. Ultimately the protection of our marine environment will depend on how well the rules are enforced.

### Education

Employment in teaching marine studies courses can be found in high schools, TAFE colleges, universities and private providers. You will need to complete Years 11 and 12 with good grades to begin to qualify for any job in this area.

There are two types of qualification to be a high school teacher. You must either complete a three-year bachelor's degree course in a range of major subject areas such as marine biology plus a one-year diploma in education or complete a four-year Bachelor of Education course at a recognised university.

To widen your skills and improve your employment prospects in marine teaching, a number of short certificate courses are available on a part-time basis. Scuba diving, sailing and small craft proficiency courses, for example, can each be completed in four full days or over two weekends.

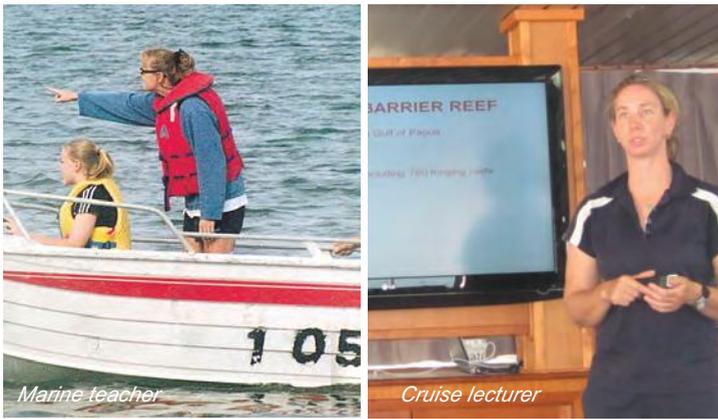


Figure 207.1 Marine education

## Harbours and port authorities

Australian ports involve a number of state and federal government departments including the port authority, customs service, water police and transport departments. Collectively, they are responsible for shipping movements, loading and unloading goods, maintaining and enforcing marine qualifications and safety regulations and prohibiting the import/export of illegal goods.

Port authorities control the movement of ships into and out of ports and are responsible for overseeing the loading and unloading of ships, called **stevedoring**. In some ports the stevedoring is contracted out to large companies.

The following is a list of the jobs available in this area and the qualifications needed.

- **Managerial** - Control of operations and staff. Most employees at this level have tertiary qualifications and a good deal of experience.
- **Office/clerical** - Deal with the large volumes of necessary paperwork. Employees have usually completed Year 12 .
- **Service** - Drive and maintain vehicles such as forklifts, cranes and boats. Most people employed here are mechanical and electrical tradespeople and their semi-trained technical assistants.
- **Stevedoring** - Handle goods such as cars, trucks, containers, bulk grains, petroleum and livestock. These jobs are mostly unskilled and need no formal qualifications. Some are semi-skilled and get their qualifications through on-the-job training and short courses such as crane driving provided by outside contractors.
- **Security** - Protect goods awaiting export or pick up. Most security personnel require limited qualifications involving a short TAFE course with most training on the job.

## Diving deeper



6. Go to careers markets and university open days to find out what university courses are available.
7. Search the university web pages and locate marine science courses.
8. Arrange a visit to your local authority and see if you can do some work experience in beach protection.
9. Visit the water police and find out what happens in their area.
10. Arrange for a careers lesson at your school and invite a number of guest speakers to give a 10-minute talk.
11. Locate some past students who have jobs in the marine industry and ask them back to school to give a talk.
12. Read the newspaper and make up a marine jobs career chart for your classroom in which you stick up advertisements for jobs in that field.
13. Visit a local surf shop and find out what knowledge and skills are necessary to work there.
14. Debate the saying *'There's a good surf happening when the surfboard shops are shut'*.



Figure 207.2 VMR radio operator



Figure 208.1 Working as a trainee in a port



Figure 208.2 Power boat licence or sailing instructor.



Figure 208.3 Aquaculture farm hand



20. List possible job opportunities available in the field of marine science.
21. Name four government departments associated with ports and outline some of their responsibilities.
22. List some of the jobs available in ports and the qualifications needed for each.
23. What are the opportunities for marine employment in local government?

All the departments discussed here have a considerable support staff of managerial and clerical personnel who deal with all the administration. There are also a number of external agencies, such as private contractors who have direct roles such as tugboat owners and pilots and indirect roles (for example, vehicle servicing), other maintenance companies, manufacturers and retailers of a large range of marine safety equipment in major ports in marine administration.

## Key words

Attitude, apprentices, bachelor's degree, catering, certificate level, commercial fishing industry, competencies, core course elements, curators, coxswain, ecotourism, elective course element, front desk operations, industry partners, interpretive, logbook, managerial, marinas, marine engineer, multitasked, nationally recognised, occupational health and safety, sales assistants, shipwrights, shipmaster, skipper, stevedoring, structured work placements, tradespeople, trainers, volunteers, vocational education, work experience, workplace assessor.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Most research into what employers want from new employees reveals two essential elements — [1] \_\_\_ and good [2] \_\_\_.
- b. Training [3] \_\_\_ are then recorded in your training [4] \_\_\_.
- c. To prove you are qualified you can study to get a higher [5] \_\_\_ level in Marine Studies to become a coxswain and then a shipmaster. Some modern workplaces allow you to do training on the job where you learn and are [6] \_\_\_ by your workmates who train you to become better qualified.
- d. Courses in the maritime industry can be done through TAFE colleges, [7] \_\_\_, tertiary institutes or the Australian Maritime College (AMC)
- e. Marine tourist attractions employ many staff involved in [8] \_\_\_ work.
- f. The jobs in the manufacturing side of air tanks, buoyancy vests and regulators are filled by trades people such as [9] \_\_\_, [10] \_\_\_ and [11] \_\_\_.
- g. Boat and shipbuilders or [12] \_\_\_ specialise in certain materials in their construction processes. Most use only one or two materials. The jobs in this industry are mostly for [13] \_\_\_, [14] \_\_\_, [15] \_\_\_ and [16] \_\_\_.



**Web references**

[www.bom.gov.au](http://www.bom.gov.au), [www.csiro.gov.au](http://www.csiro.gov.au)

**See also**  
**El Niño Ch 24 -**  
**pages 271 - 272**

**Why study the weather?**

It is important to study the weather in marine studies because

- all Australian state boating safety instructions advise people to check the weather map before going boating;
- tourism operators need to be aware of the weather on an hourly basis; and
- people who live in coastal communities need to be aware of severe coastal storms (Figure 209.2) and cyclones (Figure 209.4) which can cause havoc with essential electricity, water supplies, sewerage and on the roads.

For example, the sailor in Figure 209.3 needs to carefully plan what he will do in the next 10 minutes. The dark cloud behind him is an approaching front and could contain high winds and rain. On the other hand, it may just bring fine mist and cooler air. Beach attendants at the resort will need to think about how they may have to secure gear on the beach and people under umbrellas may be thinking about moving inside.

With more and more people living near the coast, it is important to understand how storm surges, coastal fires, storms and cyclones affect the safety of coastal communities.

**Severe Tropical Cyclone Yasi\***

Severe Category 5 Tropical Cyclone Yasi made landfall on the tropical Queensland coast on February 2011. A minimum pressure of 929 hPa was recorded with wind gusts of about 285 km/h. All residents in the path were evacuated to shopping centres and cyclone shelters causing major disruptions to their normal way of life.

- The largest rainfall totals were near and to the south of the cyclone and were generally in the order of 200-300mm in the 24 hours to 9am Thursday.
- A 5 metre tidal surge was observed at the storm tide gauge at Cardwell, which is 2.3 metres above Highest Astronomical Tide (HAT).

*\*Yasi was one of the most powerful cyclones to have affected Queensland since records commenced.*



Figure 209.1 BOM web site

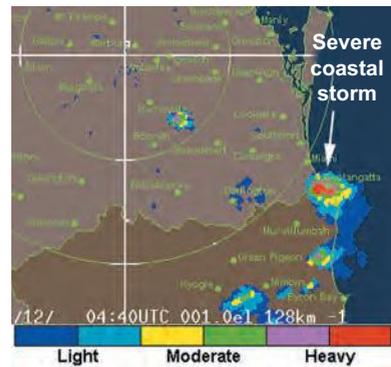


Figure 209.2 Weather radar



Figure 209.3 An approaching front

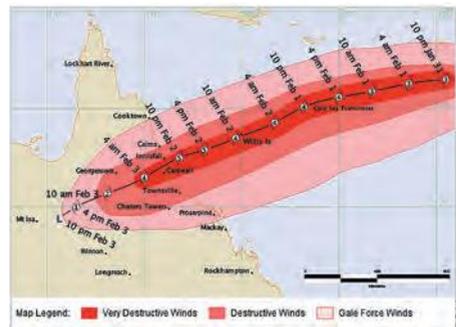


Figure 209.4 BOM track of Cyclone Yasi



Figure 210.1 Poor snorkelling conditions



Figure 210.2 Don't play on flooded fields with body boards.

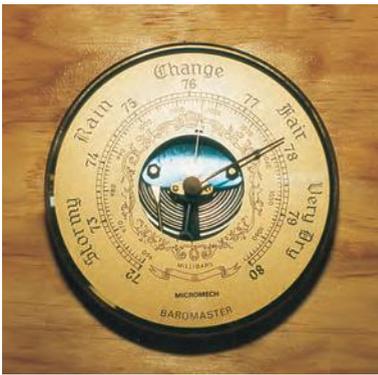


Figure 210.3 Aneroid barometer



Figure 210.4 Internet weather site

Here are some examples.

- After heavy rain and wind it is pointless planning a snorkelling trip because the water will be too dirty.
- If strong winds are forecast it may be better to postpone a whale watching trip till the seas subside.
- Camping on the coast is affected by hot dry coastal conditions in summer.
- Surf is better with offshore conditions.
- Cyclone warnings need to be obeyed.
- After heavy quick rain you should avoid playing near stormwater drains or you may get sucked into one.
- Storm surges occur with low pressure systems near the coastline and cause flooding to low level areas with salt water. This can affect the brakes in a car.

### Essential weather skills

It is not only important for everyone involved with coast and marine studies to know how to read and interpret a weather map or forecast, but also relate the forecast to planned activities. Let us now examine some of the factors that affect our weather.

## Air pressure

Air **pressure** or atmospheric pressure is the force of the Earth's atmosphere. It varies with temperature and weather. Warm air expands and rises, becomes lighter and therefore exerts less pressure.

Cold air is heavier, falls and exerts more pressure. Rapid changes in pressure produce equally rapid changes in weather: decreasing pressure is associated with wet, stormy conditions and increasing pressure with warm, fine conditions.

Air pressure, measured in **hectopascals** (hPa), can be measured by an aneroid barometer (see Figure 210.3), which connects a vacuum-filled box with a pointer (see Figure 210.5). A small change in pressure causes the box to expand or contract, moving the pointer as shown.

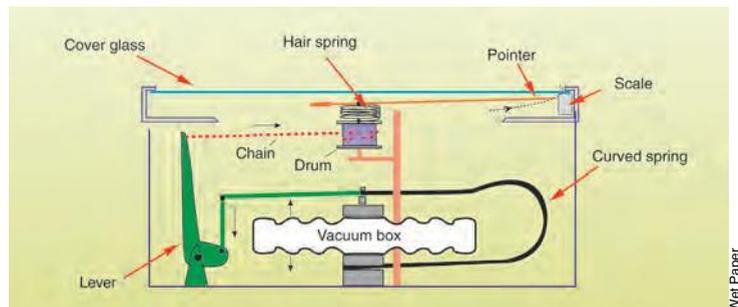


Figure 210.5 How a barometer works (Illustration Bruce Heyer)

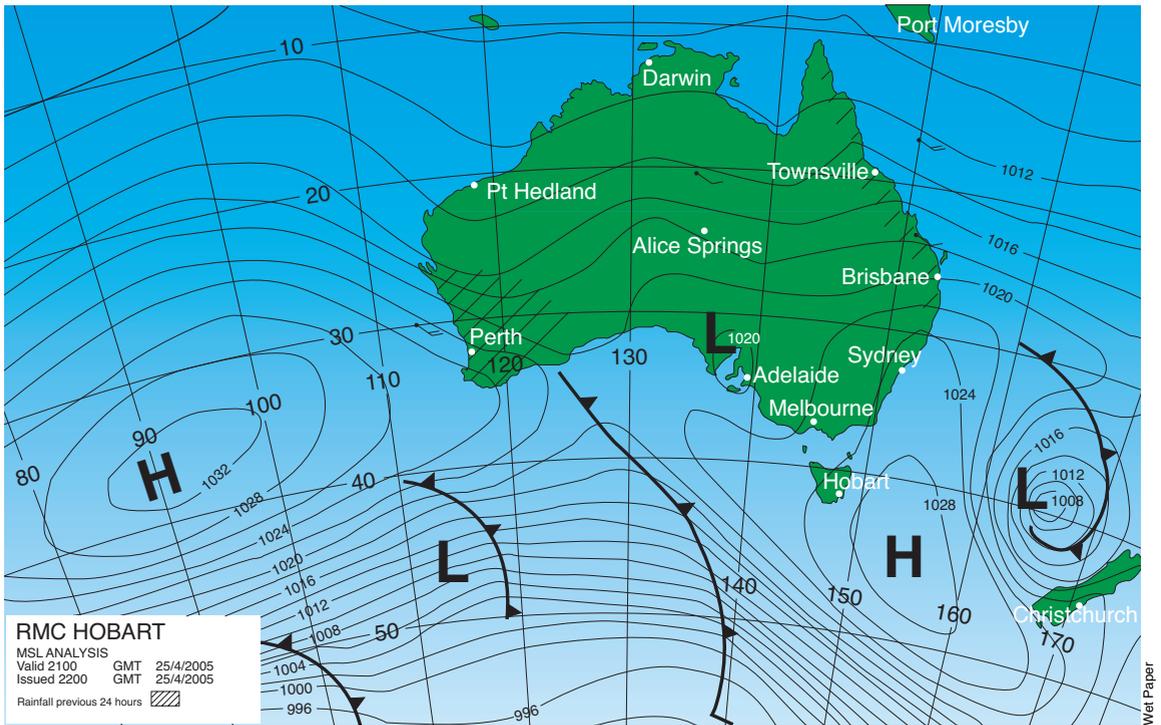


Figure 211.1 A weather map

Look at Figure 211.1. The lines connecting places of equal air pressure are called isobars. Low pressure areas (L) are called lows and high pressure areas (H) are called highs. The lines are drawn closer together to show steeper changes in air pressure.

**Fronts**

Differences in temperature and pressure, along with the Earth’s rotation on its axis, cause the air to move over the Earth’s surface in large volumes called air masses. When air masses of different temperatures meet, they produce either warm or cold fronts. Most changes in our weather occur at these fronts.

**Cold fronts** (see Figure 211.2) occur when a cold air mass moves into and under a warmer air mass, usually producing colder and unsettled, sometimes stormy weather. When the front passes, we get colder, clearer weather. **Warm fronts** occur when a warm air mass moves in and over a cold air mass, usually producing cloudy wet weather followed by warmer, clear conditions when it passes. Warm fronts are shown on weather maps by the symbol in Figure 211.3.

Although warm fronts do occur in Australia from time to time, they are rare. Fronts very rarely occur in Northern Australia, but control daily activities in Melbourne, Adelaide, Christchurch and Auckland where they are very common.

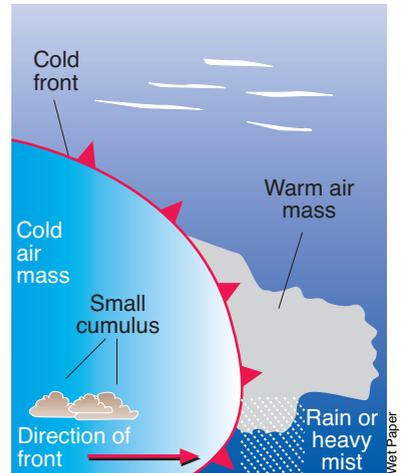


Figure 211.2 A cold front

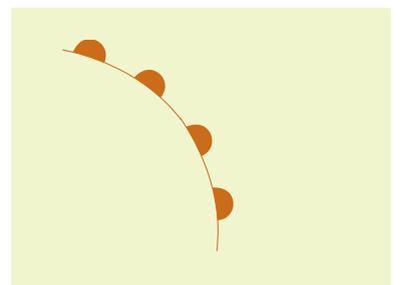


Figure 211.3 Warm front symbol



1. Describe three ways the weather has affected you so far today.
2. Explain why people should not ride body boards on flooded fields.
3. Why wouldn't you hold a thermometer by the bulb to measure the temperature of the air?
4. Why is it necessary to return the metal pins to the top of the liquid after reading a maximum and minimum thermometer?
5. How do winter surfers and divers combat the cold of ocean waters?
6. Give three reasons why the study of weather is important in a marine studies course.
7. Explain how lows and highs in air pressure are produced.
8. A marine scientist observes a reading of 950 hectopascals 1 hour after a previous reading of 1075 hectopascals on your small boat's barometer while working 5 kilometres from shore. What would this indicate about the weather and what action would you take?
9. Explain the difference between cold and warm fronts.
10. What weather conditions usually follow a cold front?



Surfers like offshore conditions  
Kaleb Smith

## Winds

Winds are important because they:

- form waves, as you will learn later in Chapter 23;
- control the size and direction of ocean swells;
- influence the speed and direction of currents; and
- determine our safety and comfort in the marine environment.

Winds are produced by differences in air pressure and density. Air will always move from a high pressure area to a low pressure area and the greater the pressure difference, the stronger the wind.

Sailboarders and surfers often talk about offshore and onshore winds because they affect surf conditions. Sailboarders prefer strong onshore winds or sea breezes and surfers prefer gentle offshore winds or land breezes.

### Offshore and onshore conditions

Land heats up and cools down much faster than water, creating pressure differences and wind as shown in Figure 212.1.

In the morning when the temperature of the sea is higher than the land, there is lower pressure over the sea than the land. Cooler air from the land replaces it, creating an offshore breeze.

In the afternoon, when the temperature of the land is higher than the water, warm air rises to create a lower pressure region. Cooler air from the higher pressure region at sea then moves in to replace it, creating the sea or onshore breeze.

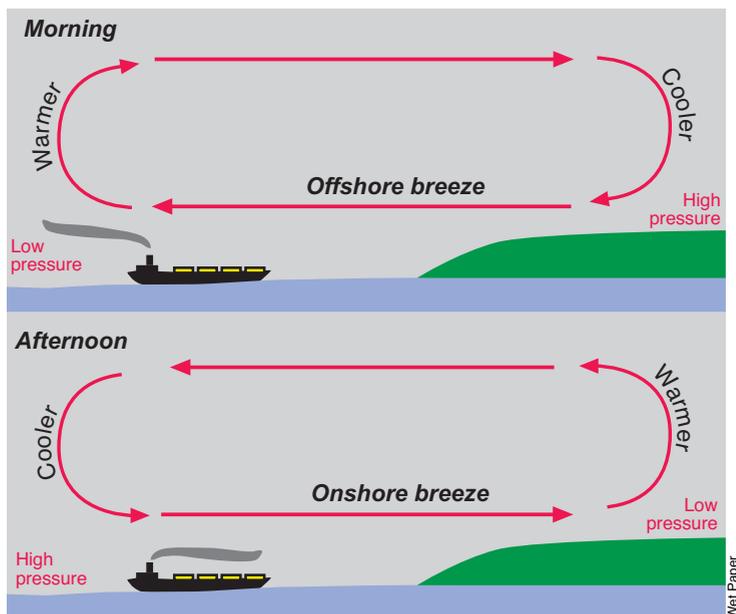


Figure 212.1 Land and sea breezes

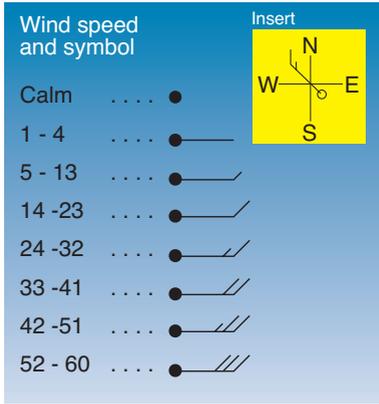


Figure 213.1 The insert shows a wind of 15 km/hr from the north-west.



Figure 213.2 Simple anemometer



Figure 213.3 Be aware of coastal fires

### Wind symbols

Weather maps show both wind speed and wind direction with the symbols shown in Figure 213.1. The angle of the tail shows wind direction and wind speed is shown by the tail strokes.

## Temperature

**Temperature**, measured in degrees **Celsius** ( $^{\circ}\text{C}$ ), is how hot or cold a substance is. We measure temperature with a **mercury** thermometer as shown in Figure 213.4. As the temperature increases, the mercury in the bulb expands and moves up the tube. As the temperature drops, so does the mercury. The bulb of the **thermometer** is placed in or on the substance being measured. Weather reports often give daily maximum and minimum temperatures, which are measured with the special thermometer shown in Figure 213.4 left. The pins are pushed by the mercury but stay in position when the mercury recedes.

### Coastal fires

As temperature rises in summer the risk of fires on the coast increases (Figure 213.3). Coupled with strong winds, huge coastal fires have killed Australians in the past.

## Weather forecasting

Data records of these five major weather factors are sent every day to the Bureau of Meteorology in major cities from hundreds of weather recording stations from all over country and the world. Some of the stations are manned by amateurs, some by professional scientists called **meteorologists** and some stations are unmanned. The unmanned stations rely upon automatic recording instruments. Data is also collected from radar and satellites orbiting the Earth.

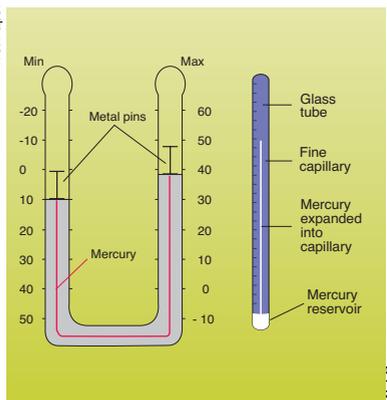


Figure 213.4 Types of thermometer

### Questions

Use your textbook to find the answers

11. Explain how winds are formed and draw a diagram to show the difference between land breezes and sea breezes.
12. Distinguish between three effects of winds.
13. What is the wind speed and direction shown on the weather map in Figure 211.1 off Townsville?
14. Explain how past predictions of weather were made.
15. What are cyclones and why are they dangerous?
16. Draw a diagram to show the difference between offshore and onshore conditions.



Figure 214.1 Cyclone damage Dunk Island from the "eye" of Yasi

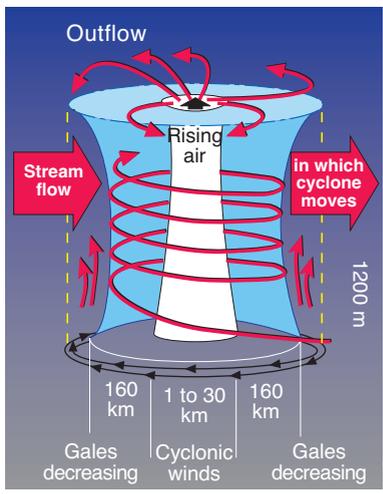


Figure 214.2 Cyclone

## Diving deeper



1. Explain why high humidity makes us sweat more and tire faster. (Hint: water evaporation is reduced when the humidity is high.)
2. Find out what instruments are in a weather station. Set one up in your school grounds and link data to classroom computers.
3. Find out how to protect coastal homes from fires, storms and cyclones - make a poster or a press release.

## Forecasting technology

Knowing weather conditions in advance is important to everyone using the sea. Professional fishers, for example, rely each day on accurate predictions of approaching wind and swell conditions at sea. This information could determine when and where to fish, or in fact whether to go at all if a storm is on the way. Three main advances in technology have improved weather forecasting today.

- Satellites containing infra-red cameras, which can take photos at night, constantly orbit the Earth and provide a continuous record of cloud cover.
- Weather balloons, containing instruments to measure temperature, pressure and humidity, are released from stations as far away as the South Pole. They can transmit this data to warn of approaching fronts.
- Radar, which can detect and accurately track the speed and direction of cyclones and storms, provides us with advance warning as to where and when they will strike.

## Weather reports

Bureau of Meteorology weather reports in Australia include storm warnings, coastal weather forecasts on the radio, recorded boating weather reports; and weather reports on the radio, the television and in newspapers. The **internet** is now playing a vital role in providing weather information.

In tropical regions, cyclones are complex low pressure systems which can cause damage to coastal towns (Figure 214.1). The cyclone has a central low pressure area with rising air as shown in Figure 214.2. The centre can be up to 30 kilometres across where destructive cyclonic winds can occur. However at the very centre, there is no wind; this is called the 'eye' of the cyclone. At distances of 30–180 kilometres from the eye, gale force winds occur and are very dangerous to mariners and people living on the coast.

## Storm surges

Heavy rain and tidal surges (Figure 214.3) can cause flooding with salt water in coastal towns and corrode car breaking systems.



Figure 214.3 A storm surge  
(After Bureau of meteorology web site [www.bom.gov.au](http://www.bom.gov.au))

# Key words

Anemometer, celsius, cold fronts, cyclones, hectopascals, internet, mercury, meteorologists, pressure, temperature, thermometer, warm or cold fronts, weather lore, weather vane.

# Summary questions

Fill in the gaps in these sentences. The missing words can all be found in the chapter.

- a. [1] \_\_\_\_\_ fronts occur when a cold air mass moves into and under a warmer air mass, usually producing colder and [2] \_\_\_\_\_, sometimes stormy weather.

When the front passes, we get colder, clearer weather.

Warm fronts occur when a warm air mass moves in and over a cold air mass, usually producing cloudy wet [3] \_\_\_\_\_ followed by warmer, clear conditions when it passes.

- b. Air pressure or atmospheric pressure is the force of the Earth's [4] \_\_\_\_\_.
- c. Differences in [5] \_\_\_\_\_, along with the Earth's rotation on its axis, cause the air to move over the Earth's surface in large volumes called [6] \_\_\_\_\_ masses.
- d. Sailboarders and surfers often talk about [7] \_\_\_\_\_ winds because they affect surf conditions. [8] \_\_\_\_\_ prefer strong onshore winds or sea breezes and [9] \_\_\_\_\_ prefer gentle offshore winds or land breezes.
- e. An [10] \_\_\_\_\_ can be used to measure wind speed and a weather [11] \_\_\_\_\_ is used to measure wind direction.
- f. Data records of these five major weather factors are sent every day to the [12] \_\_\_\_\_ in major cities from hundreds of weather recording stations from all over the world.
- g. Official Bureau of Meteorology weather reports include [13] \_\_\_\_\_ warnings; coastal weather [14] \_\_\_\_\_ on the radio; recorded [15] \_\_\_\_\_ weather reports; and weather reports on the radio, the television and in newspapers.
- h. Cyclones occur in [16] \_\_\_\_\_ regions. A cyclone is a complex [17] \_\_\_\_\_ pressure system which can cause great damage to coastal towns.

The cyclone has a central low pressure area with rising air as shown in Figure \_\_\_\_\_.



Figure 215.1 A school weather station

23. From the weather map in Figure 211.1:

- a. state the wind speed and direction for Perth;
- b. state the air pressure in Sydney;
- c. state what pressure systems are over Adelaide, Hobart and Christchurch, NZ;
- d. describe the general weather conditions for Perth, Darwin, Sydney and Brisbane;
- e. state the wind speed and predicted weather for the South Island of New Zealand;
- f. state where most rain was likely to fall;
- g. write weather forecasts for Mackay and Sydney;
- h. predict a weather forecast for Hobart in 2 days time.



**Web references**  
 (see also page 219)  
[www.marine.csiro.au](http://www.marine.csiro.au), [www.ga.gov.au](http://www.ga.gov.au)  
[www.cmar.csiro.au/remotesensing/oceancurrents](http://www.cmar.csiro.au/remotesensing/oceancurrents)



Figure 216.1 Planet Ocean  
 (Source GBRMPA - reproduced with permission)

From space, Earth appears as a blue planet (because so much of it is covered by water) and could be called ‘Planet Ocean’. However scientists know more about the surface of the moon than the ocean. For example, we have been recording land temperatures for over 200 years, but only in the late 1950s were ocean temperatures first recorded in an organised manner.

Knowing about the oceans and their resources and origins, and how they interact with the atmosphere, will help us make wise decisions about how we use our planet.

Australia's **Exclusive Economic Zone (EEZ)** was declared in 1994 with a further 2.5 million sq kilometres of sea bed ratified in April 2008 and with over 13.5 million square kilometres, is now one the largest EEZs in the world. Figure 216.2 shows that the sea area around Australia is much larger than the land area.

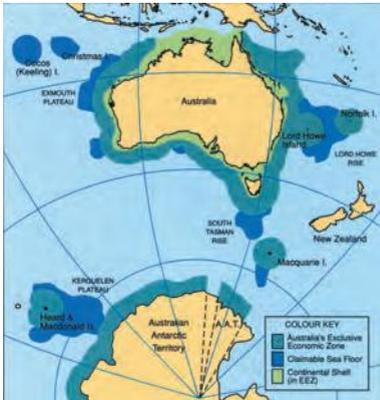


Figure 216.2 Australia's sea area is much larger than its land area.  
 (Source SOMER report - reproduced with permission)

## Facts about the oceans

The oceans of the world cover 71% of the Earth's surface. The five major oceans are the Pacific (the largest and deepest), Atlantic, Indian, Arctic and Southern (Figure 216.3). These major oceans cover 362 million square kilometres and make up nearly 66% of the Earth's water. They are linked by bodies of water called **seas** and **straits**. Seas are small areas of salty water partially enclosed by land. Straits are narrow bodies of water connecting large water masses.



Figure 216.4 You can read more about Australian Oceans at:  
[www.oceans.gov.au](http://www.oceans.gov.au)

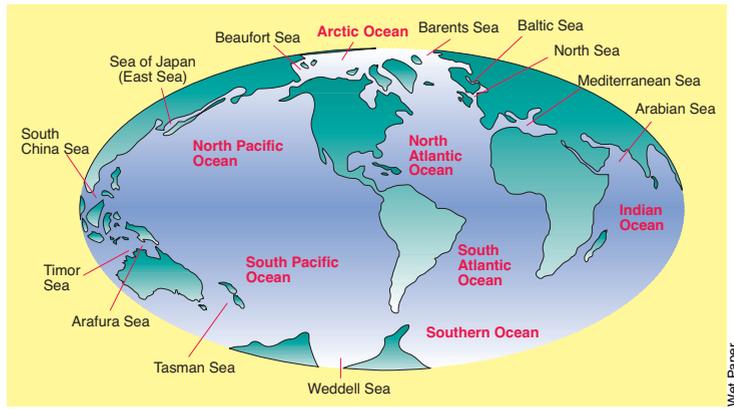


Figure 216.3 Where the world's oceans and seas are.  
 Note the Sea of Japan is now also called the East Sea

Other large masses include **gulfs** (long, narrow indentations or inlets extending far inland) and **bays** (wide indentations into a coastline). If you have an atlas you can locate three major seas, three major bays, three gulfs and three straits on the Australian and New Zealand coastlines.

The sea may occupy a much larger volume of water compared to land, but of all the water on the Earth, over 65% is oceanic - only 1% is available to drink (Figure 217.1).

## Oceanography

Oceanographers are scientists who study the oceans.

Only in the 20th century has the technology been developed to study the ocean and its depths. However, the enormous volumes and the depths of the oceans make oceanography a great challenge.

The study of the oceans involves four main branches.

- Physical **oceanography** is the study of the ocean buoyancy, temperature, the circulation of oceanic water and light penetration. Physical oceanographers are very interested in the effects the depletion of ozone in the atmosphere has on the oceans as well as on ocean currents.
- Geological oceanography is the study of the ocean floor, features of the ocean depths and coastal features. Figure 217.2 shows an offshore oil rig that relies on the data geological oceanographers relay to drilling engineers.

Geoscience Australia is responsible for monitoring earthquakes, mapping the ocean floor and preparing maps and has a great web site at:

[www.csiro.gov.au](http://www.csiro.gov.au) and follow the links to the marine division

- Biological oceanography is the study of marine plants and animals. The students in Figure 217.3 have just hauled up a sample from the ocean floor and will now identify what lives on the seabed in their area.
- Chemical oceanography is the study of the chemical composition of the oceans, salinity and the amount of dissolved gases in the oceans. The marine scientists in Figure 217.4 are about to launch a series of water collection bottles which will collect water samples from a number of depths.

## Formation

The most popular theories explaining the formation of the Earth about four to five thousand million years ago, indicate it was formed as a hot planet. The molten mass of the planet eventually cooled to form heights and basins which became the continents and the oceans.

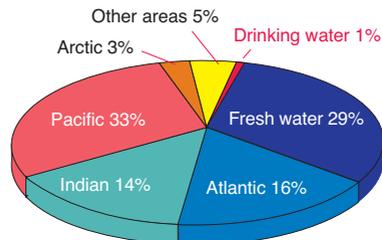


Figure 217.1 How much of the Earth's surface is ocean?  
Wet Paper



Figure 217.2 Geological oceanographers work on offshore oil rigs.  
CSIRO



Figure 217.3 Sampling bottom-dwelling animals: biological oceanography  
Wet Paper



Figure 217.4 Chemical oceanographers at work  
CSIRO



Figure 218.1 Water is added to the Earth by volcano activity.

Many **geologists** believe that volcanic activity gradually released **water vapour** into the **atmosphere** as shown in Figure 218.1. This water was originally chemically combined in the rocks and the chemical bonds were broken by the heat, releasing the water into the atmosphere. This formed a mass of clouds around the Earth many metres thick. After millions of years, the Earth lost its heat into space. As the Earth cooled, the water vapour condensed to form rain. The Earth's surface cooled even more, causing a hard layer or crust to be formed on the outside. It must have rained for hundreds of thousands of years for the oceans to gradually fill.

Ocean	Area millions of km <sup>2</sup>	Volume millions of km <sup>3</sup>	Mean depth m
Pacific	181 344	714 410	3940
Atlantic	94 314	337 210	3575
Indian	74 118	284 608	3840
Arctic	12 257	13 702	1117

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Figure 218.2 The areas, volumes and mean depths of the oceans

## Depth

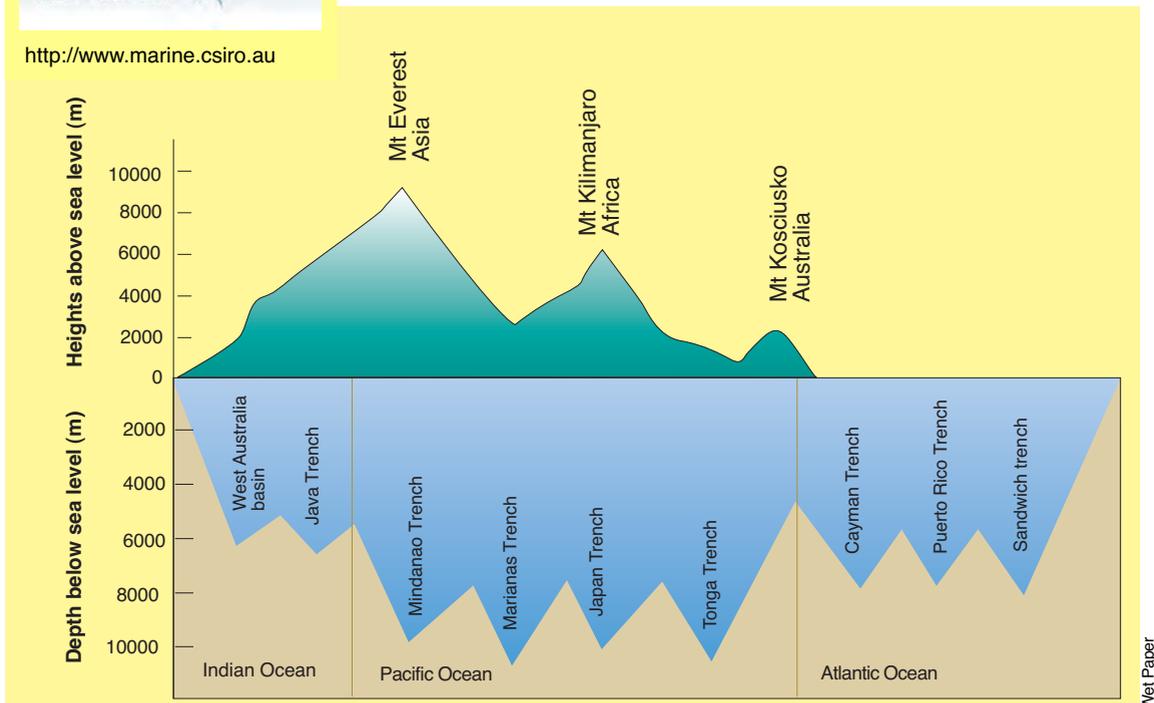
Figure 218.2 shows the mean (average) depths of the oceans. The mean depth of all the oceans is 3118 metres but the deepest part, the Marianas Trench in the Pacific Ocean, is 11 038 metres deep. Figure 218.3 shows this trench dips further below sea level than Mt Everest reaches above.

## Water level

The oceans are always losing and gaining water in a cyclical process called the **hydrological cycle** or water cycle. Figure 219.1 shows how the Sun provides the energy to convert water molecules from a liquid state to a vapour. Oceans, lakes and rivers lose water by this process which is called **evaporation**.



<http://www.marine.csiro.au>



West Paper

Figure 218.3 Comparison of mountain height to oceanic canyon depth

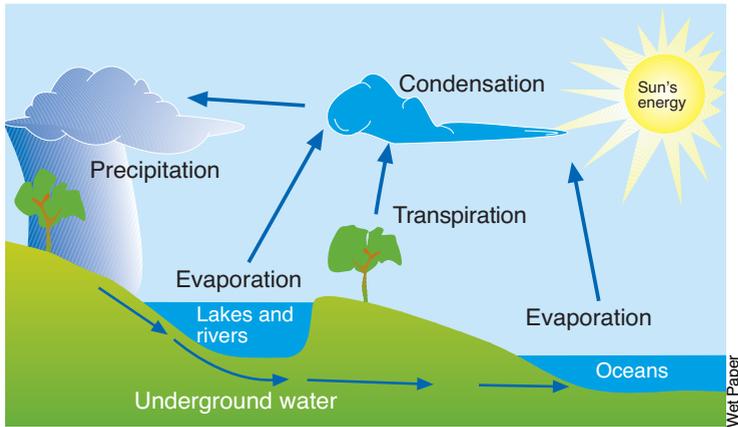


Figure 219.1 The water cycle

The water vapour forms clouds which are then moved through the Earth's atmosphere by winds. If the air cools, the water vapour converts back to a liquid and this falls as rain, hail or snow (**precipitation**).

If this precipitation occurs over the land, this water is not lost to the oceans but flows back to the ocean in rivers and underground streams. As long as the water cycle remains undisturbed, the volume of water should remain constant in the oceans.

## Climate change

### Greenhouse gases

Greenhouse gases are a natural part of the atmosphere. They absorb and re-radiate the Sun's warmth, and maintain the Earth's surface temperature at a level necessary to support life.

The problem we now face is that human actions- particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing- are increasing the concentrations of the gases that trap heat. This is the enhanced greenhouse effect, which is contributing to a warming of the Earth's surface (Figure 219.2).

Water vapour is the most abundant greenhouse gas. Its concentration is highly variable and human activities have little direct impact on its amount in the atmosphere. Humans have most impact on carbon dioxide, methane and nitrous oxide. Various artificial chemicals such as halocarbons also make a small contribution to the enhanced greenhouse effect.

In addition to warming of the Earth's surface, there has been an increase in heatwaves, warming of the lower atmosphere and deep oceans, fewer frosts, retreat of glaciers and sea ice and a rise in sea level during the 20th century of about 17 cm.

**Questions**  
Use your textbook to find the answers

1. How much of the Earth's surface is covered by the oceans?
2. Name the four major oceans. What percentage of the Earth's water is found in each of the oceans?
3. Draw a diagram to compare the height of mountains to the depth of ocean trenches.
4. Write a paragraph describing the effects of greenhouse gases on climate change.

**Some climate change web sites**

<http://epa.gov/climatechange/kids>  
<http://royalsociety.org>  
[www.environment.gov.au/education](http://www.environment.gov.au/education)  
[www.bom.gov.au](http://www.bom.gov.au)  
[www.csiro.gov.au](http://www.csiro.gov.au)  
[www.gbrmpa.gov.au](http://www.gbrmpa.gov.au)

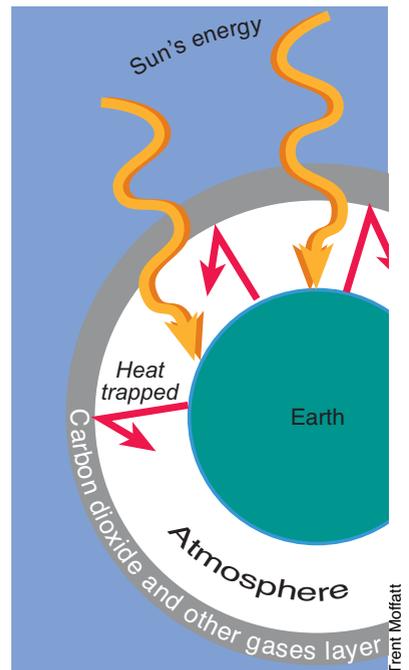


Figure 219.2 The greenhouse effect

Many species of plants and animals have changed their location or the timing of seasonal activities in ways that provide further evidence of climate change. This change in timing in seasons may be a precursor to localised extinctions for some species

## Climate change

During the past 100 years, global average surface temperature increased by about 0.7°C, (Figure 220.1). Tree rings and other records tell us that average Northern Hemisphere temperatures during the second half of the 20th century were likely to have been the highest in at least the past 1300 years.

The Intergovernmental Panel on Climate Change - an international body that assesses the latest science of climate change - has stated that *"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."*

### How much warming is likely this century?

As the Earth's surface warms, the oceans slowly absorb heat and expand, causing the sea level to rise (see Figure 220.3). This **thermal expansion** of the ocean will be a major contributor to sea level rise during future centuries.

### Ocean acidification

Carbon dioxide emitted to the atmosphere by human activities is being absorbed by the oceans, making them more acidic.



Evidence indicates that emissions of carbon dioxide from human activities over the past 200 years have already led to a reduction in the average pH of surface seawater of 0.1 units and could fall by 0.5 units by the year 2100. This pH is probably lower than has been experienced for hundreds of millennia and, critically, at a rate of change probably 100 times greater than at any time over this period.

Impacts on oceans will be greater for some regions and ecosystems, and will be most severe for coral reefs and the Southern Ocean.

The impacts of **ocean acidification** on other marine organisms and ecosystems are much less certain. You can follow recent research by typing ocean acidification into your web search engine.

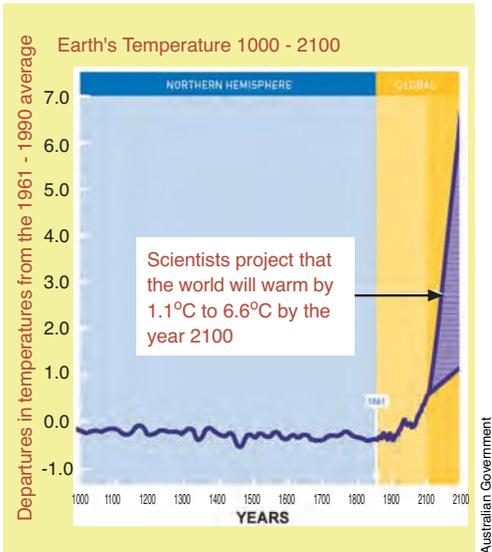


Figure 220.1 Earth's surface temperature has increased since the mid 19th century.

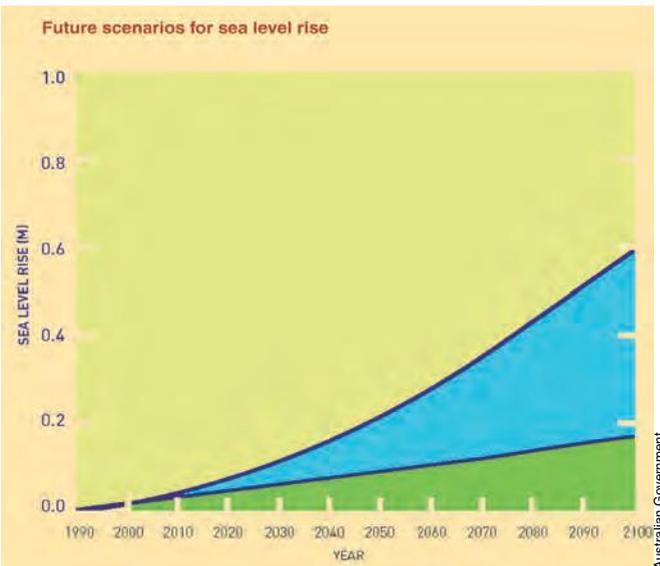


Figure 220.2 Scientists estimate that sea levels will rise between 18 and 59 cm by the year 2100 as oceans expand and glaciers melt.

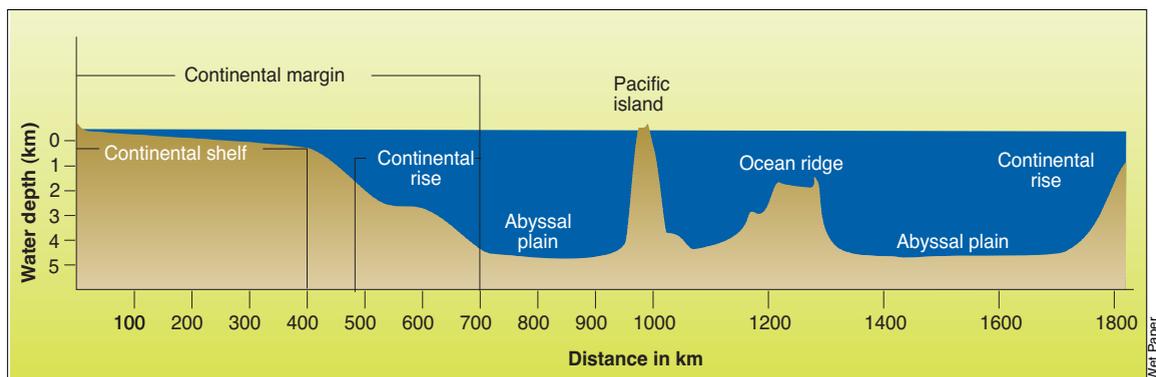


Figure 221.1 Ocean topography

## Ocean shape

Scientists have only in the last 20 years gained a good understanding of the ocean floor.

All oceans have shallow places and deep places with the occasional island on top of an undersea mountain as shown in Figure 221.1. The shallow places are around the continents and ocean ridges. These areas are built up from sediments from rivers and creeks. The oceans get deeper as we move off the continental slope and continental rise.

The deep ocean basin floor makes up 70% of the ocean floor and 50% of the Earth's surface. Most of this area is extremely flat and is called the **abyssal** plain. The mid-ocean ridges, mountain chains up to 1000 kilometres wide, have only been discovered in the last 40 years. Ocean trenches also occur in this area.

## Why is the ocean salty?

*Ref: Chapter 6 Sea water*

Have you ever accidentally swallowed sea water and noticed how salty it tastes? Where does this salt come from? For millions of years, precipitation has been completing the water cycle. The water falling on land dissolves the salt and minerals found in rocks and washes it out to sea.

The main mineral dissolved is sodium chloride or common salt. All salts found in the sea are listed in Figure 221.2 and in Chapter 6 you learnt that this was ocean **salinity**.

When the water again evaporates from the ocean to continue the water cycle, the salts are left behind in the oceans, making the remaining water salty.

Geochemists who study the chemistry of the Earth and the oceans calculate that the salt contained in one litre of sea water

Name	Formula
Sodium chloride	NaCl
Magnesium chloride	MgCl <sub>2</sub>
Magnesium sulphate	MgSO <sub>4</sub>
Calcium chloride	CaCl <sub>2</sub>
Potassium chloride	KCl
Calcium carbonate	CaCO <sub>3</sub>
Magnesium bromide	MgBr
Sodium sulphate	Na <sub>2</sub> SO <sub>4</sub>

Figure 221.2 Sea salts and their chemical formulas



Figure 221.3 Mining salt at Bowen, Queensland





5. Oceanography is the study of the oceans. Name its four branches and explain what is studied in each branch.
6. Draw a fully labelled diagram of the hydrological water cycle.
7. Define these terms:
  - a. precipitation
  - b. condensation
  - c. transpiration
  - d. greenhouse effect
8. Why is the greenhouse effect so called? Which gases cause the greenhouse effect?
9. Chlorofluorocarbons are found in what types of products? Suggest some ways to avoid using them.
10. Draw a diagram of the ocean shapes showing the following:
  - continental shelf
  - continental rise
  - abyssal plain
  - ocean ridges
11. How much of the Earth's surface is made up of the ocean basin floor?
12. How do salts get into the oceans?
13. Why are some seas more salty than others?
14. What are *nodules* and what minerals are found in them?
15. How many grams of rock have been weathered to make up a litre of salt water?
16. What is the EEZ and how important is it to Australia?



would have been extracted by weathering of 600 grams of rock and dissolving all soluble parts. Substances such as boron, sulphur and chlorine probably dissolved directly into the water.

## Mining ocean resources

People have been getting salt from the sea for thousands of years. If we extracted all the salt available in the oceans, it would cover the land to a depth of 150 m. Our salt is still produced as it has always been, by filling shallow pools called salt pans with sea water and allowing it to evaporate so that the salt is left behind. We also extract salt by mining it from dry seabeds.

We mine other elements from the ocean, too. Marine mining was first developed on the shallow continental shelf using mostly dredge mines to search for diamonds or precious ores. In many countries, most dredging operations are done in gravel sand but coral sand is also mined for titanium and other minerals.

Some countries are now mining mineral nodules found on the deep ocean floor. These nodules are rich in magnesium, copper nickel and cobalt.

Other mining operations search for oil and gas. A large percentage of our petroleum and gas now comes from oil fields under the oceans. Timor Sea gas fields will be worth billions of dollars to East Timor and Australia in future years. (See Chapter 16).



Figure 222.1 Loading a gas tanker

# Trace elements

The 11 elements shown in Figure 223.1 make up 99.9% of the total mass of elements dissolved in the oceans. There are 92 naturally occurring elements found on earth and 80 of these have been detected in sea water. These elements are found in minute amounts and are called trace elements. Gold is even found dissolved in the oceans and most people are unaware that gold will dissolve in water because of its very low dissolving rate.

## The importance of trace elements

Trace elements are very important to organisms living in the oceans. Few can survive for long in artificial sea water that does not contain trace elements. We don't know much about the role of these trace elements in many cases but phytoplankton (diatoms) need silicon and marine plants need manganese, zinc, iron and copper.

Many marine algae and some fish have very high concentrations of these trace elements in their bodies because they are able to extract them from the ocean in a process called bio-accumulation. Oysters concentrate zinc in their tissues and lobsters concentrate copper in theirs.

Bio-accumulation can create health problems. People living in a small Japanese coastal village called Minamata were devastated by mercury poisoning in the late 1970s when pollution from local industry entered the local seafood. The oysters the villagers ate had accumulated high levels of mercury in their tissues, which then affected the humans.

# Monitoring the oceans

## Remote sensing

Satellite remote sensing involves gathering information about features on the Earth's surface from orbiting satellites. Buoys are positioned beneath the surface of the water and their position can be fixed by satellite at least once each day.

This position can be radioed back to an oceanographer who then uses a computer to plot their movements. Satellites can also send back infra-red images to Earth of the ocean surface temperatures. The movements of the currents can be detected using these images. A current transports water of a given temperature into areas which have a different water temperature. The different water temperatures show up as different colours in the image (see Figure 224.1 over).



Element	t/million/t of sea water
Chlorine	19 215
Sodium	10 680
Magnesium	1 290
Sulphur	895
Calcium	410
Potassium	385
Bromine	65
Carbon	28
Strontium	8
Boron	5
Fluorine	2

After Lemman

Figure 223.1 Elements from the sea

## Diving deeper



1. Research one of the following topics and prepare an oral report:
  - a. the development of oceanography
  - b. the detection and prediction of earthquakes
  - c. the removal of minerals from the oceans
  - d. the different ways in which people use and abuse our oceans
  - f. climate change and sea levels
2. Surf the mining company web pages by typing 'petroleum' into your favourite search engine. Find out how much oil and gas reserves Australia has and where these are located.
3. In Figure 220.2 on sea level rise, the numbers presented are based on thermal expansion alone. The IPCC has not included estimated inputs from glaciers and the melting of the Greenland and Antarctic icesheets. Find out how much further the sea levels could rise.

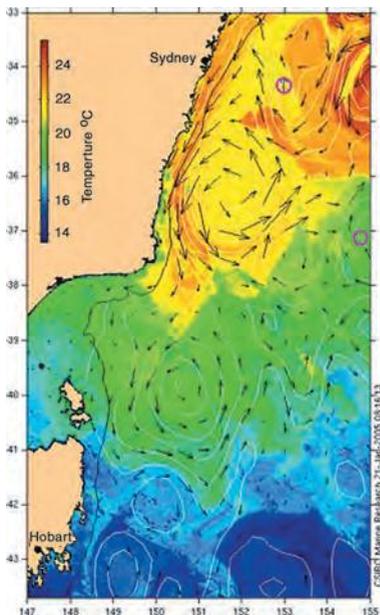


Figure 224.1 Satellite image of sea temperatures  
Courtesy CSIRO marine

By filtering the light images from Earth, the satellites can also detect the amount of chlorophyll in the water, thus checking the distribution of phytoplankton (the plants of the ocean). Since phytoplankton are the food of the smaller fish, who in turn are food for larger fish, their presence indicates good commercial fishing areas.

Another method of obtaining a picture of the Earth's surface is by using microwaves. The microwaves can penetrate clouds and can detect wind speeds, water vapour, rain, ice cover and the surface temperature of the water. Special pencil beam microwaves can even measure the roughness of the ocean (waves). This is so accurate we can measure the surface wake of large ships and submarines.

## Key words

Abyssal, atmosphere, chlorofluorocarbons, climate change, evaporation, geologists, greenhouse effect, gulfs, hydrological cycle, oceanography, ocean acidification, precipitation, seas, straits, water vapour.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

17. a. What are trace elements?  
b. What are the two most abundant elements in the sea?
  18. Many marine creatures have very high levels of trace elements in their bodies. Explain how they obtained these minerals.
  19. What is bio-accumulation and why is it a problem for humans who eat seafood?
  20. Describe two methods of obtaining energy from the sea.
  21. What information on the oceans can be obtained from satellites?
  22. Draw a bar graph of the data in Figure 223.1.
- a. Physical oceanography is the study of the oceans' [1] \_\_\_\_, [2] \_\_\_\_, the circulation of oceanic water and light penetration.
  - b. Many geologists believe that [3] \_\_\_\_ activity gradually released water vapour into the [4] \_\_\_\_.
  - c. The oceans are always losing and gaining water in a cyclical process called the [5] \_\_\_\_ cycle.
  - d. Oceans, lakes and rivers lose water by this process which is called [6] \_\_\_\_.
  - e. A build-up of [7] \_\_\_\_ \_\_\_\_, methane and other gases in the atmosphere is preventing the heat from the Earth escaping into [8] \_\_\_\_ . This is called the [9] \_\_\_\_ effect.
  - f. [10] \_\_\_\_ (CFCs) are synthetic chemical gases used in [11] \_\_\_\_, and refrigeration and air conditioning coolants. They are also used to produce [12] \_\_\_\_ \_\_\_\_ for such things as insulated food cartons.
  - g. Energy from the sea comes from [13] \_\_\_\_, tides and currents.
  - h. [14] \_\_\_\_ are providing scientists with new ways of measuring ocean currents.

# Chapter 20 Coastlines and marine life



Mike Sturgeon

Bob Moffatt

## Web references

[www.ga.gov.au/education/facts/dimensions](http://www.ga.gov.au/education/facts/dimensions), [www.wapc.wa.gov.au](http://www.wapc.wa.gov.au)  
[www.environment.gov.au/education](http://www.environment.gov.au/education), [www.epa.qld.gov.au](http://www.epa.qld.gov.au), [www.reefed.edu.au](http://www.reefed.edu.au)

Beaches in Queensland and New South Wales compared to the cliffs in Victoria and Western Australia, are made of completely different materials. The forces of very different geological history that shaped them are also worlds apart and as a result a completely different set of plants and animals will be found on these coastlines.

A knowledge of the composition and shape of our coastline allows us to appreciate what development can happen there, what life abounds, and how its basic structures need to be preserved. This knowledge also helps explain different marine life adaptations.

**Coastlines** are also an important part of our national heritage and so should be studied as part of any marine studies course.

Four types of coastlines are sandy, rocky, offshore island and reefs and this chapter looks at how these were formed and some of the animals and plants that live there. Wetlands are discussed in the next chapter.

## Importance

The coastline varies markedly from southern shores with high cliffs, large flat granite outcrops in Western Australia and sheltered headlands, wetlands and coastal estuaries in New South Wales.

What makes our coast such a special place? Possibly the sand, the clear water and the dune plants that provide cool spots to sit in the shade. For many of us, the coast is a refuge from the stresses of modern life; our earliest memories go back to days spent with a bucket and a spade or a body board.

As teenagers, you appreciate that relaxed lifestyle. Parents, appreciate that the beach is a great place for children to use up their energy. As you get older still, a beach, becomes a place for a quiet run or exercise or a place to unwind.

Coastlines have become national treasures to be preserved as they are, with no pollution and no hassles. It is up to us to keep them that way.



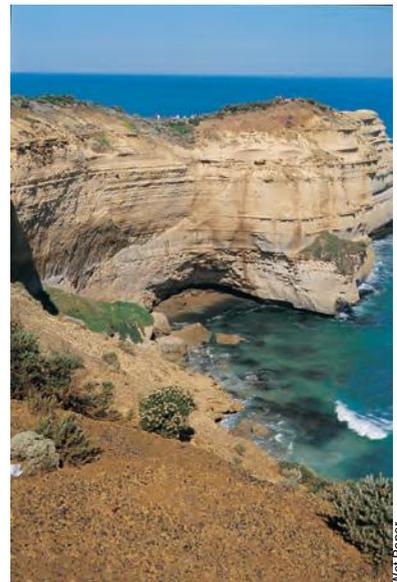
Wet Paper

Figure 225.1 East coast beach facing the Pacific Ocean



Bob Moffatt

Figure 225.2 Limestone coast WA



Wet Paper

Figure 225.3 Coastline facing the Southern Ocean



Figure 226.1 West coast beach facing the Indian Ocean



Figure 226.2 Sand dunes and golden sandy beaches



Figure 226.3 Coastal river mouth



Figure 226.4 Spinifex

## Forces that shape coastlines

The coastline is made of different compositions of mud, sand, coral and rock shaped by wind, waves and water.

**Wind** erodes the headlands and controls the plants that grow on them. For example, the coastal plants that grow on the windswept headland in Figure 226.1 are much smaller than those in the sand dunes in Figure 226.2. This is because the winds in Western Australia are generally stronger than those in New South Wales. **Waves** continually wash against coastlines, eroding the base of cliffs and moving rocks and sand along the coast. Sandstone headlands, like those shown in Figure 225.3, become very unstable because their foundations are constantly cut away by waves.

**Large river systems** deposit layers of mud and silt where they enter the sea. As the water slows it deposits soil it has brought down from higher levels. These layers encourage extensive mangrove swamps to develop like those around Darwin or in the Hinchinbrook Channel in north Queensland. Fast-flowing rivers turn eroded rocks into fine sand (Figure 226.3) because only the toughest sand grains such as quartz and felspar can remain.

## Sandy coastlines

The golden beaches are formed from **sedimentary** rocks that have been eroded by wave and wind action or ground into small pieces while rolling down the beds of fast-flowing rivers (Figure 226.3). When this sand dries on a beach, the wind blows it up to form sand dunes around trees and bushes. The size of the dunes depends on the speed of the wind - the stronger the wind the bigger the dune. The fine white sand of barrier reef beaches is made from coral pieces that have been ground up by wave action.

## Dune plants

The size and shape of sandy beaches varies between seasons. Generally, larger winter waves erode beaches and summer waves rebuild them. The dunes therefore provide a reserve of sand in winter and prevent sand blowing inland during summer.

In urban areas, **sand dunes** form between the road or buildings and the sea. Some people consider this a nuisance because the dunes block access to the beach and block out the view of the sea. Sand dunes protect land plants and animals by acting as a barrier to strong winds and reducing land erosion caused by large waves during storms.

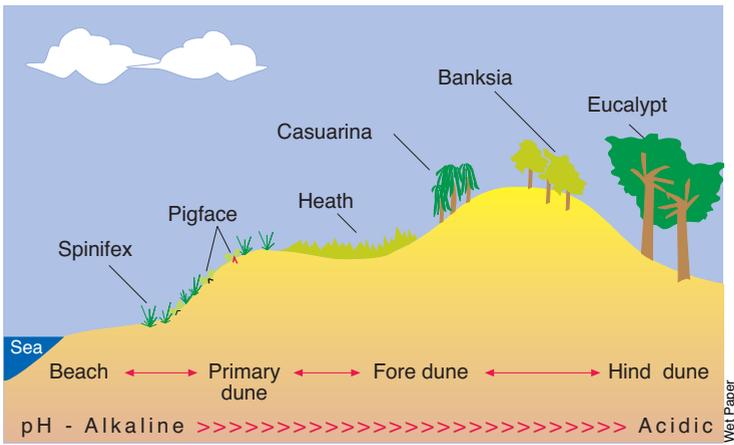


Figure 227.1 Plant succession on an ideal sand dune

### Succession

Dune plants in undisturbed areas vary in size and structure and certain plants are found in distinct **zones** from the beach to the back of the dune (hind dune). This zonation of plants is called a **succession** (Figure 227.1).

In a succession, small simple pioneer plants colonise a barren area, either bare rock or sand, and establish themselves by adapting to local conditions. In doing this, they improve the soil and prepare it for more complex plants to colonise the area, which in turn, prepare for the next group and so on, right up to large trees in a dense forest.

### Common dune plants

Close to the sea grows coastal spinifex (Figure 226.4), a simple salt-tolerant plant that colonises the bare sand near the beach. Spinifex has large, branched roots which bind the sand and restrict its movement.

Pigface (Figure 227.2) and other water-storing plants grow next inland in the primary dune where they improve the moisture content of the soil and send out runners to bind the sand.

Casuarina trees (Figure 227.4) protect the plants of the hind dune that are affected by salt by sieving out salt as it blows in from the sea. You can taste this salt if you lick the leaves of a casuarina tree. The casuarina tree roots have special features which improve the nitrate levels in the soil.

This improved soil encourages the establishment of the larger trees such as banksias (Figure 227.5), pandanas and then eucalypts in the hind dune.

As the nature of the soil changes from beach to hind dune, it alters in pH values from **alkaline** on the beach to **acidic** on the hind dune.

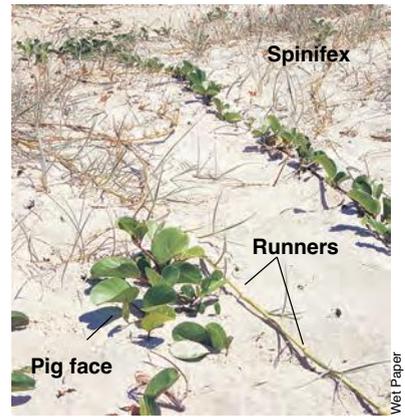


Figure 227.2 Pigface



Figure 227.3 Coastal heath



Figure 227.4 Casuarina tree

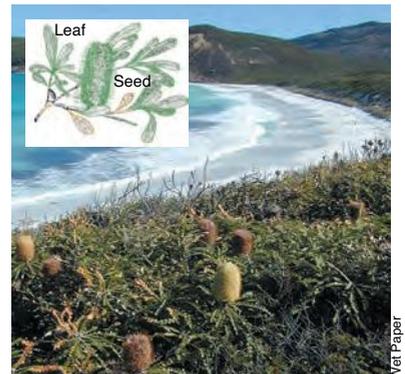


Figure 227.5 Banksia Esperance WA

# Rocky coastlines

## Life on a wave-cut platform

A wave-cut platform is formed over a long period of time as waves constantly erode a cliff face as shown in Figures 228.2 and 228.4. The wave-cut platform can be divided up into a number of zones, three of which are described below.

- The **supra-littoral** or splash zone is above the high tide mark. It only gets wet when spring tides combine with large ocean swells. Simple land plants, scattered insects and mobile animals inhabit this zone.
- The **littoral** zone is between the high and low tide marks. Different parts of the zone are covered in water for various amounts of time, for example, for 4 hours a day at the high tide mark and 20 hours a day at the low tide mark. Barnacles, mussels, crabs, anemones and seaweed are some of the organisms that inhabit this zone.
- The **sub-littoral** zone is below low tide mark and is always covered in water, except during a special spring tide. A large range of marine organisms inhabit this zone including brown, red and green seaweeds, worms, various shellfish, starfish, sea urchins, octopi, shrimps, zooplankton and small fish.



Figure 228.1 Wave cut platform Sydney

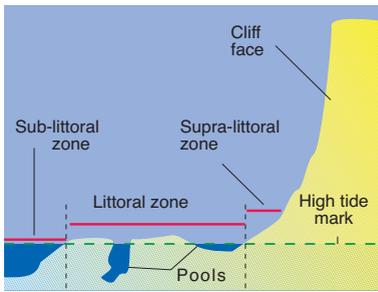


Fig 228.2 Zones and features of a wave-cut platform

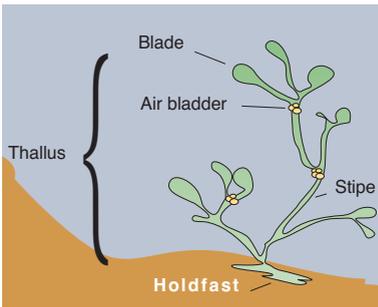


Figure 228.3 Generalised structure of a seaweed

## Physical features

The physical factors affecting organisms on the rock platform are temperature, light, wave action, wind speed and direction, as well as salinity of water in rock pools. Figure 229.1 summarises how animals and plants adapt to these features.

## Rocky shore plants

### Algae

Algae are found in rock pools and in the sub-littoral zone. They are a simple plant form and have a body structure called a **thallus** (Figure 228.3) which is made up of a broad leaf-like structure called a **blade** which allows oxygen into the plant.

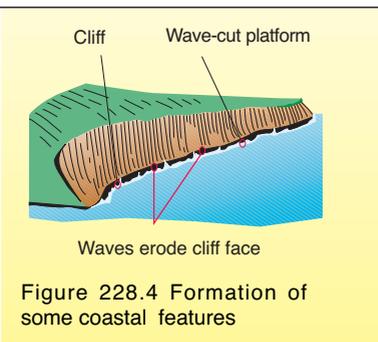
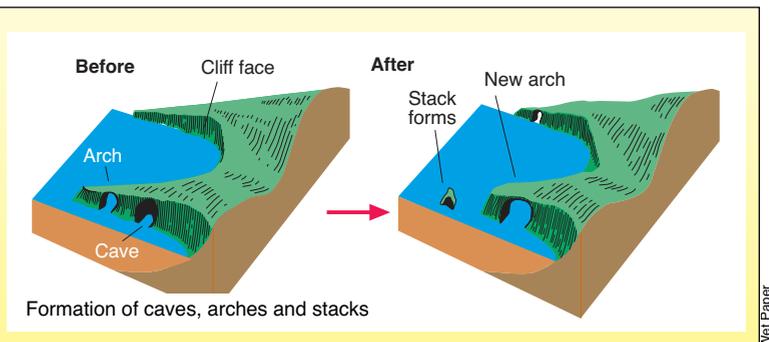


Figure 228.4 Formation of some coastal features



Formation of caves, arches and stacks

Effect	Animal adaptations	Plant adaptations
Waves	Muscular foot, conical shape, size	Holdfast, leathery leaves
Heat	Withdraw into a shell, move into water	Leathery leaves
Salt/fresh water	Able to control amount of salt in body	Able to secrete excess salt
Wind speed	Hide under rocks, withdraw into shell	Strong roots
Tides	Withdraw into shell, move to rock pool	Holdfast, plants live in clumps
Predators	Colour, withdraw into shell, hide under rock	Tough trunks, seeds, leaves
Food	Filter feeders, scavengers, scraping mouth parts	Nitrogen fixing in root system
Reproduction	Lots of eggs and sperm, external fertilization at sea, larvae swim back to rocks	Tough seeds, alternation of generation

Figure 229.1 Some adaptations by marine life to life on a rocky shore

Algae that can be seen with the eye are called seaweeds and include the green, brown and red algae which are attached to the seabed or any hard surface. The **stipe** of the seaweed is like a stem and is made of flexible material which allows the seaweed to bend back and forth, absorbing most of the shock from waves and ocean currents. The **holdfast** anchors or attaches the seaweed to rocks, corals or even sand (see over Figure 230.3).

### Green algae

Green algae are a major group of marine plants that contain the green pigment **chlorophyll**. The most well-known of the marine green algae is the sea lettuce or *Ulva* (Figure 229.3). Green algae can reproduce by **spores**, or by eggs and sperm in a process called alternation of generations (Figure 229.4). The first sexual **sporophyte generation** produces a second generation of plants called the **gametophyte generation**. The gametophyte generation is either a male or a female and when the time is right, they release either eggs or sperm which join up again to grow into a sporophyte generation.

**Alternation of generations** is a common adaptation used by plants to increase the survival of the species. Other adaptations of algae include air bladders or fluid-filled sacs which increase the surface area available for photosynthesis.

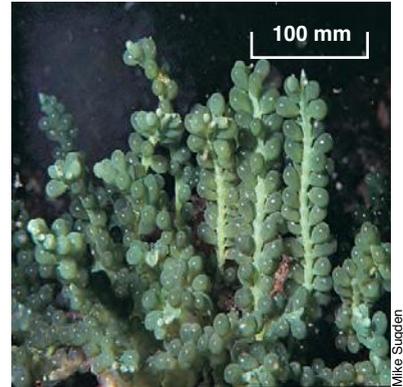


Figure 229.2 Green algae

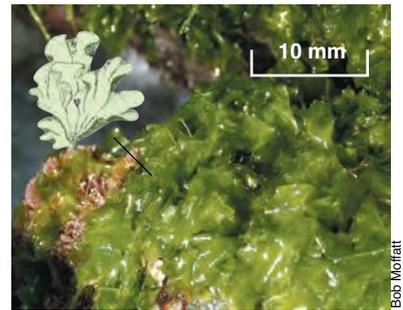


Figure 229.3 *Ulva* - A common green algae

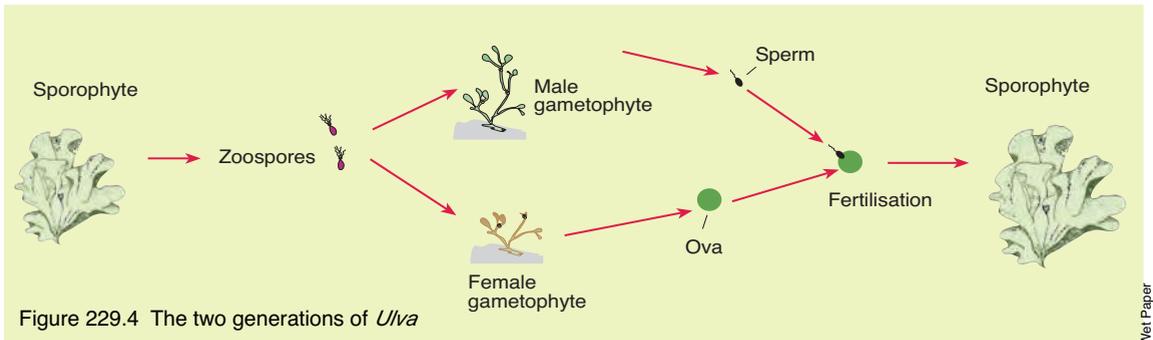


Figure 229.4 The two generations of *Ulva*



Figure 230.1 Brown algae



Figure 230.2 Neptune's necklace

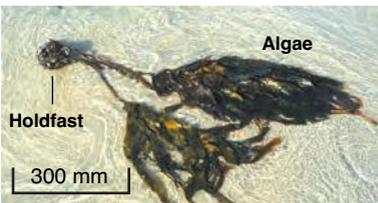


Figure 230.3 Brown algae and holdfast

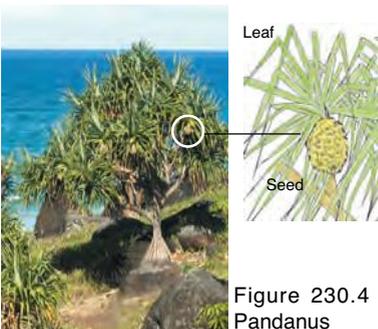
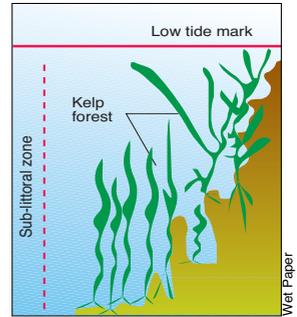


Figure 230.4 Pandanus

## Brown algae

**Brown algae** (Figure 230.1) is a complex marine plant that is commonly called seaweed or incorrectly just called kelp. This type of algae contains the pigment chlorophyll and another pigment called carotene so it has a brown colour.

Bull kelp, perhaps the best known of the kelps, has fronds 7 metres long and up to 30 centimetres wide and requires lots of oxygen to grow. This is why it is found in the surf zone off many southern beaches. The most distinctive of the brown algae is bubble weed, which has large irregular bladders that are often filled with water. Some of the fleshy types of brown algae (**bull kelp**), are the main source of agar jelly. Agar is used for growing bacteria and moulds on agar culture plates, and for cooking in some Asian cultures.



Brown algae lives in a variety of marine environments, and can withstand a range of conditions. The bead-like algae, Neptune's necklace (Figure 230.2), lives abundantly on the rocky platforms of southern areas of Australia's coastline. Also common in the southern oceans are the true kelps, some of which grow into large underwater forests. Another brown algae, sargassum can be found at or below low tide levels around Australia but it behaves differently in the Atlantic Ocean. Off Bermuda, sargassum grows in coastal waters. When the top part breaks, the seaweed floats out to sea and covers the ocean's surface for thousands of square kilometres — an area that has come to be called the Sargasso Sea.



## Pandanus

Screw pine or **pandanus** (Figure 230.4) is a small spreading evergreen tree up to 6 metres high with stout prop roots which firmly anchor the tree in loose sand. A prop root is a root formed from the stem, usually close to the ground, which helps hold the stem erect and anchor the plant. The fruit resembles a pineapple and turns a yellow-orange when ripe. Screw pine is sand and salt tolerant and can withstand exposure to strong winds.

When growing on the seaward slope and crest of the frontal dune it helps bind the sand and prevent wind erosion. When established at close spacing on the crest of the frontal dune it functions as a windbreak, protecting less tolerant hind dune plants from the damaging effects of salt-laden winds.

## Rocky shore animals

See also Chapters 5 and 26

### Sponges

(Refer to page 294)

Adult sponges grow attached to rocks, sea plants, the shells of marine animals. They can be found at all depths from the intertidal zone.

### Jellyfish

(Refer to page 295)



These animals can get together to form colonies of specialised individual cells such as the Bluebottle.

### Sea anemones

(Refer to page 296)



Sea anemones can move by sliding on their basal disc or by somersaulting from place to place. They are found in pools under rocks and in crevices.

### Crabs

(Refer to page 298)



Crabs of every shape and size can be found on and under rocks. They are flat and able to squeeze between rocks to avoid breaking waves.

### Barnacles

(Refer to page 298)



They are the dominant life form in the wave zone because they are cemented to the rocks and have a conical shape to disperse the force of the wave. When the wave backs off, they extend their legs to feed on plankton in the white wash.

### Sea urchins

(Refer to page 299)



Sea urchins are covered in long, brittle spines that can make them dangerous to touch. They hide in rock pools in crevices so they can avoid being smashed by waves.

### Shells

(Refer to pages 300 - 302)



Chitons are cemented to rocks and can withstand the force of huge waves. They scrape algae off rocks with modified mouth parts.

Oysters have two shells that are held together by a strong muscle. This makes them almost impossible to get open by predators and stops them from drying out in between the tides.

Periwinkles have a retractible foot which is used to withdraw the head and eyes into the shell if attacked. At the base of the foot is an operculum which seals the animal inside.

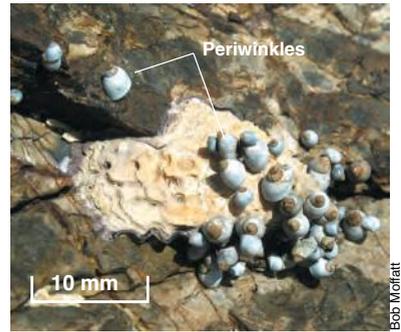


Figure 231.1 Periwinkles and oyster

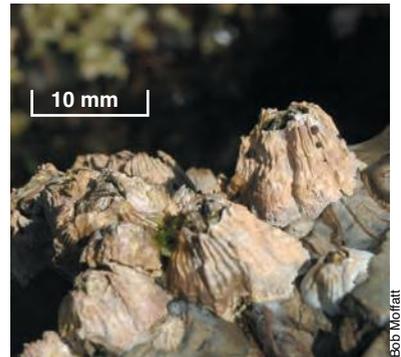


Figure 231.2 Barnacles



Figure 231.3 Hat shells (limpets)

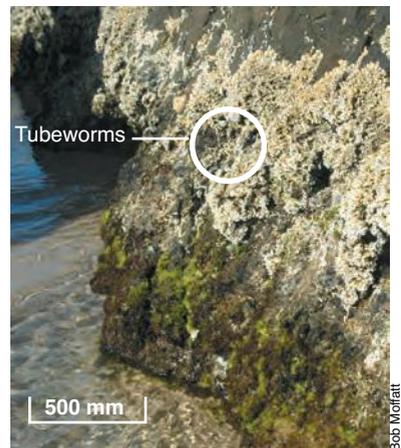


Figure 231.4 Tube worms

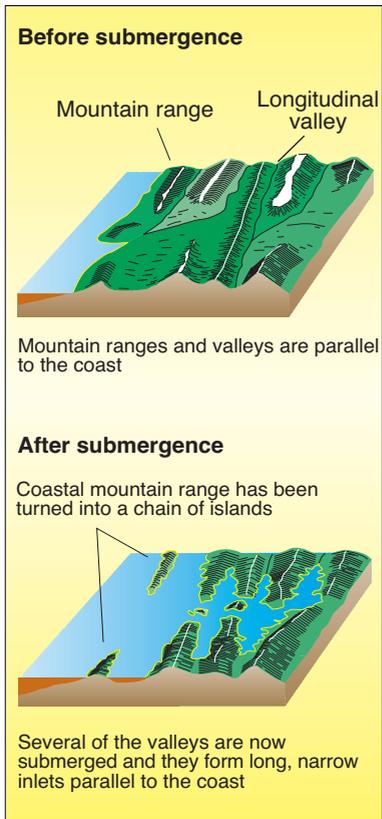


Figure 232.2 How an offshore island forms.

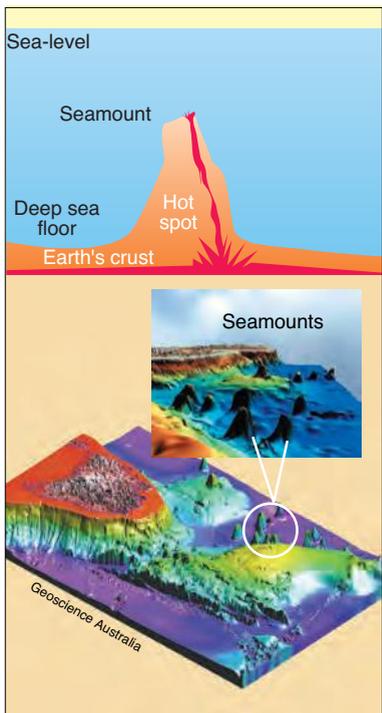


Figure 232.3 Seamount formation



Figure 232.1 Offshore island

## Offshore islands and reefs

Hundred of thousands of years ago, the sea level was much lower than it is now and many of the rivers we use now for boating and swimming had steep-sided cliffs and ran through mountain valleys. However, climate change raised the water level and the river valleys filled with water (called **submergence**). The higher water level and subsequent wave action turned the hilltops nearer the sea into offshore islands (Figure 232.1 and 232.2).

Offshore islands can have rocky outcrops called **bommies** which can rise up sharply from the ocean floor and make boating dangerous. Bommies support an enormous amount of ocean life, encouraged by the cold, oxygen-rich water and a large supply of animal and plant plankton.

### Seamounts

Seamounts form as a result of **hot spots** in the Earth's crust forming undersea volcanoes as shown in Figure 232.3. Geoscience Australia recently mapped a series of seamounts off the east coast of Tasmania resulting in the area being declared a marine national park.

### Reefs

#### Oceanic reefs

Oceanic reefs are found around islands which have formed from volcanoes that blast their way to the sea surface from weaknesses or hot spots in the sea floor. In the next book in this series - *Marine Science for Australian students*, you will learn that these volcanoes move on large oceanic plates and that these volcanic islands shift with the moving plate. This causes the islands to sink 1 centimetre a year and go on to form the barrier reefs and **atolls** shown Figure 233.1.

The oceanic reef is close to the island, with a small lagoon. As the island sinks further, the lagoon gets bigger and a reef forms. At its final stage the island peak disappears and an atoll ring of islands is left.

The reef is very important to Pacific island people because it protects villages, towns and cities during cyclones. The reef is also full of marine life, providing a local, fresh food supply. The conservation of oceanic reefs is critical.

**Ribbon reefs**

A **ribbon reef** is an elongated reef with its long axis parallel to the edge of the continental shelf or coastline (Figure 233.4). The reef front and algal rim are on the seaward side, grading into reef flat and finally to the reef back on the leeward side. Water flowing through gaps between reefs brings nutrients and promotes reef growth along the borders of these gaps.

**Fringing reefs**

**Fringing reefs** can be found growing around continental islands (Figure 233.2) or along mainland shores (Figure 233.3). A continental island is really an underwater mountain with its peak above the sea’s surface. Corals and marine plants (algae) may settle and grow in the shallow waters around the peak, forming a fringing reef.

**Patch reefs**

**Patch reefs** grow up from the continental shelf and accumulate sand and debris in which plants grow. They contain a lagoon and a reef crest that support an enormous amount of life. Patch reefs are very fragile geological structures so special management conservation plans have been put in place to protect them.

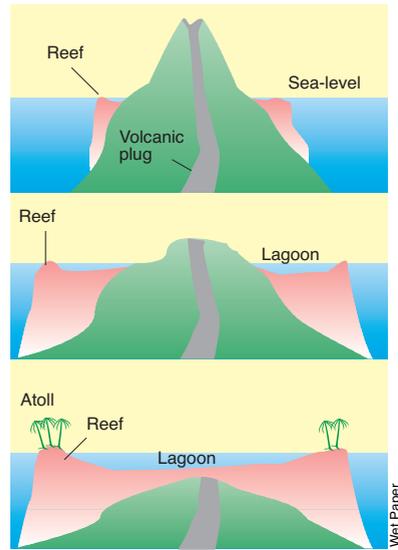


Figure 233.1 Atoll formation



Figure 233.2 Fringing island reef Qld

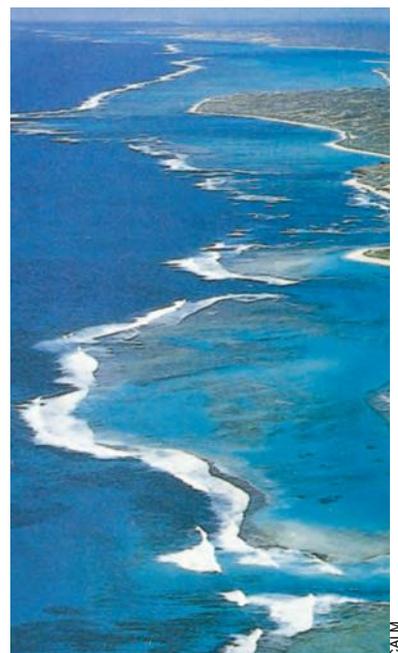


Figure 233.3 Fringing mainland reef WA

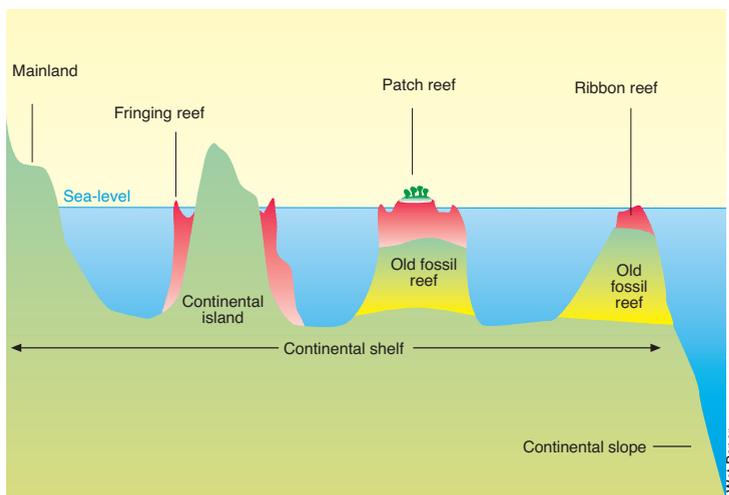


Figure 233.4 Comparison of ribbon, patch and fringing shelf reefs

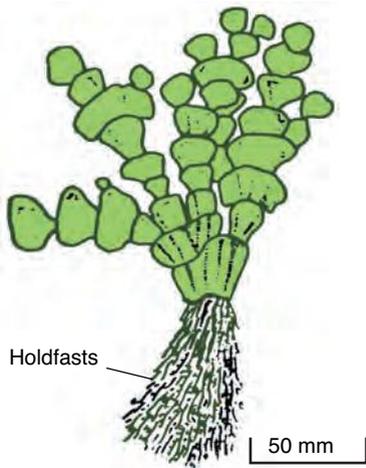


Figure 234.1 *Halimeda* sp  
Wet Paper

## Reef plants

*Halimeda* is very important in reef building because calcium carbonate is incorporated into the cell walls and holdfasts of this plant. Many scientists refer to these types of algae as the mortar of the reef, cementing other living materials such as corals together. Some reefs may be entirely built from encrusting algae and coral polyps.

## Reef animals

See also Chapters 2, 3, 26 and 27

### Sponges

(Refer to page 294)



Adult sponges grow attached to reefs and corals. They are found everywhere on the reef and at great depths.

### Jellyfish

(Refer to page 295 and Chapters 2 and 3)



Dangerous jellyfish found in the reef include the box jelly and irukandji. Jellyfish or medusa are the laval stages of many reef animals.

### Corals

(Refer to page 295 – 296)



Corals are the dominant life form on the reef and make up the largest living animal on Earth. Corals can be soft or hard and grow in warm tropical waters.

### Crayfish

(Refer to page 280 - 281)



Crayfish and lobsters can be found on and under rocks. They are spiny skinned with a great tail muscle to help them retract into their burrows to escape predators.

### Tube worms

(Refer to page 297)



Living in the coral are worms that filter feed on passing plankton. They are trapped in the coral and their only movements are with their feeding appendages.

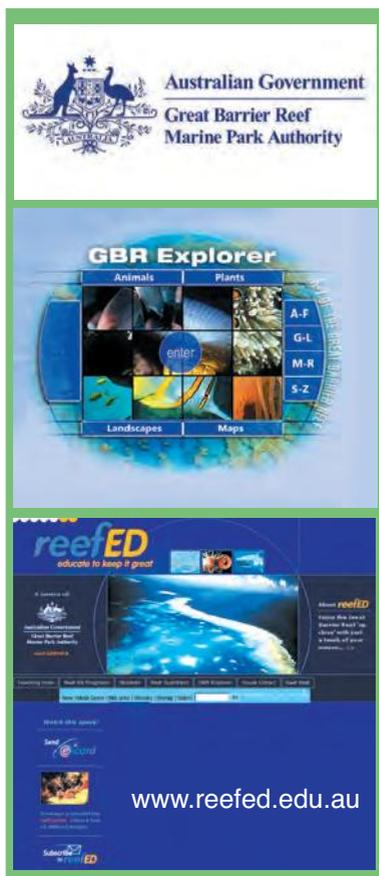
### Sharks and rays

(Refer to pages 304 - 305 and Chapter 3)



Sharks and rays are predators on the reef. Sharks are important to reef animals because they weed out the sick and injured animals before they have a chance to breed. This way only the fittest of the species are left to breed.

Rays can be seen cruising in shallow waters at high tide foraging for shells and worms in the sand. At low tide some can hide in crevices on coral ledges.



GBRMPA

Figure 234.2 The great barrier reef explorer at [www.reefed.edu.au](http://www.reefed.edu.au) has thousands of reef animals and plants for you to see and download for school projects.

# Key words

Acidic, alkaline, alternation of generations, atolls, bommie, chlorophyll, fringing reef, gametophyte generation, holdfast, hot spot, littoral, oceanic reef, offshore island, patch reef. physical feature, ribbon reef, sand dune, seamount, sedimentary, sporophyte generation. stipe, sub-littoral, submergence, succession, supra-littoral, thallus, zone..

# Summary questions

Fill in the gaps in these sentences. All the missing words can be found in the chapter.

- a. A knowledge of the [1] \_\_\_\_\_ and shape of our coastline allows us to [2] \_\_\_\_\_ what development can happen there, what life abounds, and how its basic structures need to be preserved.
- b. [3] \_\_\_\_\_ continually wash against coastlines, [4] \_\_\_\_\_ the base of cliffs and moving rocks and sand along the coast. [5] \_\_\_\_\_ headlands become very unstable because their foundations are constantly cut away by waves.
- c. [6] \_\_\_\_\_ plants in undisturbed areas vary in size and structure and certain plants are found in distinct **zones** from the beach to the back of the dune (hind dune). This zonation of plants is called a [7] \_\_\_\_\_ .
- d. The [8] \_\_\_\_\_ factors affecting organisms on the rock platform are [9] \_\_\_\_\_ , light, wave [10] \_\_\_\_\_ , wind speed and [11] \_\_\_\_\_ , salinity of water in rock pools.
- e. Green algae are a major group of marine plants that contain the green pigment [12] \_\_\_\_\_ . The most well-known of the marine green algae is the sea lettuce or [13] \_\_\_\_\_ .
- f. Bull kelp, perhaps the best known of the kelps, has [14] \_\_\_\_\_ 7 m long and up to 30 cm wide and requires lots of [15] \_\_\_\_\_ to grow. This is why it is found in the surf zone off many [16] \_\_\_\_\_ beaches.
- g. Seamounts form as a result of [17] \_\_\_\_\_ \_\_\_\_\_ in the Earth's crust forming [18] \_\_\_\_\_ volcanoes. [19] \_\_\_\_\_ Australia recently mapped a series of seamounts off the east coast of Tasmania resulting in them being [20] \_\_\_\_\_ a marine national park.
- h. [21] \_\_\_\_\_ is a very important in reef building because [22] \_\_\_\_\_ \_\_\_\_\_ is incorporated into the cell walls and holdfasts of this plant. Many scientists refer to these types of [23] \_\_\_\_\_ as the [24] \_\_\_\_\_ of the reef, [25] \_\_\_\_\_ other living materials such as corals together.



- 1. Name three forces that shape coastlines.
- 2. What is the difference between the four types of coastline discussed in this chapter?
- 3. Why does the size and shape of sandy beaches vary?
- 4. Define plant succession.
- 5. What are dunes?
- 6. Draw a colour diagram for each of the following:
  - a. Plant succession on an ideal sand dune
  - b. Formation of caves, arches and stacks
  - c. How an offshore island forms
  - d. Comparison of ribbon, patch and fringing shelf reefs
- 7. Name eight effects on animals and plants on a rocky shore.
- 8. What is the advantage of alternation of generations to green algae?
- 9. What is a seamount and how does it form?
- 10. What is the difference between a patch reef and a ribbon reef?
- 11. Why is a holdfast important to a rocky shore plant?
- 12. Why is *Halimeda* important to reef growth.
- 13. Identify this plant.



# Chapter 21 Estuaries and marine life



### Web references

[www.reefed.edu.au](http://www.reefed.edu.au), [www.mesa.edu.au](http://www.mesa.edu.au),  
[www.fish.wa.gov.au](http://www.fish.wa.gov.au), [www.dpi.qld.gov.au](http://www.dpi.qld.gov.au)



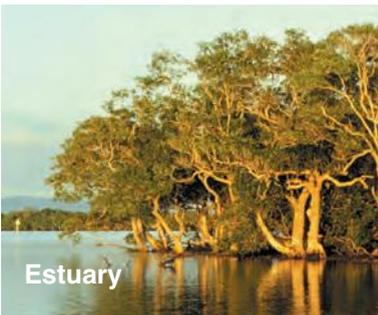
Estuary

Figure 236.1 Wave affected estuary



Estuary

Figure 236.2 Tide affected estuary



Estuary

Figure 236.3 River affected estuary

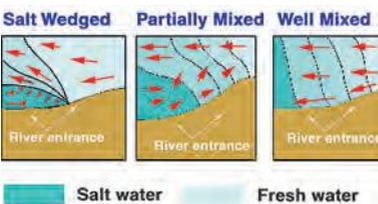


Figure 236.4 Salinity affected estuary  
Wet Paper

## Estuaries

An **estuary** is a semi-enclosed body of water where salt from the open sea mixes with fresh water draining from the land.

### Types of estuaries

Three types of estuaries in Australia identified by the National Oceans Office are wave affected (Figure 236.1), tide affected (Figure 236.2) and river affected (Figure 236.3). Other marine scientists have classified estuaries according to their type of water mixing as shown in Figure 236.4.

### Human use

Boating, fishing, swimming and bird watching are just a few of the many recreational pursuits people enjoy in and around estuaries. Estuaries are often cultural and historical centres for coastal communities, serving as focal points for celebrations, customs and heritage. In Australia, many of the remaining aboriginal sites are situated along estuarine shorelines. In addition, estuaries provide considerable aesthetic enjoyment for the people who live around them.

### Importance

Estuaries are essential for the survival of many birds, fish and mammals. Estuaries have been referred to as the "nurseries of the sea", as they provide many species of fish with sheltered waters for spawning and safe habitat for juveniles to develop.

Estuaries have also been called the "supermarkets of the sea" because many commercially valuable fish species grow in estuaries. Many wild catch animals such as tuna are caught offshore and shipped back in large cages to grow bigger in estuaries while other industries such as oysters are grown exclusively there. Estuaries contain important plants such as seagrasses and mangroves. Without seagrasses and mangroves, our inshore seas would be like underwater deserts and would not contain the basic food supplies for our billion dollar fishing industry. Many development companies and tourist operations are yet to learn and appreciate the importance of seagrasses. Some migratory wader birds also rely on estuaries as resting and feeding grounds during their long journeys.

The coastal seas of which estuaries form a part occupy about 0.5% of the total volume of the ocean, but within them grow 30% of the ocean's plant and animal life, and about 50% of the world's fish catch is harvested in this zone.

## Mangroves

The sheltered tidal waters of estuaries support unique communities of plants and animals which are specially adapted for life at the margin of the sea, and estuarine environments are among the most productive on earth.

Mangroves are a very important estuarine plant providing a unique ecosystem for millions of animals and plants. More mangrove species live in the tropics than in temperate waters (Figure 237.1) because there is a higher rainfall and more mud for them to grow in. No mangroves are found in Tasmania.

### Intertidal plants

#### The tidal zone

The term **mangrove** can be used in three ways: the trees themselves (Figure 237.2), the forest, and the habitat. Mangrove forests can grow over 10 metres in height in tropical Australia. Mangroves are found growing in the intertidal areas of sheltered shores, estuaries and bays or in the lee of large islands. They grow best at river entrances and creeks where salt has been deposited to form low flat areas of mud. Here the velocity of the river is slowed which allows silt to settle out and accumulate. This mud and silt is rich in nutrients and is ideal for mangrove development.

Mangroves are the temporary habitats for fish population and are in the top three of the most productive ecosystems on earth.

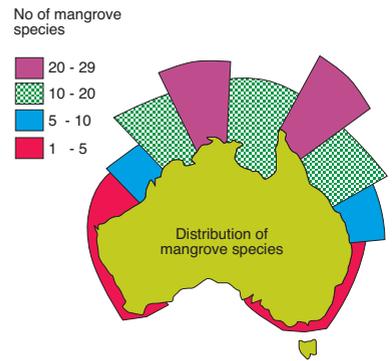


Figure 237.1 Mangrove distribution  
Dave Claridge and Wet Paper

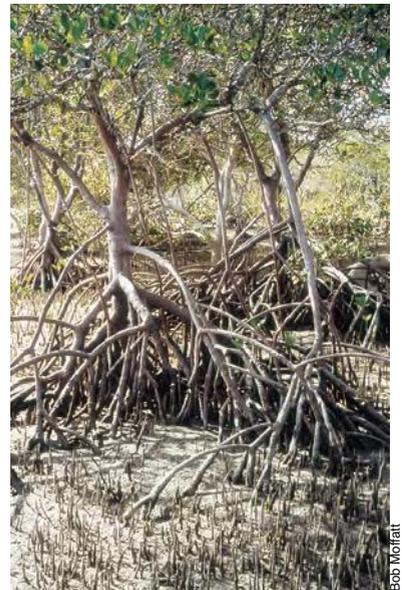


Figure 237.2 Mangroves



Figure 237.3 Our fishing industry depends on seagrass beds.



Figure 237.4 Immature whiting live in mangroves.

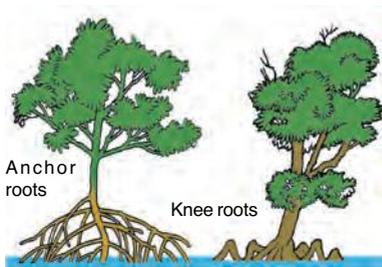
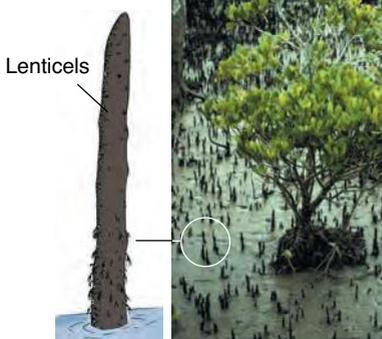


Figure 238.1 Anchor root system types  
Rose Bedford



Fisheries Old

Pneumatophores



Wet Paper

Figure 238.2 Pneumatophores



Fisheries Old

Figure 238.3 Salt excretion

## Adaptations

Mangroves grow in an environment where the water is very salty and the oxygen level in the muddy soil is often low. Mangroves must adapt to an unstable muddy soil, flooding by daily tides and air that is full of salt. They do this by a well developed root system, specialized roots and leaves that can exclude, excrete or accumulate salt.

### Root systems

All mangroves have a system of sideways spreading roots (Figure 238.1). Mangrove root systems are invariably very shallow, and most species do not appear to have tap roots. In mangrove areas, the amount of biomass under the ground is greater to that above ground thus reducing the chance of mangroves being washed away. Nutrients required by the plant are extracted from the mud by a series of fine hair-like roots that grow out from the main root system. These fine hairs absorb essential minerals and nutrients in a environment that is very low in oxygen. A simple test is to poke a stick into the mud and smell along its length. The depth that oxygen is no longer present will be obvious by the strong smell.



### Intake of air

**Respiration** takes place by diffusion through **lenticels** (minute openings) in the roots and stems of plants. To enable this to happen, mangroves have developed a number of specialised adaptations. **Pneumatophores** (see Figure 238.2) are peg-like erect roots growing upwards from the root system. They enable the mangrove to take air into the plant for photosynthesis.

### Salt regulation

The mechanism by which salt content is regulated is a function of the whole plant and not individual parts. This involves one or a combination of the following processes—exclusion, excretion or accumulation.

**Exclusion** is where plants which are salt excluders have a sort of super filter, a selective absorption process which enables them to take in water and filter most of the salt out.

**Excretion** occurs by means of salt glands in the leaves as shown in Figure 238.3. **Accumulation** occurs where mangroves which accumulate excess salt, deposit it in bark or old leaves. Species which do this often have succulent or thickened leaves. These leaves fall to the forest floor and become part of the detrital build up. For some deciduous species scientists have theorised that the leaf fall each year is a prelude to the new growing season.

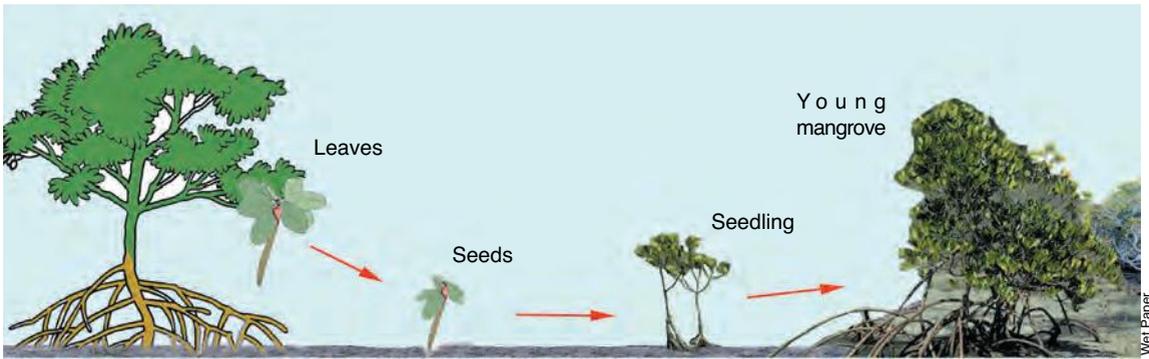


Figure 239.1 Mangrove life cycle

**Reproduction**

A mangrove is a tree and so has flowers, shoots, roots, stems and leaves as shown in Figures 239.1 - 239.4. Mangroves reproduce by male and female flower parts fertilising each other and forming a seed. In some species these seeds are specialised in that they germinate while still attached to the tree and are long and thin so that when they drop to the ground they stick in the mud. If they fail to strike, the seed is covered by a tough sheath to prevent it from drying out and enabling it to float. Once the seed has anchored itself, roots quickly grow and a seedling forms. It may take many years for the seedling to grow to a young mangrove tree.

**The problem of seed dispersal/establishment**

The seeds of mangroves are buoyant and are adapted to dispersal by water, sometimes over considerable distances. While various mangrove species produce large crops of seeds each year, only a few successfully take root. Mud banks exposed at low tide are formed of river silts in sheltered areas creating an ideal environment for seedlings to develop.

When fully developed, the root network of these pioneer species serves as a barrier to slow down tidal movement as shown in Figure 239.5.



Figure 239.5 Pioneer species

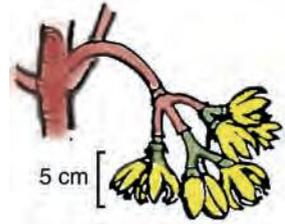


Figure 239.2 Mangrove flower  
Michael Mitchie

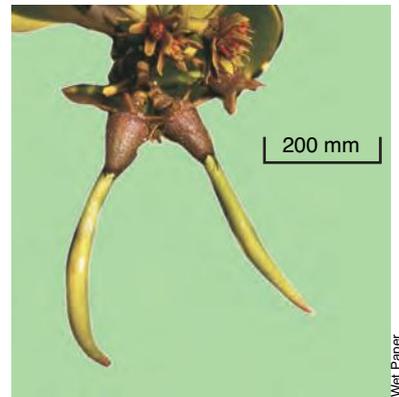


Figure 239.3 Mangrove seed

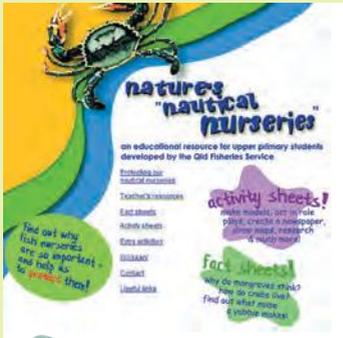


Figure 239.4 Mangrove seedling

## Diving deeper



Log onto the Queensland Government Natures Nautical Nurseries web site and complete any of the activities on mangroves or download the free information for your school projects.



<http://www.dpi.qld.gov.au>

## Zonation

One of the most unusual features of a mangrove forest is the development of bands of dominant species which run roughly parallel with the shoreline or the banks of tidal creek systems as shown in Figure 240.1. The typical mangrove forest of eastern Australia is divided into the outer zone, the middle or main zone and the landward zone or littoral fringe.

In southern Australia, where the number of species is limited, mangroves are found in pure stands or in mixtures in which no form of zonation is able to be recognised. In Victoria and South Australia, mangrove areas are monocultures of *Avicennia marina*.

### **The outer zone (seagrass - mangrove)**

This is the area which is subjected to tidal inundation at least once every twenty-four hours. At the seaward edge of this region is a strip, often only one or two trees wide, of mature pioneer species. These are usually large trees and small saplings and seedlings may extend seaward of them.

### **The middle zone (mangrove - saltmarsh)**

This area is subject to less regular tidal inundation — some parts may be covered only on the four days surrounding the spring tides at new and full moon.

### **Landward zone (saltmarsh - melaleuca forest)**

This area is above high tide mark but often has semi-saline lakes and supports a thick forest of trees. In urban Australia this has almost disappeared due to housing development.

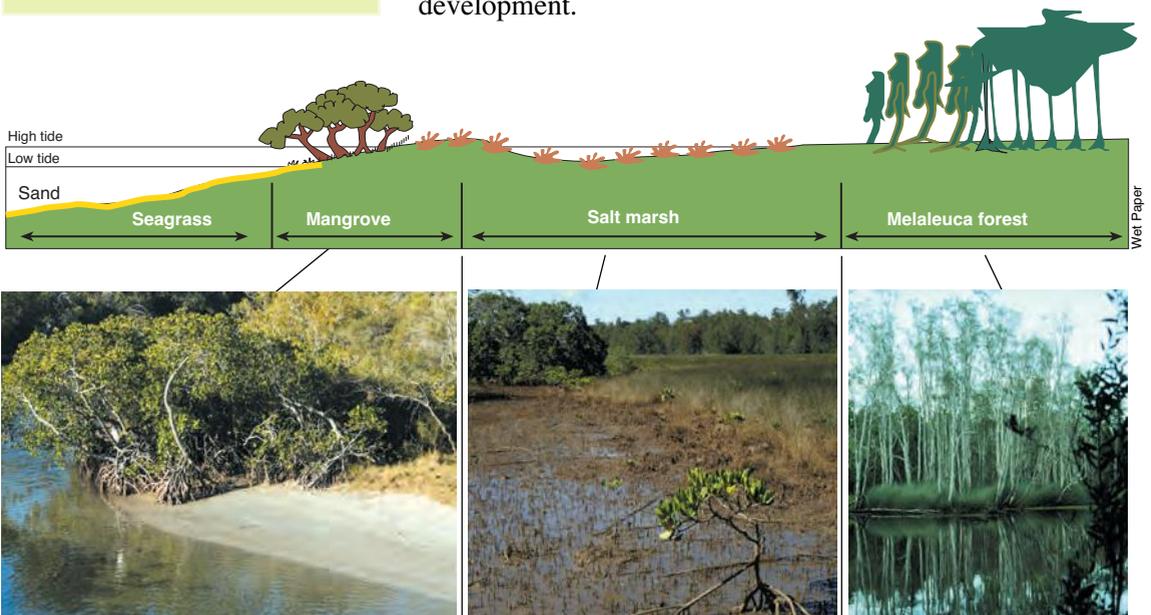


Figure 240.1 Intertidal zones

(Illustration Bob Moffatt, photographs Bob Moffatt (L and C) and Dave Claridge (R))

## Mangroves as shelter

Mangroves are fundamentally important in that they offer a habitat or shelter for other plants and animals. Plants such as lichen and fungi (Figure 241.2) attach themselves to mangrove trunks. Small fish use the tangled roots of the mangrove forest as a protection from predators.

The incredible richness of the **food chains** in mangroves supports a large number of commercial and recreational fish species for at least a part of their life cycles.

The most common permanent dwellers of the mangroves however are molluscs and crustacea. Mud crabs make their homes there, even though they spawn in the open sea. Other crabs using the mangrove as a habitat include fiddlers and soldier crabs. Small fish such as whiting, mudskippers (Figures 241.4) and yabbies seek shelter from predators.

Other species of molluscs include mud whelks (Figure 241.3), periwinkles, oysters and various scallop species. Spiders live in the leaves and on the branches.

Mangroves, together with associated wetlands, are important bird habitats. Both seabirds and terrestrial species are attracted to such areas. The Pied stilt is one such bird that feeds on invertebrates in mud at low tide. Terrestrial species which feed on the mudflats, and in shallow water surrounding mangroves areas include, pelicans (Figure 241.5) and egrets, stilts, spoonbills, ibis, jabiru and heron. Such species may also roost in mangroves. Waders also use the areas. Mudflats with nearby seagrass beds and intertidal banks tend to attract the greatest number of wading birds.

Many of the waders are summer visitors which have migrated from the northern hemisphere's winter. Some of these visitors include:

- golden plovers, a migrant from the Arctic regions;
- tattlers, migrants from Siberia or North America;
- curlews and godwits, migrants from eastern Asia.

Many of these species are listed in international conservation agreements with China and Japan.

Few terrestrial animals live in or visit the mangroves. Bats and flying foxes use the mangrove forest as a roosting site during the day, and occasionally wallabies and dingoes are seen at or near the landward fringe.

Mangrove forests of northern and eastern Australia are home to the saltwater crocodile, and some species of land snakes and sea snakes are found in mangroves.



Figure 241.1 Pied stilt

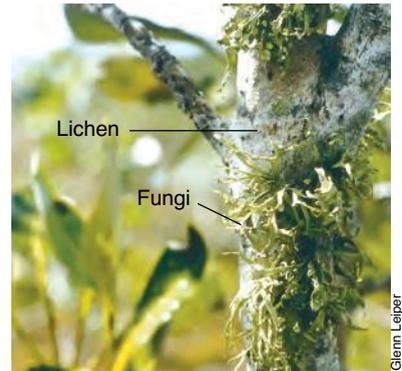


Figure 241.2 Lichen and fungi



Figure 241.3 Mud whelk



Figure 241.4 Mudskipper

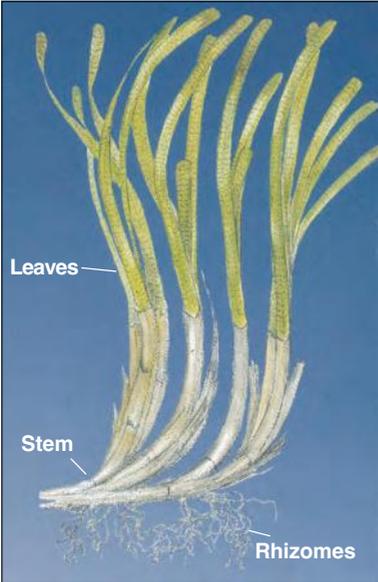


Figure 241.5 Pelicans



Old Fisheries Service

Figure 242.1 Marine Biologist and seagrasses



CSIRO Division of Fisheries



Bob Moffatt

Figure 242.2 Seagrass



Old Fisheries Service

Figure 242.3 Seagrass beds

# Seagrasses

**Seagrasses** are flowering plants with roots, stems, leaves and flowers that have adapted to living completely submerged in sea water. Because they have flowers, they are classified as angiosperms but they are not related to either seaweeds or true grasses. This group of plants is important because they grow into seagrass meadows that protect and hold the otherwise shifting sands of sand bars. Seagrasses are also a vital source of food and shelter for many organisms and are the nurseries for many species of fish (for example flathead Figure 243.3).

*Zostera*, which is commonly called eel grass or dugong grass, has narrow grass-like leaves and stem-like **rhizomes** (Figure 242.2) that bind the sand together.

## Reproduction

Seagrass plants reproduce like flowering land plants, needing the production of **pollen** which will attach itself to other flowers. The flower is then fertilised and seed is produced. The remarkable thing is that, in many cases, the whole reproductive process occurs underwater, with the released pollen drifting in the current. Some seagrasses, however, produce flowers on long stems during low tide and reproduce in much the same way as land plants.

## Significance

Seagrasses are the homes for literally thousands of animals, from the herbivorous dugong to the smallest of zooplankton. A shortlist of the animals that seagrass benefits would include fish such as flathead, snails, amphipods, jellyfish, baby prawns, bacteria, shellfish, mussels and baby fish.

This is best illustrated by Figure 243.1 opposite.

- A. Grazing animals such as snails and amphipods live on the outside of the seagrass.
- B. Suspension feeders attached to the seagrass catch small planktonic animals.
- C. Carnivores such as flathead hide in between the seagrass waiting for small fish as prey.
- D. Amphipods live on the dead remains of animals from above which accumulate on the leaf.
- E. A mantis shrimp waits on the seagrass leaf to prey on other animals.
- F. Bacteria live in the rhizome root system and fix nitrogen from the water. Scientists also believe they detoxify heavy metals.

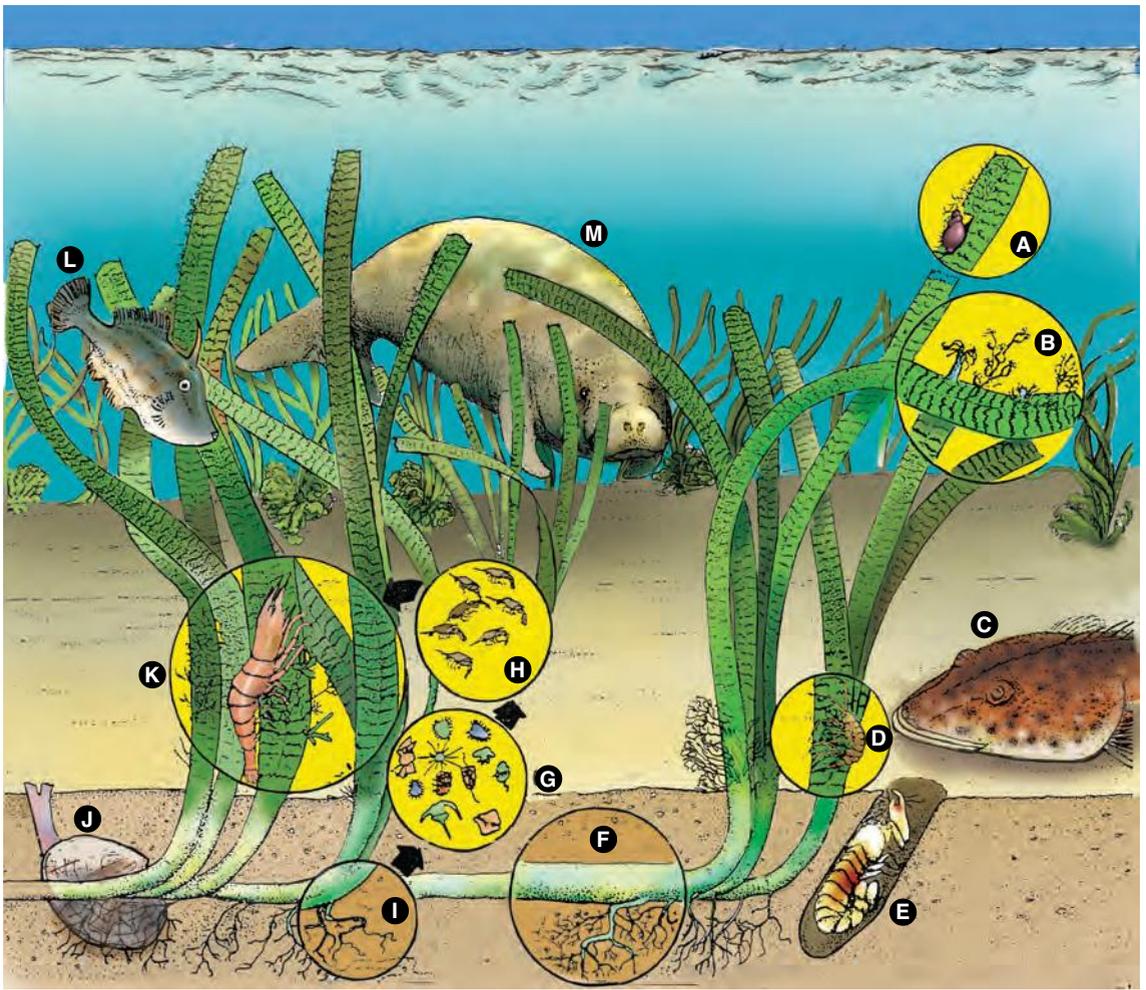


Figure 243.1 Seagrass beds are a complex ecosystem.  
 (Illustration WA Fisheries, reproduced with permission, coloured by Kerry Kitzelman)

- G. Small protozoans – single celled marine animals live off phytoplankton.
- H. Bigger crustaceans – the meiofauna feed on the single celled protozoans.
- I. Bacteria decompose dead rhizomes.
- J. A small clam filter feeds on plankton and detritus from above the mud.
- K. A small prawn clings to the seagrass feeding on plankton.
- L. A herbivore fish, leather jacket feeds on the seagrass.
- M. Another herbivore, the dugong feeds on the seagrass.

Seagrass beds are a complex ecosystem in themselves.

Can you see the effect an algal bloom would have on the microfauna in the illustration above? This is why seagrasses and estuaries need to be managed in such a way as to allow human use, while still allowing the seagrass beds to grow.

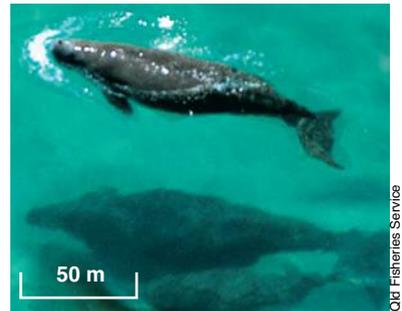


Figure 243.2 Dugong



Figure 243.3 Flathead

# Estuary food chains

Ref: [www.ladydenman.asn.au](http://www.ladydenman.asn.au)

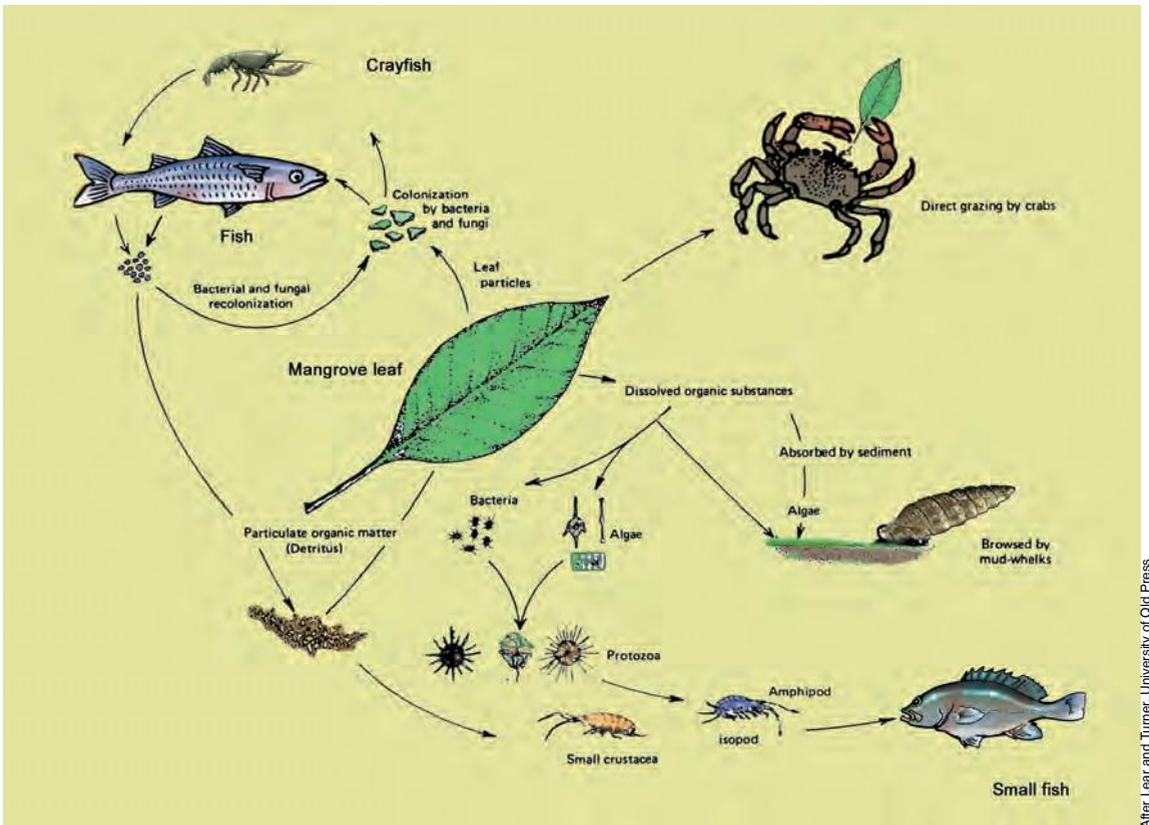


Mangroves, saltmarshes, mudflats and seagrass beds form the basis of complex food webs. Together they support a wealth of life from microbes through to fish and birds. Mangrove leaves decompose to provide food for other marine life (Figure 244.2).

Solar energy plus nutrients in river sediments provide the basic resources for mangroves to grow. Each year more than 100 tonnes of mangrove leaves are produced and fall into the estuaries of Jervis Bay. These break down with the aid of microbes. This **detritus** is then consumed by marine snails, crabs, fish and prawns.

The seagrass beds in Figure 244.1 can be seen at low tide near a river mouth and contain a complex ecosystem similar to mangroves. Snails, crabs, schrimp, and other small invertebrates in the seagrass constantly feed off detritus washed in and out with the tide. They provide a food source for smaller fish that migrate over the seagrass as the tide comes in. As the tide goes out, these fish migrate out to sea only to be eaten by larger predatory fish.

Figure 244.1 In temperate estuaries seagrasses can be seen covering the entire river mouth at low tide.



Alter Lear and Turner, University of Old Press

Figure 244.2 Mangrove leaf life cycle

# Problems facing estuaries

The biggest problem facing estuaries today is **loss of habitat**.

Everyone wants that river or ocean view but seagrasses and mangroves will continue to die unless land clearing is stopped. The construction of marinas and canal estates are just two examples (Figures 245.1 - 245.2) of how habitat is lost by development. Stormwater is probably the second biggest killer of seagrass and mangroves. Chapter 29 discusses water quality in more details.

## What governments are doing

Laws that protect estuaries include fishing exclusion zones, go slow areas for turtles and dugongs, licences for aquaculture, stormwater management plans and devices. Coastal zone management plans also set limits to housing development with mangroves totally protected now from clearing.

Many Australian states now have **stormwater management systems**. The gross pollutant traps in Figure 245.4 show how some councils are tackling the problem of pollution from the catchment.

## What you can do

Seagrasses do not like land fertiliser because it promotes the growth of too many other competing algae, choking them to death. Some simple things that we can all do to look after estuaries include using garden fertiliser sparingly, or to plant native vegetation that needs no fertiliser. Chapter 30 has many other useful ideas on nutrient reduction.



Figure 245.1 Loss of habitat



Figure 245.2 Marina



Figure 245.3 Stormwater pipe

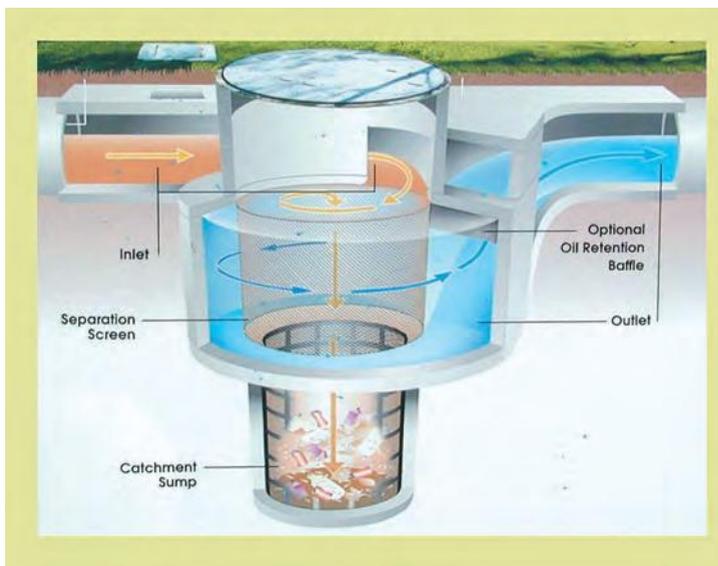


Figure 245.4 Gross pollutant trap Glenelg South Australia





1. Name the three types of estuaries in Australia and explain what makes them different.
2. Explain the statement - estuaries have been referred to as the nurseries of the sea.
3. Give three reasons why estuaries are referred to as the supermarkets of the sea.
4. Why do more mangrove species live in the tropics than in temperate regions?
5. How do mangroves remove salt?
6. What stops mangroves from falling over?
7. How do mangroves reproduce?
8. Draw a diagram showing zonation in mangroves.
9. How does a seagrass reproduce underwater?
10. Name five animals found in mangroves.
11. Draw a labelled diagram of a seagrass.
12. Why is the death of seagrass a problem for local fishers?
13. Draw a mangrove food web showing the fate of a mangrove leaf.
14. What is a gross pollution trap and draw a diagram to show how it works.
15. What is the greatest threat to mangroves and seagrasses today? Justify your answer.



## Key words

Detritus, ecosystem, seagrass bed, epifaunal suspension feeders, estuary, food chain, fungi, gross pollution trap, lenticel, loss of habitat, mangrove, salt excretion, shelter, meiofauna, mudskipper, pneumatophores, rhizome, stormwater management system, tidal zone, zonation.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. [1] \_\_\_\_\_ are essential for the survival of many birds, fish and mammals. Estuaries have been referred to as the "[2] \_\_\_\_\_ of the sea", as they provide many species of fish with sheltered waters for [3] \_\_\_\_\_ and safe habitat for [4] \_\_\_\_\_ to develop.
- b. Mangroves are found growing in the [5] \_\_\_\_\_ areas of sheltered shores, estuaries and bays or in the [6] \_\_\_\_\_ of large islands. They grow best at river [7] \_\_\_\_\_ and creeks where [8] \_\_\_\_\_ has been deposited to form low flat areas of [9] \_\_\_\_\_.
- c. Mangrove root systems are [10] \_\_\_\_\_ very shallow, and most species do not appear to have [11] \_\_\_\_\_ roots. In mangrove areas, the amount of [12] \_\_\_\_\_ under the ground is greater to that above ground thus [13] \_\_\_\_\_ the chance of mangroves being washed away.
- d. The seeds of mangroves are [14] \_\_\_\_\_ and are adapted to [15] \_\_\_\_\_ by water, sometimes over considerable distances. While [16] \_\_\_\_\_ mangrove species produce large crops of seeds each year, only a few [17] \_\_\_\_\_ take root.
- e. The most common permanent [18] \_\_\_\_\_ of the mangroves however are molluscs and [19] \_\_\_\_\_. Mud crabs make their homes there, even though they [20] \_\_\_\_\_ in the open sea.
- f. Seagrasses are also a [21] \_\_\_\_\_ source of food and shelter for many organisms and are the [22] \_\_\_\_\_ for many species of fish.
- g. Without mangroves and seagrasses, our [23] \_\_\_\_\_ seas would be like underwater deserts and would not contain the basic food supplies for our [24] \_\_\_\_\_ dollar fishing industry.
- h. Many Australian states now have [25] \_\_\_\_\_ management systems.

# Chapter 22 Coastal engineering



## Search engine words

Search for - artificial reef, boulder wall, breakwater, canal, desalination plant, groyne, harbour, lighthouse, marina, oil rig, port, sand bypassing systems, training wall, wind farm.

**Coastal engineering** includes the construction in, near or on the coast of houses, high-rise, marinas, groynes, underwater cabling, sand pumping jetties, aquariums, boulder walls, artificial reefs, desalination plants and canal estates. In Western Australia, pollution of inland lakes lead to the construction of a new river mouth at Dawsville (Figure 247.3) which resulted in an enormous growth in housing development. In recent years billion dollar **desalination plants** have been built to supply water to growing cities as shown in Figure 247.1.



Figure 247.1 Desalination plant under construction

## Engineering structures

### Desalination plants

Desalination is a technology that separates dissolved salts and other minerals from seawater or other salty water to provide clean drinking water.

Desalination technologies already exist and have been used for over 20 years. In Australia, the most common desalination process is **reverse osmosis** (Figure 247.2), which involves the removal of salts and other minerals out of the water as it moves through a membrane process (moving through a thin sheet of material) under high pressure. Other processes include thermal distillation, which involves evaporating the salt water and collecting the purified vapour; and electro dialysis, which involves removing salts by separating and collecting their chemical components through electrolysis (using an electric current).

### Physical barriers

The construction of a physical barrier to the sea is one method that is used to stop erosion of the foreshore. These physical barriers are mostly just made of rock and lie parallel to the coast. **Boulder walls** are one of the most common structures used in the prevention of beach erosion and in many coastal developments are mandatory with the cost borne by the developer or home owner.



Boulder wall construction

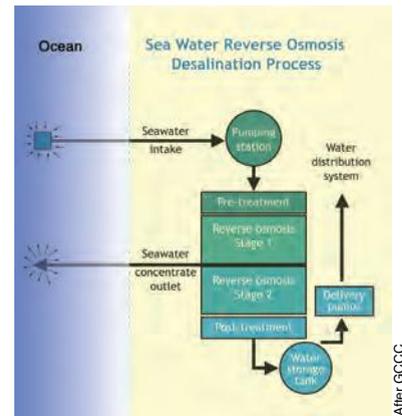


Figure 247.2 Desalination plant process

Australian Water Association  
[www.awa.asn.au](http://www.awa.asn.au)



Figure 247.3 The Dawsville cut in the mid 1990's, Western Australia



Figure 248.1 Groynes NSW

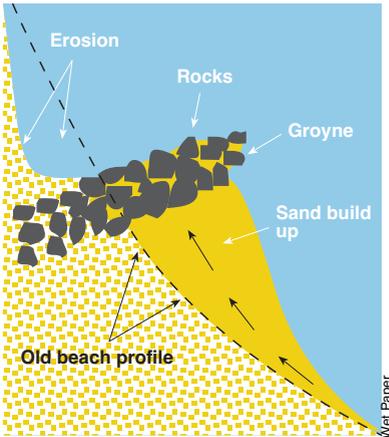


Figure 248.2 How a groyne works.

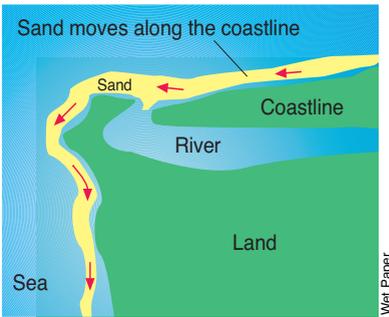


Figure 248.3 Natural sand movement along a coastline

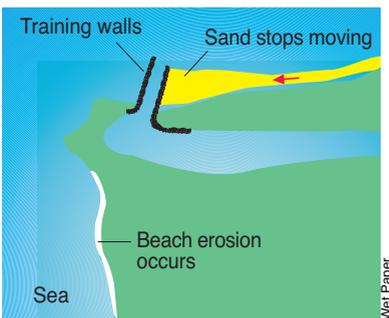


Figure 248.4 The effect of building training walls on sand movement

These structures are no sure barrier to the sea as storm surges can easily destroy the walls. Houses and buildings need to have deep piles so that waves cannot erode foundations.

## Groynes

Groynes are constructed to trap sand passing the eroded areas (Figure 248.1). **Groynes** are basically boulder walls built at right angles to the beach. These walls need to extend far enough out to sea to form a barrier to longshore sand movements. They act as headlands trapping the moving sand. They slow down these longshore currents and cause them to deposit their load of sand against the wall (Figure 248.2).

The major impact of groynes is that they merely transfer the problem along the beach. To overcome this some beaches have a series of groynes or groyne fields. This of course will present a problem to the next beach, as it will have little or no sand arriving to replenish its own eroded sand.

Groynes do not prevent beach erosion during severe storms as they cannot prevent offshore movement, so beaches that have been built up by groynes over years can be washed away in an overnight storm. Also groynes destroy the scenic look of wide long expanses of beach.

## Breakwaters

A **breakwater** is similar to a groyne as it goes out at right angles to the beach for a certain distance before it veers in the direction of longshore current. Breakwaters cause accretion on the updrift side resulting in the buildup of sand on the beach. An area of protection occurs behind the breakwater and erosion occurs further along the beach. This also protects an area from the forces of the sea and thus offshore movement of the sand.

## Training walls

As Australia was developed, nearly all of the trade and traffic was by sea. Towns and cities were built where there were good harbours and fresh water. Local river entrances had to be used as harbours and these entrances were not well protected, so engineers built training walls to secure a safe passage for trawlers and recreational fishers.

In many places these **training walls** (Figure 248.2) created problems because they halted the natural flow of sand causing beaches on the updrift side to lose their supply of sand estimated in some places at 500 000 cubic metres of sand a year.

Over time sand destined for these beaches was trapped behind the training wall severely affecting the dynamics of the beaches on the other side.

## Problems with training walls

On Queensland's Gold Coast, a set of training walls was built to allow ships to enter and leave the local river (Figure 248.4).

The walls were built in from a natural headland which protected the famous surfing point at Kirra Beach. In the natural system that supplied sand to beaches such as Kirra, waves would bring sand from New South Wales, past the rivermouth and on to the beach. However, the training walls halted the natural flow of sand, causing the local beach to lose its supply of sand and **beach erosion** to occur.

To combat this, the government built two groynes as shown in Figure 249.1. However, they had only minimal effect on the erosion and much more money has had to be spent to fix the problem.

## Sand bypassing systems

The solution to sand being trapped by a training wall was to build a sand by-pass system as shown in Figures 249.2 and 249.3. Here sand is picked up by a pumping jetty using a series of jet pumps, and gravity fed to a pump station on shore.

From here the sand was pumped to the other side of the river (Figure 249.4) usually at night when the electricity was supplied at an off peak rate. The sand flowed out of a pipe onto the beach which was then picked up by the long shore current on the other side of the wall.

Engineers could then calculate the amount of sand required by the beach on the other side and pump the required amount of sand to stop erosion. However five years later the build up of sand has been so great at Kirra, that the world class surf break has disappeared.

## Artificial off-shore reefs

### Hard reefs

Artificial off-shore barriers reduce wave action on the beach and can be constructed parallel to the beach to slow down the waves, decreasing their energy directly in front of the reef.

The lessening of wave action will decrease the longshore currents set up by the waves, thus reducing the erosion.

This is a costly method which is proving a very effective long term solution to coastal erosion and is creating a growing field of employment for coastal engineers. It has been suggested that these offshore reefs could even be constructed of strips of plastic simulating seaweed, which would reduce the velocity of the ocean currents allowing the sand to be deposited at the desired point.



Figure 249.1 Groynes at Kirra Point



Figure 249.2 A sand bypass system



Figure 249.3 By pass jetty



Figure 249.4 Sand pumped onto beach

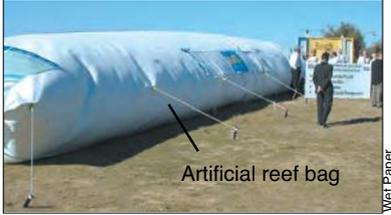


Figure 250.1 Artificial reef and bag



Figure 250.2 Port Kembla



Figure 250.3 Navigation markers



Figure 250.4 Dredge in canal

In Western Australia one artificial break at Cables between Cottesloe and Leighton beaches hasn't proved as successful as its \$2 million price tag and 10 years of research might suggest. The long term effects of this reef are still being monitored as it has been placed on a shore sheltered by an island with infrequent storm wave impact. Hard reefs however provide a great place for SCUBA diving and fishing as they allow places for fish to grow and reproduce.

### Soft reefs

Artificial reefs are a new innovation in coastal engineering based on world's best practice. The reef shown in Figure 250.1 was constructed from geotextile bags to avoid the unsightly rocks of a groyne.

### Ports, harbours and marinas

Approximately 98% percent of all goods come to Australia by sea and ports, harbours and giant jetties (Figure 250.2) have been built so ships can load and unload cargo. These large structures have a marked effect on coastal infrastructure and have to be built now to strict environmental and safety guidelines.

On a smaller scale, marinas have been built to provide the boating public places to moor their boats. These too provide engineers with environmental challenges such as sewerage disposal, electricity and water supply, storm protection as well as marina infrastructure. Harbours require lights and markers (Figure 250.3) to guide boats in safely. Special materials and paints are necessary to withstand the severe sea conditions. Moorings are floats or places where boats and yachts are tied up for short or long periods. The anchoring mechanisms need to be designed so the mooring does not move.

Piers are permanent structures that are constructed in low energy wave areas to provide an amenity for local fishers, yacht owners, divers or swimmers. Famous piers can be found dotted along the entire Australian coastline.

### Canals

These were structures built in the early 1970's for a culture of home owners who wanted waterfront property. Dredges would pump up sand from coastal wetlands so residential properties could be built as shown in Figure 250.4.

### Problems

For marine animals canal development has meant reduced habitat because large areas of mangroves were cleared and estuarine water movements changed.

This had the effect of killing off other nearby coastal wetlands. Fish breeding habitats disappeared, birds had no habitat and with housing development and increased population, rivers were dammed and nutrient runoff increased.

For councils, the problem of floods increased. Canal development changed the natural flow of waters to rivers. The solution was to build dams inland to reduce the effects of floods, but this then had the effect of reducing inland habitat.

## Lighthouses

These used to be managed by lighthouse keepers but have now been completely automated. Reliable technology needed to be developed to guarantee safety to shipping.

## Oil rigs

Bass Strait and the North West Shelf are two areas around Australia where oil and gas rigs exist. The design of these need to allow for minimal environmental impact, good living conditions for staff, safe work places for drilling to occur and supply pipelines to transport oil and gas many thousands of kilometres under the sea.

## Overseas telecommunications

Cables were laid in the 20th century when satellite communications were not as advanced. Most telecommunications now are transmitted by digital technology.

## Wind farms

Wind farms (Figure 251.3) produce clean energy, reduce greenhouse gas emissions and ultimately help mitigate climate change and may become part of the coastal landscape of the future. They are still experimental.



Figure 251.3 Wind farm Esperance WA

## Offshore tourist pontoons

Figure 251.5 shows an offshore snorkelling pontoon built to moor tourist vessels.

## Beach stormwater drains

New environmental legislation in most Australian states prohibits chemical discharge into the environment. Stormwater issues arise where local councils have to design gross pollution traps or catchment strategies that will achieve this objective or face prosecution. In many cases there is an engineering solution either at the manufacturing end of the production cycle or the pollution end of the drain. Chapter 21, page 245 discussed stormwater gross pollution traps.



Figure 251.1 Jetty

Bob Moriatt

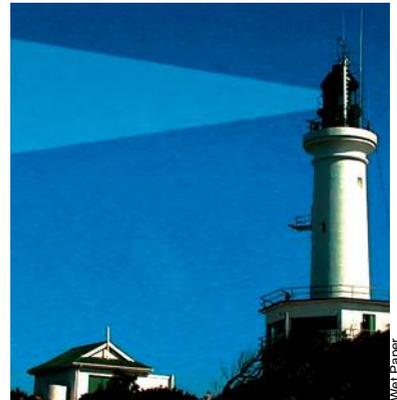


Figure 251.2 Lighthouse

Wiet Paper



Figure 251.4 Oil rig

National Oceans Office



Figure 251.5 Offshore pontoon

Bob Moriatt

## Diving deeper



1. Research why training walls have been built at the mouth of so many of our rivers.
2. Find out how offshore artificial reefs help beach construction.
3. Build a model groyne to show that you understand what it is and why they are constructed. Research how effective they are in preventing beach erosion during severe storms.
4. Research the progress of the artificial reef in Queensland built to protect Narrowneck beach from erosion.
5. Create a sand tray model to show what a beach and sand dune system looks like on your nearest beach.
6. Design the perfect artificial offshore reef break.
7. Debate high density development on the coastal zone - just how much development should be allowed?
8. Make a model oil rig or poster to show how oil and gas are mined from the sea.
9. Make a model boat harbour complete with lights and facilities.
10. Design a wind generator.
11. Use your digital camera to make a collection of coastal engineering structures from your nearest coastal area.
12. Design a house to withstand a cyclone.
13. Visit a lighthouse and write a report on its history.

## Key words

Artificial reef, beach erosion, boulder wall, breakwater, canal, coastal engineering, desalination plant, groyne, harbour, lighthouses, marinas, offshore tourist pontoons, oil rig, port, rock revetment, sand bypassing systems, training wall, wind farm.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. [1] \_\_\_\_\_ includes the construction in, near or on the coast of houses, high-rise, marinas, [2] \_\_\_\_\_, [3] \_\_\_\_\_, sand pumping jetties, aquariums, boulder walls, artificial reefs and [4] \_\_\_\_\_ estates.
- b. [5] \_\_\_\_\_ walls are one of the most common structures used in the prevention of beach erosion and in many coastal developments is [6] \_\_\_\_\_ with the cost borne by the developer or home owner.
- c. Groynes do not prevent beach [7] \_\_\_\_\_ during severe storms as they cannot prevent offshore movement, so beaches that have been built up by groynes over years can be [8] \_\_\_\_\_ away in an overnight storm.
- d. A [9] \_\_\_\_\_ is similar to a groyne as it goes out at right angles to the beach for a certain distance before it veers in the direction of longshore current. Breakwaters cause [10] \_\_\_\_\_ on the updrift side resulting in the buildup of sand on the beach.
- e. The solution to sand being trapped by a training wall was to build a [11] \_\_\_\_\_ - \_\_\_\_\_ system. Here sand is picked up by a pumping jetty using a series of [12] \_\_\_\_\_, and gravity fed to a pump station on shore.
- f. Hard reefs however provide a great place for [13] \_\_\_\_\_ diving and fishing as they allow places for fish to grow and [14] \_\_\_\_\_.
- g. [15] \_\_\_\_\_ eight percent of all goods come to Australia by sea and ports, harbours and giant [16] \_\_\_\_\_ have been built so ships can load and unload cargo. These large structures have a marked effect on coastal [17] \_\_\_\_\_ and have to be built now to strict environmental and safety guidelines.
- h. In many cases there is an [18] \_\_\_\_\_ solution either at the manufacturing end of the [19] \_\_\_\_\_ cycle or the pollution end of the drain.

# Chapter 23 Waves



### Web references

[www.coastalwatch.com.au](http://www.coastalwatch.com.au), [www.ga.gov.au](http://www.ga.gov.au), [www.slsa.com.au](http://www.slsa.com.au), [www.surfrider.org.au](http://www.surfrider.org.au)

The study of waves is important because not only do they shape our coastline, move sand along our beaches, determine where marine life is found on a rocky shore, and control our fishing and tourism industries, they also provide a surfing way of life that we have come to enjoy (Figures 253.1 and 253.2).

The winter waves in Hawaii break with such force that if you lie in bed on the North Shore of the island, you can hear the cutlery rattle in the kitchen drawers. Big waves can provide great thrills, but they can bring great damage to beaches, property and sometimes lives. In 2004 a huge seismic wave or tsunami struck 5 countries in the Indian Ocean causing enormous loss of life. How can waves cause so much damage, endanger some, and be a source of excitement to others?

To answer these and other questions we need to understand how waves are formed, how they move and where their energy comes from. We also need to learn about different types of waves and the ways we can use them safely for recreation.

Firstly, let's have a close look at the structure of waves to observe some of their main features.

## Wave characteristics

### Wave shape

All waves have a length and a height as shown in Figure 253.3. The top of the wave is the **crest**, the lowest point of the wave is the **trough** and the distance between waves is the **wavelength**.

Rough weather at sea breaks up wave crests. As waves become steep and top heavy, they break when their height gets to about one-seventh of their wavelength.

During calm weather, waves move through the ocean at speeds of 15 to 30 kilometres per hour and only break when they reach the shore. As the water becomes shallower towards the shore, the approaching wave gets steeper because other waves bank up behind it.



Figure 253.1 Body boarding



Figure 253.2 Reef break at Sunset Beach, Oahu, Hawaii

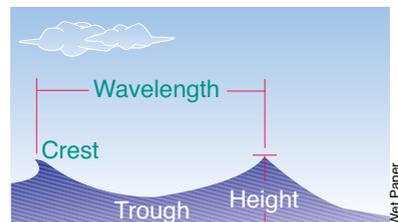


Figure 253.3 Structure of an ocean wave

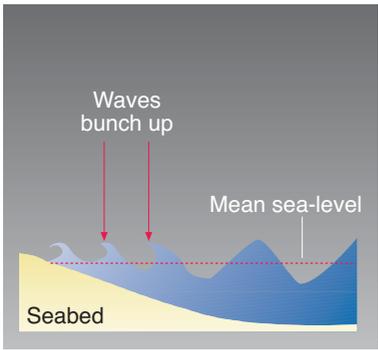


Figure 254.1 Waves approaching the shoreline

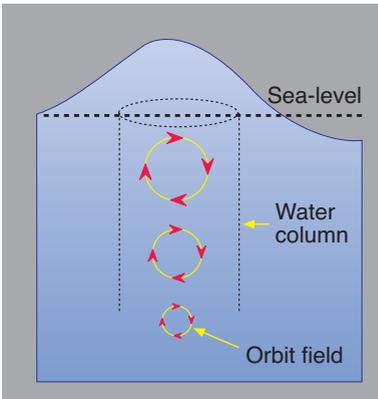


Figure 254.2 Water movement in waves



Figure 254.3 Swell waves are found at sea.



Figure 254.4 The bigger the fetch the bigger the wave

The wave gains height and then breaks when the crest falls over as shown in Figure 254.1. Objects are only carried forward by a wave as it is about to break.

Next time you go to the beach, watch unbroken waves as they pass a stationary boat or surfers sitting on their boards. You should see that the boat or surfers will only move up and down in the one spot.

If you look very closely you will see them move slightly forward, then back in a circular path.

This means that although unbroken swell waves appear to be moving forward, they are actually only moving up and down in circular **orbit fields** as shown in Figure 254.2.

The energy within these waves, however, is carried forward at right angles to the up and down motion of the wave. This is difficult to understand because you cannot actually see the energy. It may help to compare it with a row of dominos toppling over after the first one is pushed. The dominos appear to move forward but actually stay in the one place, the energy of their movement travels forward to the end of the line.

### Wave formation

Waves are formed by winds which blow over specific areas at sea called **fetch** zones, shown in Figure 254.5.

The winds in these areas initially produce small ripples. As these ripples join together, they form **waves** in a rising sea. Finally the waves move out of the fetch zone and become ocean **swells** and are transported throughout the world's oceans without breaking. They appear as a rolling series of crests and troughs and can reach large heights and long wavelengths.

The length of the fetch zone determines the wavelength - a longer fetch zone creates a longer wavelength and a bigger wave (Figure 254.4).

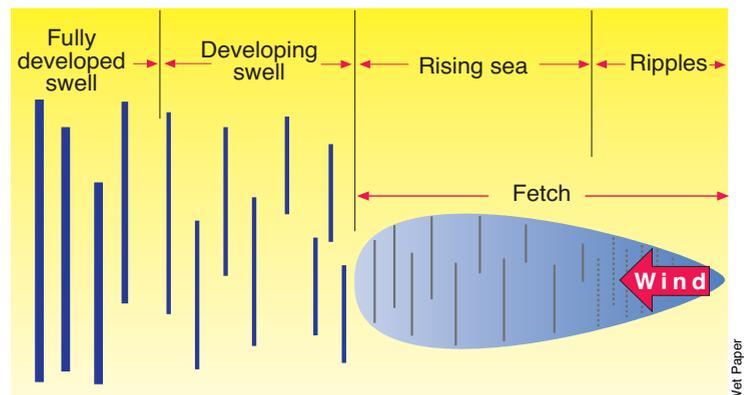


Figure 254.5 How waves are formed in a fetch.

## Types of waves

Waves break when they move into shallow water on a reef out at sea and near headland or coastal beach. Three types of waves are **spilling**, **surgings** and **plunging** — all determined by the shape of the ocean floor, the wind direction and the tide.

A surfer could catch part of the wave as it surged, take off as the wave spilled and ride it through a plunging part until all of the wave had broken. These parts of the ride are called **sections** and can vary with swell, tide and wind. When waves break, they release their energy. The speed with which a wave breaks depends upon the slope of the seabed. If the slope is steep, the waves gain height fast, form a barrel (see over Figure 256.4).

Breaking waves have a top (the **lip**), the broken part or **whitewater** or foam, a smooth **face** and an area in front of the whitewater called the **impact zone** (Figures 255.1 - 255.3).

### Spilling waves

If the seabed slopes gently, waves tend to build up slowly, with a smaller crest breaking over a larger wave body. This type of wave usually breaks in sections or peaks, appearing to ‘peel’ from one side of the beach to the other. Surfers prefer this type of wave because of the possibility of longer, safer rides.

### Surging wave

These waves occur over reefs or at the base of rocks as the wave rises from deep water. Surfing waves are very dangerous for rock fishermen as large amounts of water rise quickly lifting the person off the rock and sweeping them out to sea (Figure 255.4).

### Plunging wave

The full width or face of the wave usually breaks at once, releasing a large amount of energy. This type of wave is called a ‘dumper’ or ‘close out’ by surfers and is avoided because it is potentially dangerous and cannot be ridden far (Figure 255.2). Sometimes waves plunge in sections called a **barrel** which is the ultimate experience for a surfer, (see over).

## Types of break

The seabed structure and slope is called the seabed **topography**. Generally speaking:

- the larger the swell, the larger the wave;
- the lower the tide, the hollower the wave; and
- the steeper the slope, the steeper and higher the wave.

A rocky or reef bottom usually produces more consistent waves with larger faces. Offshore winds hold the wave up, offering a larger, slower-breaking face.



Figure 255.1 Spilling wave parts



Figure 255.2 Plunging waves can be very dangerous



Figure 255.3 Barrel section of a wave

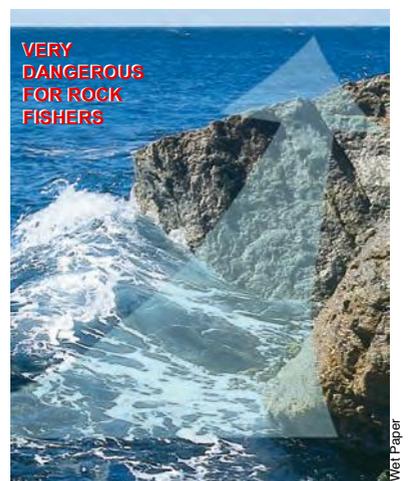


Figure 255.4 Surging waves are very dangerous for rock fishermen



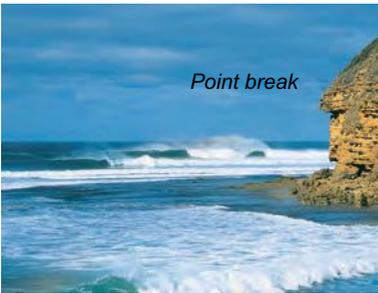
Bob Moffatt

Figure 256.1 Beach break



Wet Paper

Figure 256.2 A left hander beach break, City Beach, Perth



Surfing Australia

Figure 256.3 Famous point break, Victoria



Bob Moffatt

Figure 256.4 Surf break Snapper Rocks

## Research

Use your school computer to check out the surfing at Teahupoo. Then research what ocean seafloor shape makes this wave so narlie. What other words describe this type of wave? What is the green room in surfing language?

## Beach breaks

Sandy seabeds produce waves called beach breaks which can occur at many sandbanks along the length of a beach, as shown in Figure 256.1. Beach break waves usually peel off from a peak to both left and right. Because each sandbank can vary in distance due to the beach and bottom slope, these waves can be different sizes and shapes.

**Beach breaks** change position, size and shape because the constant movement of sand by waves, currents and tides regularly shifts the sandbanks and alters the seabed topography.

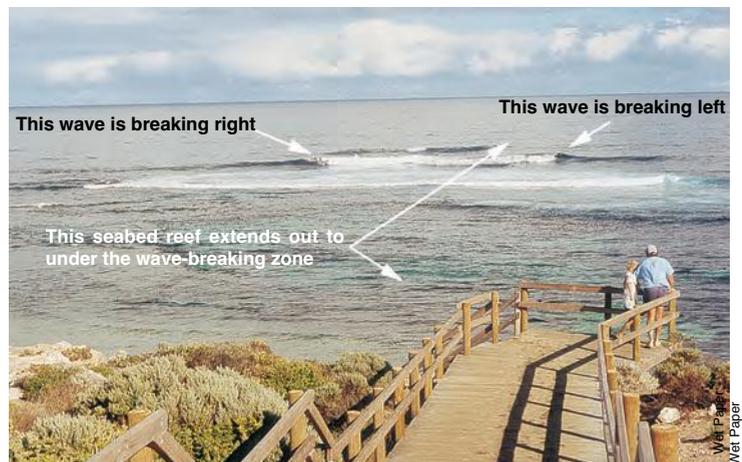
## Point breaks

Reef or rocky seabeds are called **point breaks** (Figure 256.3). They are mostly located on headlands or rocky points though some are found on small, isolated reefs (these are called **bommies**).

**Point break** waves usually peel off in one direction only, depending on which end of a beach the headland is located. If on the left end, facing the sea, the waves peel to the left and are called 'left hand break'. If on the right end, the waves peel off to the right and are called 'right hand break'. Figure 256.1 shows the difference between a left hand and a right hand break. Because the bottom topography on point breaks is stable, the waves tend to be a consistent shape making them easier to ride than beach breaks.

## Reef breaks

These are perhaps the most critical of wave breaks as the wave passes over live coral. In Figure 256.4, the wave has passed over a vertical reef ledge from very deep water. The white water is breaking in a lagoon making this type of wave very difficult to ride.



Wet Paper

Figure 256.5 Seabed topography at Margaret River which produces some of the largest rideable waves in Western Australia.

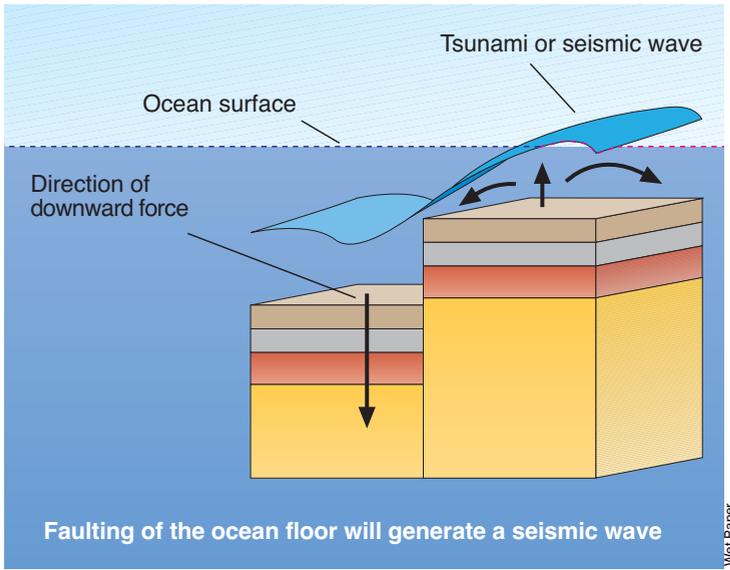


Figure 257.1 Faults and seismic waves

**Seismic sea waves (tsunamis)**

**Tsunamis** (pronounced ‘soon armies’) are produced by large, sudden movements in the Earth’s crust, such as those caused by earthquakes and volcanoes (Figure 257.1).

A lot of people imagine these waves travel throughout the ocean at great heights and then crash ashore. In fact they may only be a few centimetres high, but because of their great speeds, they rear up to great heights when they do reach the shore.

Tsunamis are shock waves caused by the sudden movement of a large volume of water. This movement of water is mostly caused by underwater earthquakes or volcanoes. The waves formed travel long distances (Figure 257.2) and have wavelengths of up to 200 kilometres, wave periods of up to 20 minutes, and speeds of up to 800 kilometres per hour and can travel around the world.

On December 26, 2004, an undersea earthquake registering 9.0 on the **Richter scale** struck 250 kilometres south-west of Sumatra. The ocean floor dropped almost 40 metres and unleashed a seismic wave that killed over 250 000 people in eight countries across Asia and with effects as far as Somalia in East Africa and even off the west coast of Western Australia.

In March 2011 large areas of Japan's northern Pacific coast were swamped by a devastating tsunami, engulfing entire towns following a major 8.9 offshore quake.

For the first time humankind was able to see the massive force from these waves and with the advent of U tube (Figure 257.3), we can now witness the devastation caused by these events.

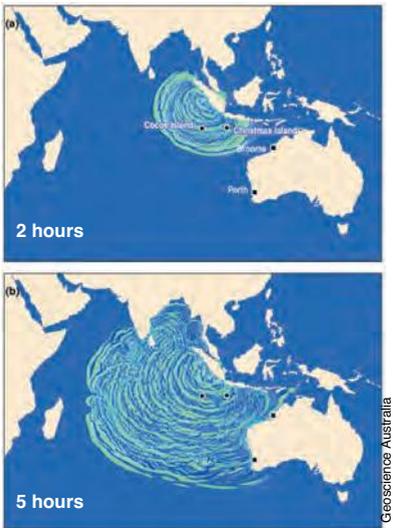


Figure 257.2 Modelling of an Indian Ocean Tsunami  
(Data supplied by Geoscience Australia based on 1833 earthquake)



Figure 257.3 Photo from U Tube footage of Tsunami approaching coastline

**Tsunamis in Australia**

A tsunami is recorded on Australia's coastline about once every two years.

Most are very small and classified low risk. However, several large tsunamis have hit Australia's north-west coast. This area is classified moderate risk, due to its proximity to Indonesia and other countries where large earthquakes and volcanic eruptions can occur.

Tsunami risk area in Australia

Further information:  
Geoscience Australia [www.ga.gov.au](http://www.ga.gov.au)

# Effects of waves

## Waves and beaches

Have you ever wondered why the amount of sand on the beach changes between summer and winter?

In summer, the beach is wider with more sand, and narrower with less sand in the winter. After heavy winter storms, beaches in some areas can temporarily disappear. This is because waves are able to build up and erode beaches in a seasonal **cycle**.

During the winter months or during a cyclone season, high winds and storms make waves larger. Violently breaking waves create a strong backwash which moves sand from the beach and out to sea, where it forms a sandbank. This sand **erosion** makes beaches steeper and narrower, as shown in Figure 258.1.

During summer, waves tend to be smaller so they gradually move sand inward from the offshore sandbank on to the beach where it is deposited in layers. The edge of a deposited layer of sand is called a **microridge** and can be seen as a line on a beach. Onshore winds then blow this sand into grass and trees further up the beach to form the sand dunes shown in Figure 258.2.

If we cut down these trees, trample the grass and build highrise buildings on the sand dunes, the sand will blow away, the beach will erode and the buildings will fall into the sea. This happened in Surfers Paradise when a series of cyclones struck the beaches in 1967. Sea walls costing \$20,000 (at that time) per 25 metres had to be built and buried to protect the home units from falling into the sea in future storms (Figure 258.3). It would have been less expensive to leave the sand dunes alone.

## Waves and marine life

Marine organisms live on the shoreline in various habitats and environments.

**Intertidal** organisms have adapted to withstand the destructive power of waves. For example, barnacles have developed a very hard shell, small size, conical shape and the ability to cement themselves to rocks. Shells have developed a strong muscular foot to suction onto rocks and other animals such as crabs are flat and thin so they can squeeze into crevices.



Figure 258.1 Beach erosion, NSW

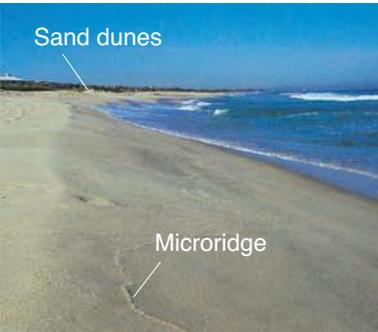


Figure 258.2 Beach building near Bunbury, WA



Figure 258.3 Sea walls costing \$20,000 per house have had to be placed in front of housing and buried.



Figure 258.4 Seagrass after a storm WA

Kelp has developed a thick skin, a long, thin shape and a root system called a **holdfast**, which is second in tenacity only to the barnacle, to keep it attached in its chosen environment (see Figure 259.1).

On the beach where the dumpers break, living under the sand is safer, so everything burrows down. Small shelled animals called pippies use a strong foot to dig themselves in and a sandworm's long segments each have a number of legs or bristles which bind them to the sand particles.

However, even the best **adaptations** cannot always withstand the force of the waves. Storms devastate kelp and seagrass beds and plant material can often be seen piled high on many southern beaches in Tasmania, Victoria and South Australia. The same is true for shells which pile up in places where they are dumped when the wave energy slows. Even barnacles do not escape the destructive power of waves as shifting sand often covers them up.

## Surfing the waves

Breaking waves release a considerable amount of energy which can be harnessed for our needs. For example, energy from waves can be used to create an alternative source of electricity.

However, we mostly use the energy from waves for sport and recreation, including body surfing, body boarding, surf skiing, sailboarding and board surfing.

The ability to catch waves, which is common to all the above surfing activities, has the same basic principles. For this reason, we will take a close look at and make a case study of board surfing.

### Clothing

The basic surfing equipment is board shorts and lycra shirt in summer, or wetsuit and booties, and even a helmet, for when the water temperature drops below 20°C. In summer and winter, you should use plenty of waterproof 15 + sunscreen as, over the years, the sun's ultraviolet rays can damage the skin and turn normal cells into cancer cells.

A wet suit will keep you warm as it allows a very thin layer of water to enter the suit. This water heats up from your body heat (see Chapter 8 page 105). Booties and a rubber hood for your head will also be needed if you surf in southern waters to avoid ice-cream headaches and sea urchin spine injuries. However in warmer waters a lycra rashie will protect your skin from burning.



Figure 259.1 Kelp can be strewn on beaches after storms.

## Diving deeper



1. Research the best places for a surf at your nearest beaches.  
Include in your research whether the places are points, beach breaks or a combination of both.  
Note the best conditions for surfing, such as wind direction, time and tide.
2. Describe the waves and conditions preferred by the following:
  - a. boardriders
  - b. sailboarders
  - c. fishers
  - d. body boarders
3. Research the seasonal cycle of your nearest beach. Make sketches over a year.
4. Research the cause of the 2004 Asian tsunami.
5. Make up a table of surfers lingo. Write a paragraph using it to explain how a surfer would describe to his friends an epic surf session.



Figure 260.1 Deck grip, wax and leg rope

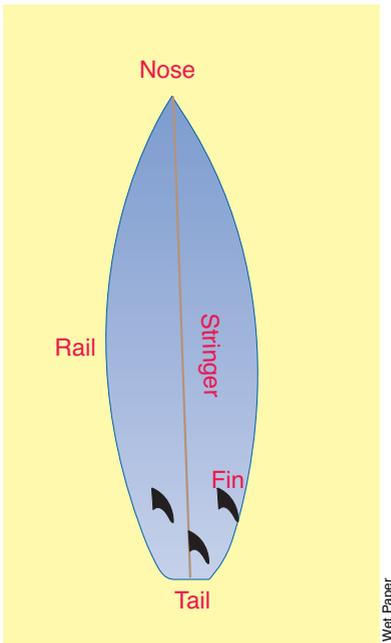


Figure 260.2 Surfboard underside



Unfortunately the days of leaving your car keys or bike in the dunes are gone. So where do you put your valuables these days? Many board **leg ropes** (Figure 260.1) have a pouch where you can fit a key; and many board-short manufacturers now make a pocket for the same purpose.

## Equipment

Surfboards come in many lengths and designs. Figure 260.2 shows a basic surfboard design from the bottom surface. The surfboard is the most expensive piece of equipment you need for this sport so it is a good idea to buy a second-hand board at first. Besides being much cheaper than a new board, it won't matter so much if you dent it while learning. Also you will have more of an idea of the size and design that suits your style after gaining some experience.

Surfers apply **wax** to the top surface of surfboards to improve their grip. You may not need to do this if the board is fitted with a gorilla grip, a non-slip layer of rubber latex shown in Figure 260.1.

So that you don't lose your board when you fall off (or '**wipe out**' which often happens when learning), a leg rope attaches the surfboard to your body.

## How to surf

Learn to paddle your board in a quiet place, such as a river, before you enter the surf. Get a feel for your board by lying down and paddling along while keeping the nose out of the water by about 50 millimetres. Now practise getting to your feet quickly. To do this, put the board on the sand, practise paddling and then jump up quickly.



Figure 260.3 A beginners surf

The quicker you can get up, the easier it will be to get your board going when you are in the surf. If your right foot is in front of your left foot you will be a '**goofy foot**' surfer and if it's the other way around you will be a '**natural stance**' surfer. The difference between the two is shown in Figure 261.1 and will affect the way you surf.

## Paddling out

Find a nice even break (as shown in Figure 260.2) to learn how to ride your board in the surf. Paddle out to an area behind where the wave is breaking (called the take off point) as shown in Figure 261.2. Use the techniques you taught yourself in the river and paddle out to avoid the surfers riding in (see surfing rules in Figure 262.4 over).

Use **rip currents** to help you paddle out. These currents, which go out to sea at right angles to the beach, make paddling faster and easier because they usually don't have breaking waves for you to paddle out through. Rip currents also occur near rock walls and headlands.

Breaking waves can make life very difficult for beginner surfers because, as you try to paddle out through them, they tend to wash you back to the shore.

A technique called **duck diving** helps to reduce the amount of energy you need to swim through breaking waves.

- To do this, paddle hard and grab the rails just behind the nose with both hands and move slightly forward.
- Now push the nose down and through the wave as it breaks.

Transfer your weight to the back of the board as the wave goes over you and dig your knees in to lift the front of the board.

As a general rule the bigger the wave the deeper you need to duck dive.

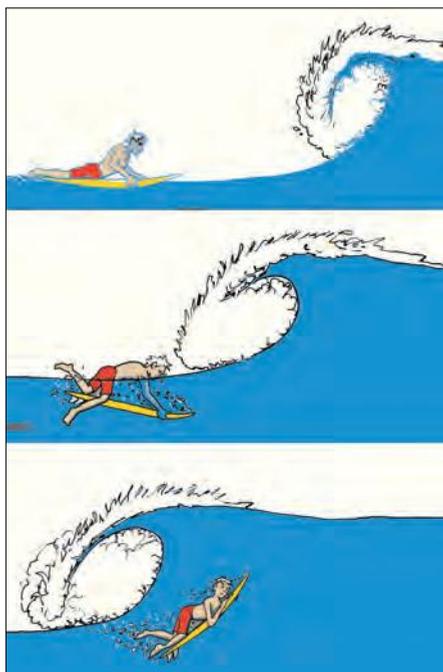


Figure 261.3 Duck diving is a useful way to get through breaking waves



Figure 261.1 The difference between a goofy foot and a natural stance



Figure 261.2 Paddling out



1. What factor initially produces waves?
2. Draw a fully labelled diagram of a wave showing its crest, length, height and trough.
3. Use a sketch to describe how a wave approaches a shore.
4. Explain how a *dumper* is formed.
5. Describe how waves break in deep water.
6. Describe what will happen to a cork floating in the sea if it is picked up by a swell wave and a breaking wave.
7. Why are waves on point breaks said to be so consistent?
8. Explain how the topography of the seabed floor can affect the shape of a wave.



Figure 262.1 How to catch a wave



Figure 262.2 How to roll under a wave

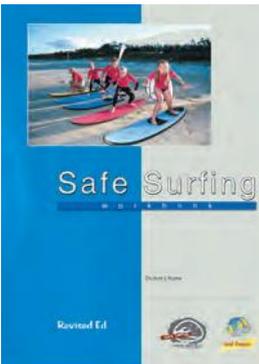


Figure 262.3 Safe Surfing Workbook  
www.wetpaper.com.au

## Catching a wave

This part is the most difficult so don't be disappointed if you don't manage to catch a wave in your first few attempts. Paddle one or two more strokes until you are sure you are on the wave.

If the nose of the board dips, arch your back to shift your weight to the rear of the board. Place both hands on the rails under your shoulders, straighten your arms and jump up really quickly, placing your feet over the stringer line.

## Turning on a wave

With your knees bent, and feet over the centre as before, transfer your weight onto your back foot to dig the tail and fin into the wave. This acts as a pivot and assists the start of your turn. These skills will take some time and lots of practice to achieve.

## Surfing code of ethics

Before you catch a wave, you must be aware of the rules of surfing courtesy and safety as summarised in Figure 262.4.

<p><b>Don't drop in</b></p> <p>Surfer A is nearer the shoulder and has right of way. B must give way to A. If B does catch the wave he/she is "dropping-in" on surfer A. <i>Don't drop in.</i></p>	<p><b>Never throw your board</b></p> <p>Surfer B has fallen off the board and let go. <i>Always hold onto your board so that it does not hit others causing serious injury</i></p>
<p><b>Caught inside - stay inside</b></p> <p>Surfer A should try to avoid surfer B who is either stationary or paddling out. <i>B must paddle into the broken wave so as not to interfere with A.</i></p>	<p><b>Paddle wide to stay alive</b></p> <p>Surfer A, riding the wave, should try to avoid surfer B who is either stationary or paddling out. <i>Paddle wide to allow A to make full use of the wave.</i></p>
<p><b>Don't snake</b></p> <p>Surfer B is not entitled to catch the wave that has already been caught and ridden by A. <i>This is a 'Snake' Do not snake.</i></p>	<p><b>Don't surf beyond your ability</b></p> <p>It takes many years to ride challenging waves. <i>If you are a learner, don't go out in a crowded line-up or in big surf.</i></p>

Figure 262.4 Some surfing rules

# Key words

Adaptations, beach break, crest, duck diving, dumper, energy, erosion, face, fetch, goofy foot, holdfast, intertidal, leg rope, lip, microridge, natural stance, orbit field, plunging wave, point break, reef break, richter scale, rip current, seismic sea waves, spilling wave, surfboard, surging wave, swell, topography, trough, tsunamis, wave characteristic, wave formation, wave shape, wavelength, wax, whitewater, wipe out.

# Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. The study of waves is important because not only do they [1] \_\_\_\_\_ our coastline, move sand along our beaches, [2] \_\_\_\_\_ where marine life is found on a rocky shore, and [3] \_\_\_\_\_ our fishing and tourism industries, they also provide a surfing [4] \_\_\_\_\_ that we have come to accept.
- b. The top of the wave is the [5] \_\_\_\_\_, the lowest point of the wave is the [6] \_\_\_\_\_ and the distance between waves is the [7] \_\_\_\_\_.
- c. Breaking waves have a top (the [8] \_\_\_\_\_), the broken part or [9] \_\_\_\_\_ or foam, a smooth [10] \_\_\_\_\_ and an area in front of the whitewater called the [11] \_\_\_\_\_.
- d. [12] \_\_\_\_\_ waves usually peel off in one direction only, depending on which end of a beach the [13] \_\_\_\_\_ is located. If on the left end, facing the sea, the waves peel to the [14] \_\_\_\_\_ and are called 'left hand break'.
- e. [15] \_\_\_\_\_ are produced by large, sudden movements in the Earth's crust, such as those caused by [16] \_\_\_\_\_ and volcanoes.
- f. During the [17] \_\_\_\_\_ months or during a [18] \_\_\_\_\_ season, high winds and storms make waves [19] \_\_\_\_\_. Violently breaking waves create a strong [20] \_\_\_\_\_ which moves sand from the beach and out to sea, where it forms a [21] \_\_\_\_\_. This sand [22] \_\_\_\_\_ makes beaches steeper and narrower.
- g. [23] \_\_\_\_\_ organisms have adapted to withstand the destructive power of waves. For example, [24] \_\_\_\_\_ have developed a very hard [25] \_\_\_\_\_, small [26] \_\_\_\_\_, conical [27] \_\_\_\_\_ and the ability to cement themselves to rocks.
- h. If your right foot is in front of your left foot you will be a '[28] \_\_\_\_\_' surfer and if its the other way around you will be a '[29] \_\_\_\_\_' surfer.



- 9. What main factor makes a tsunami so dangerous?
- 10. Explain the difference between *swell* and *breaker waves*.
- 11. Construct a table that outlines the differences between reef, point and beach breaks.
- 12. What is a *microridge* and how does it form?
- 13. How are barnacles and kelp adapted to life in the waves?
- 14. What clothing and equipment is required for board surfing?
- 15. What is a *gorilla grip* and why is it useful?
- 16. When you first arrive at a beach, what should you do before going into the water?
- 17. Explain what *dropping in* means and why it is not recommended.
- 18. Why is paddling out so energy-sapping for beginner surfers?
- 19. List three ways to make paddling out easier and faster.
- 20. Why, when turning a surfboard, do you need to put weight on your back foot?
- 21. Where is Australia's greatest risk from a tsunami? What factors make this area a risk?
- 22. Draw a diagram to show the parts of a wave.
- 23. What is *snaking* and why is it bad practice?

# Chapter 24 Tides and currents



Geoff Jensen

Bob Moffatt

**Web references**  
[www.bom.gov.au](http://www.bom.gov.au), [www.csiro.gov.au](http://www.csiro.gov.au),  
[www.aims.gov.au](http://www.aims.gov.au), [www.marine.csiro.au](http://www.marine.csiro.au)



Old Fisheries

Figure 264.1 Pumping for yabbies at low tide



Wet Paper

Figure 264.2 How can you tell that this barge is unloading at high tide?



Wet Paper



Wet Paper

Figure 264.3 High and low tides

**Tides** are the periodic rise and fall of water on the Earth's surface. This rise and fall of the water level has a great effect on our lives.

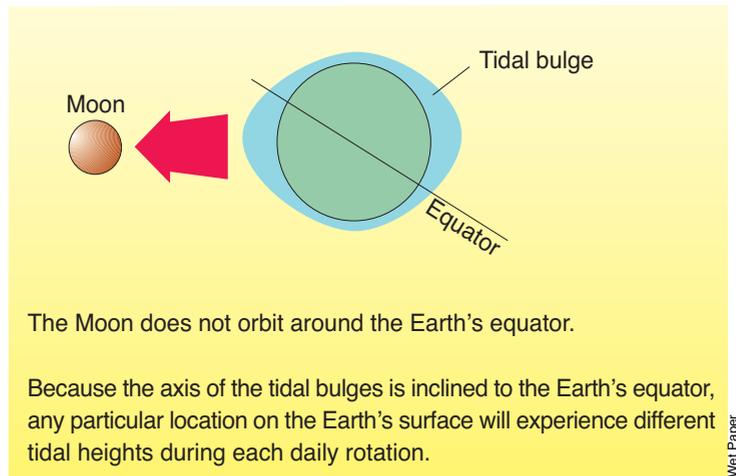
Understanding tides helps in the building of marine structures, such as jetties and boat ramps by marine engineers; navigating coastal waters and harbours by marine shipping; navigating shallow tidal creeks; mooring boats; driving vehicles along the foreshore; collecting bait, such as yabbies and worms, on tidal flats; sailing, snorkelling, swimming, picnicking and camping or fishing, because many areas fish better on different tides.

## What causes tides?

The tides are caused by the **gravitational attraction** of the Moon and the Sun on the Earth (Figure 264.4).

The force of the Moon's gravity pulls out a bulge of sea water on one side of the Earth. Another tidal bulge forms on the other side of the Earth because of the **centripetal force** of the Earth's spin.

The result is two high tides every 24 hours.



Wet Paper

Figure 264.4 The Moon's effect on tides

## Centripetal force

**Centripetal force** is the force that acts on bodies such as the Earth and the Moon which keeps them moving in a circle. The Moon's pull acting against the Earth's centripetal force causes tidal bulges in the oceans of the Earth.

To show how this works, try this experiment. Place 1 litre of water in a 9 litre bucket. Make sure the bucket has a sturdy handle. Now whirl the bucket at a uniform speed around your head. What happens when you do this and what forces keep the water in the bucket? What happens as the speed at which you whirl the bucket is reduced?

As the Earth rotates, a particular position on the coastline will experience two high tides and two low tides a day as it passes through the two tidal bulges.

The time interval between one high tide and the next low tide, or vice versa, is called the duration of the tide. The average duration of the tide is 6 hours.

The time of high tide varies by about an hour a day because, as the Earth spins round the Sun, the Moon orbits the Earth. Therefore, the Moon passes over the same point on Earth every 24 hours and 50 minutes. So the tides are 50 minutes later each day. (See Figure 265.1).

## Spring and neap tides

The gravitational attraction exerted by the Sun also helps produce tides, but the Sun's effect is only about 40% that of the Moon.

**Spring tides** occur where the Earth, Moon and Sun are in a straight line. The gravitational pull of the Sun and the Moon are combined and the tides are at their highest.

These tides occur when the Moon is in full or new Moon phases (as shown in Figure 265.2).

During a first-quarter Moon and again at the last quarter Moon phase, the Sun is at right angles to the Moon. Their separate gravitational pulls cancel each other out and produce a smaller high tide and a higher low tide.

This is a **neap tide**. The tidal range between high tide and low tide is small during a neap tide.

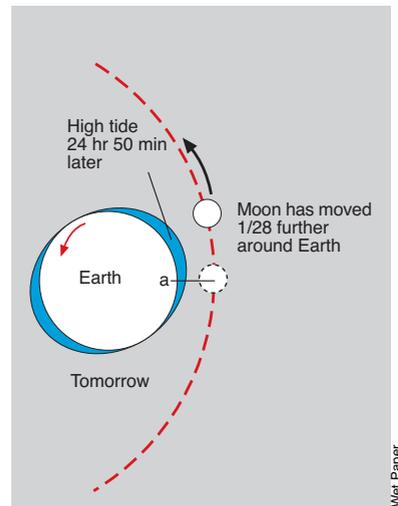
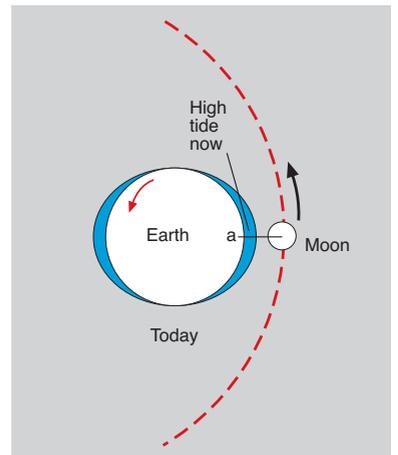


Figure 265.1 High tide occurs later each day.

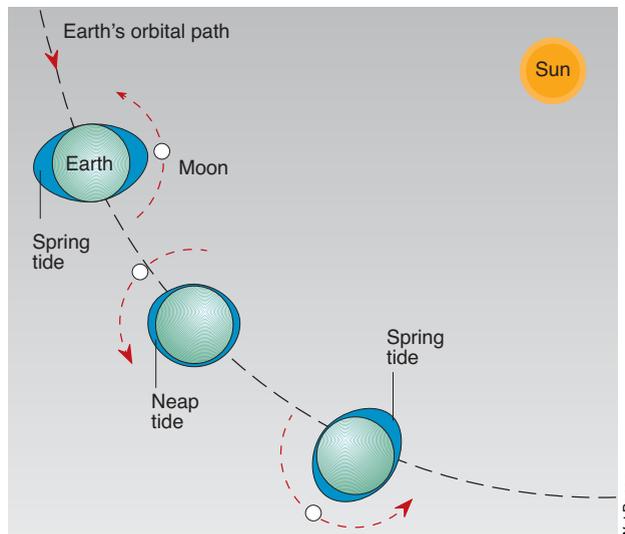


Figure 265.2 Spring and neap tides

## Tide heights

<b>Derby, Western Australia</b>	
Time	Height
0438	0.4 m
1050	9.3 m
1708	0.7 m
2330	10.9 m
<b>Fremantle, Western Australia</b>	
Time	Height
0849	1.3 m
1901	0.5 m
<b>Darwin, Northern Territory</b>	
Time	Height
0639	6.4 m
1219	2.7 m
1748	5.7 m
<b>Mackay, Queensland</b>	
Time	Height
0309	5.1 m
0826	1.8 m
1445	0.3 m
2140	5.5 m
<b>Brisbane, Queensland</b>	
Time	Height
0349	0.6 m
0908	1.7 m
1510	0.3 m
2154	2.4 m
<b>Sydney, New South Wales</b>	
Time	Height
0232	0.4 m
0822	1.3 m
1308	0.6 m
2029	1.8 m
<b>Melbourne, Victoria</b>	
Time	Height
0105	0.2 m
0842	0.9 m
1608	0.6 m
2138	1.2 m

Wet Paper

Figure 266.1 Some tide heights

# Tide height and tidal range

The **tidal range** is the difference in height between high and low tides for a given place on the Earth's surface. Tidal ranges vary greatly all over the world. The tidal ranges are only a few centimetres in enclosed seas such as the Mediterranean and the Black Sea but are a startling 15 metres in narrow estuaries such as the Bay of Fundy in Nova Scotia, Canada.

In Australia there is also a great tidal range. On the northern Australian coast between Darwin and Wyndham, the tidal range is spectacular. Further west, at Derby, the tidal range is 10.5 metres and 8.5 metres at Broome.

These are average heights and more exceptional heights are often recorded. Other areas of Australia, such as Fremantle on the Western Australian coast, have a mean tidal range of only 63 centimetres, and there is only one tide a day. Figure 266.1 shows some tidal ranges from around Australia.

## What affects tides?

The height and time of the tide at a certain position on the coastline depend on a number of factors: the weather, the shape of the coastline, the depth of the water along the coastline, the flow of water from the rivers running into the estuaries, and the slope of the foreshore.

### Storm surges

**Storm surge - see also page 214**

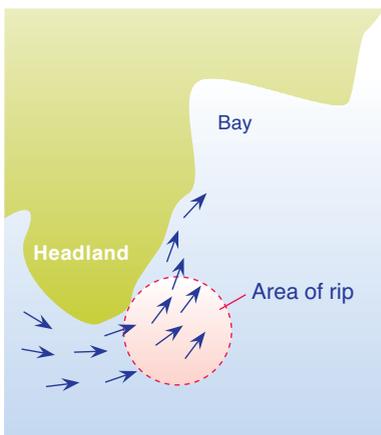
As storms and cyclones approach land, their winds whip up the sea and push a bank of water towards the coast. The height of the storm surge depends on the intensity of the low pressure system (see page 268). Cyclones in Queensland have caused storm surges of 2–5 metres. If these storm surges occur at high tide, they can cause massive flooding of low-lying coastal areas.

### Shape of the coastline

Because coastlines are not straight and oceans are not even in depth, the time at which a tidal bulge reaches an area varies. Headlands and other promontories slow down the water movement and therefore cause differences in tide times. The water is also slowed down by its frictional drag against the ocean floor. The deeper the water, the less the effect of the drag. Water moving past a coastline on a falling tide can also set up strong rip currents, as shown in Figure 266.2.

### Rivers

Tidal currents are also affected by river currents. The tidal currents take time to move up the creeks and rivers flowing into the estuaries, because the natural flow of water out of these rivers and creeks slows down the tidal current.



Wet Paper

Figure 266.2 Headlands, tides and rips

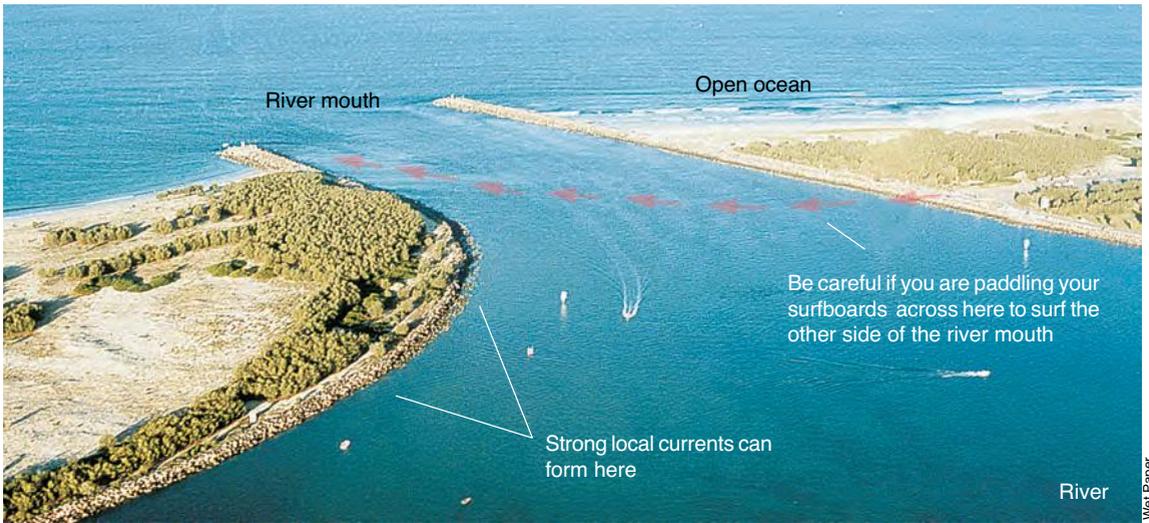


Figure 267.1 Strong currents can form in narrow channels

Some surfers paddle out across river mouths to the other side for a better surf. Apart from wearing a bright coloured shirt to avoid being run over by boats, the surfers should take into account the speed and flow of the current (Figure 267.1). Strong **tidal currents** can form when large rises and falls occur around headlands.

Time your activities in these areas for the top or bottom of the tide to avoid the full force of the tidal current. This current can be very strong when water flows through a narrow channel. Tidal flow are usually well marked on local charts, which also show the speed of the current.

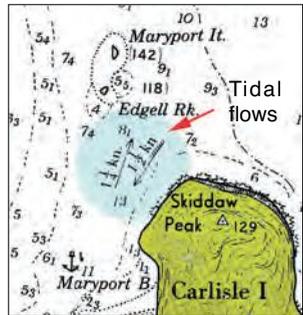


Figure 267.3 Tidal flow

## Overflow currents

When driving a small boat near a river mouth on a strong incoming tide, you will notice a disturbance in the water surface called a **rapid**. This is when the incoming tide passes over a submerged rock or reef causing the water to hump up into an **overflow current** as shown in Figure 267.2. If the wind blows into these humps, uneven breaking waves can form making boating hazardous. In boating, wind blowing into the direction of the tide (Figure 267.4) creates uneven waves leading to the saying “**wind over tide - expect a rough ride**”.

In some rivers in Australia, high water at the mouth is 4 hours earlier than at places 10 kilometres upstream. The tidal range greatly increases when the current approaches shallow water, especially if the estuary is funnel-shaped.

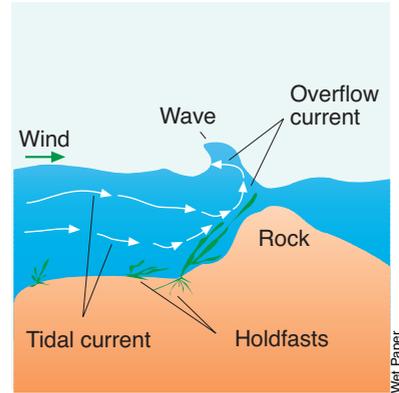


Figure 267.2 Overflow currents caused by strong tidal flows



Figure 267.4 Wind over tide - expect a rough ride.



## Questions

Use your textbook to find the answers

1. Which has the greatest influence on the tides along our coast: the Moon or the Sun? Explain why.
2. How long does it take the Moon to orbit the Earth?
3. Why are the tides approximately 50 minutes later each day?
4. What is *centripetal force*?
5. Why might large tankers always try to enter harbour at high tide?
6. Draw the position of the Earth, Moon and Sun when we experience:
  - a. a neap tide
  - b. a spring tide
7. List the four factors that affect the time and height of a tide.
8. Define the terms *inter-tidal zone* and *inter-tidal range*.
9. The shape of an estuary affects the tidal range.
  - a. What shape produces large tidal ranges?
  - b. Where are the tidal ranges greatest?
10. What are king tides?
11. Define the terms *apogee* and *perigee*.
12. If the tidal range at Mackay is 4 metres and high tide is at 8am, predict the height of the tide at 10 am.
13. An amateur fisherman is fishing in a depth of 8 metres at 9 am. He checks the tide book to find high tide of 2 metres will be at 10 am. What will be the depth of water at 1 pm? Will the tidal current be greater? Explain your answer.

## Atmospheric pressure

The predicted tidal height is based on an average barometric pressure and if the atmospheric **pressure** decreases, the tidal level increases. A low pressure system off the coast of Sydney in July 1984 caused the sea level to rise 30 centimetres in less than 24 hours.

## Wind

Tides can also be affected by winds, particularly along very shallow coastlines. In Europe on 31 January 1953, a North Sea storm produced a wave of water 3.0–3.5 metres high.

This caused major damage to Holland and other low-lying areas in Europe. In 1970 in the Bay of Bengal, a storm surge increased the water level by 3.8 metres and caused extensive flooding in Bangladesh, killing about half a million people.

## Predicting tide heights

Tide experts have been able to explain why the highest tide occurs during the day in summer and during the night in winter. This occurs because the orbit of the Moon around the Earth and the orbit of the Earth around the Sun are elliptical. The Sun is closer to the Earth in summer than it is in winter.

The elliptical orbit of the Earth by the Moon sometimes brings the Moon closer to the Earth. At its nearest point, the Moon is said to be at **perigee** — a distance of 356 803 kilometres from the Earth. The Moon will then exert a greater gravitational attraction than when it is furthest from the Earth at a distance of 407 104 kilometres. Here the Moon is said to be at **apogee** (shown in Figure 268.1). When perigee coincides with the spring tides, the tides rise about 20% higher than normal. These are the so-called king tides.

Tidal prediction programs are now available which are suitable for home computers and programmable calculators. There is, however, no great global theory that can be used to calculate the tides in an area. If a new island was suddenly formed, many measurements would need to be taken to obtain basic information to calculate the island's tide fluctuations.

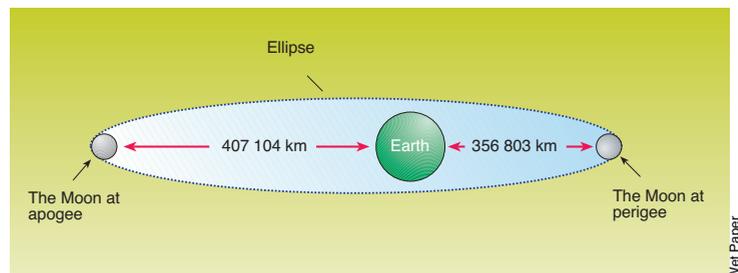


Figure 268.1 Apogee and perigee



Figure 269.1 Tracker buoys and study areas

**Further research**

[www.aims.gov.au](http://www.aims.gov.au)  
[www.csiro.gov.au](http://www.csiro.gov.au)

## Currents

Studying and understanding ocean currents is important for maritime safety and the economy. Local currents, such as **rip** currents on surfing beaches, have claimed many lives. Strong currents caused by **tidal** flows continually create marine hazards. They even damage our marine environment as ships and pleasure boats drag their anchor chains over reefs and coral outcrops.

Marine scientists have only recently begun to investigate ocean currents. In the Pacific Ocean, the study of the **El Niño** phenomenon off Peru is beginning to unlock the mysteries of our global weather patterns. In the future, this information may be used to determine when farmers should plant crops.

Tracker **buoys**, like the one shown in Figure 269.1, are used by organisations such as the Commonwealth Scientific and Industrial Research Organisation (**CSIRO**) and the Australian Institute of Marine Science (**AIMS**), to discover the secrets of our coastal currents and help us understand coastal oceanography.

This chapter deals with three types of currents: ocean, coastal and local currents.

## Ocean currents

**Ocean currents** are movements of sea water caused by wind and the Earth's rotation, among other factors.

What causes currents? Sunlight heats the air more over the equator than it does over the poles. This unequal heating causes air to rise and fall at different places (shown in Figure 269.2). Where air rises, it leaves areas of low pressure behind and where it falls, areas of high pressure form. These are the highs and lows we learnt about in Chapter 18.

As the Earth spins from west to east (or left to right), the high and low pressure **air cells** move. These moving air cells are called **trade winds** and blow in one prevailing direction, depending on their **latitude** (Figure 269.3). The factors which determine wind direction were discussed in Chapter 18.

## Diving deeper



1. Collect information on tide times from your local paper for one week. Check your paper for the times of moon-rise and sunrise for this same period. How much later does the Moon rise each day?
2. Use local tide information to find out when the next spring tides will occur.
3. Obtain a chart of the local area and find the direction of the flood tidal current at various places.

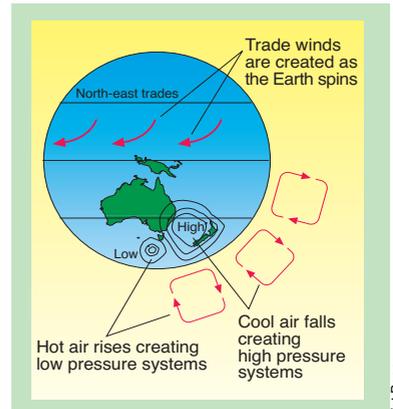


Figure 269.2 Wind cells are caused by air rising and falling.

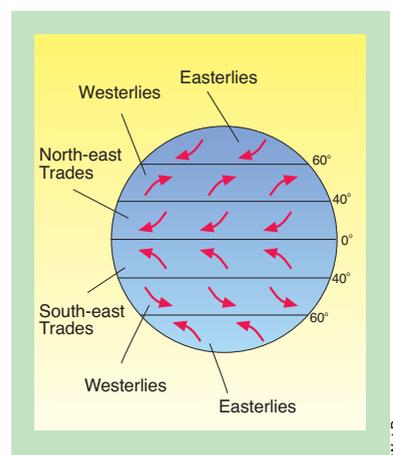


Figure 269.3 Wind patterns of the Earth

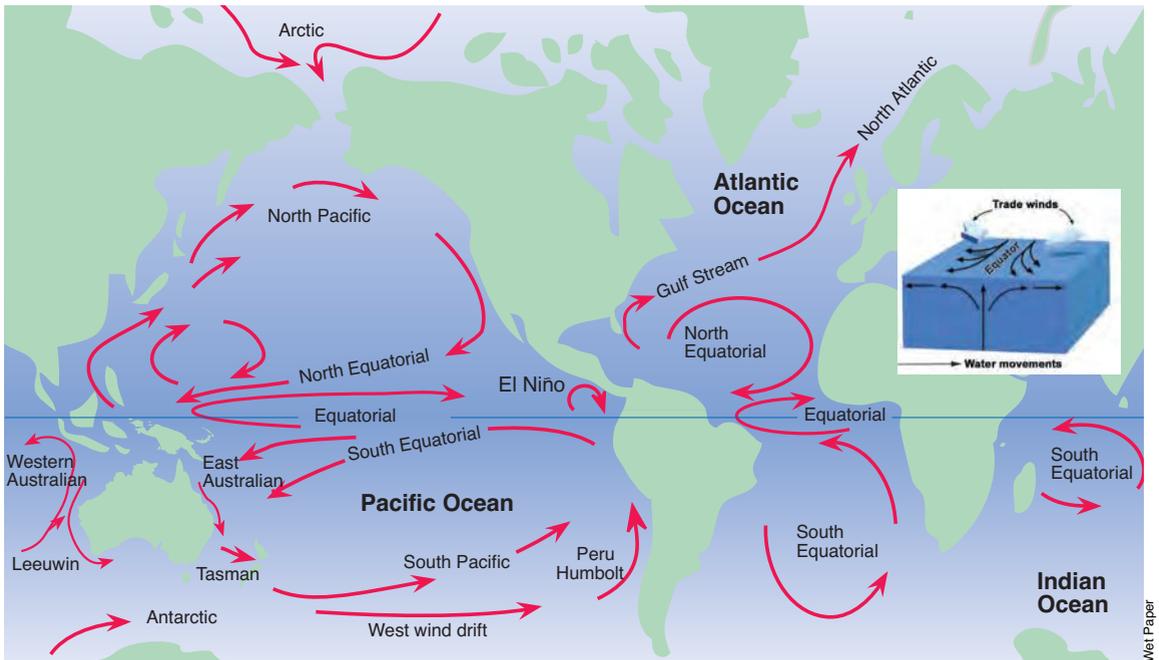


Figure 270.1 Major world ocean currents



Figure 270.2 Significant coastal upwelling sites caused by currents

### La Niña

La Niña refers to the extensive cooling of the central and eastern Pacific Ocean and in Australia (particularly eastern Australia). La Niña events are associated with increased probability of wetter conditions. Changes to the atmosphere and ocean circulation during La Niña events include:

- Cooler than normal ocean temperatures across the central and eastern tropical Pacific Ocean.
- Increased convection or cloudiness over tropical Australia, Papua New-Guinea, and Indonesia.
- Stronger than normal (easterly) trade winds across the Pacific Ocean (but not necessarily in the Australian region).
- High (positive) values of the SOI (Southern Oscillation Index).

Source: [www.bom.gov.au](http://www.bom.gov.au)

The trade winds blow ocean water along to form currents. Because of the prevailing wind direction, these currents move in large circles or **gyres**. South of the equator, they turn counter-clockwise and north of the equator they turn clockwise (see Figure 270.1). Ocean currents are biologically important. They mix oxygen and carbon dioxide from the atmosphere into the water and, in areas called **upwellings**, mix in elements from the rich benthic layers deep in the sea (Figure 270.2).

### Southern Oscillation Index

The Pacific has warm and cold currents. The cold Peru and Antarctic currents sweep northwards past South America to higher latitudes and become warmer. Trade winds then blow the currents towards Australia and New Zealand.

As the trade winds move over the Pacific, they create areas of different pressure. The air pressure over Darwin is related to that at Tahiti. When the pressure in Darwin is high, the pressure over Tahiti is low and the pressure oscillates between the two. This is called the Southern Oscillation and an index called the **Southern Oscillation Index (SOI)** is calculated from pressure differences between the two. You may have seen this on television weather reports.

The **Walker circulation** is the name given to the way that trade winds circulate air to and fro across the Pacific Ocean. The trade winds drive oceanic air west across the ocean to Indonesia and Australasia where the damp warm air forms monsoon rain patterns.

This warm moist air rises and, because it cannot rise over the land mass of South-east Asia, is pushed eastward by the air behind it to sink again towards the cooler water off Peru.

As we know, trade winds also push water around. Just like turning on a fan at one end of the bathtub to make the water pile up at the other end, easterly trade winds push large amounts of warm water across the Pacific. (Water temperatures can be measured by buoys as shown in Figure 271.1).

When these easterly trade winds from North America slow down, interesting changes occur in weather patterns on both sides of the Pacific.

## El Niño— a weather pattern that affects us all

Suddenly, for some reason, the push on the ocean surface falls and warm water that was once driven westward now runs back towards the central Pacific.

This disrupts the ocean-atmosphere system shown in Figure 271.2, causing hot air to rise and split the Walker circulation pattern.

In the eastern Pacific, a branch of the Peru current breaks off, stopping cold water from entering upper layers of oceanic water. When this happens an El Niño is said to occur. It dramatically affects the world's climate and occurs every three to seven years.

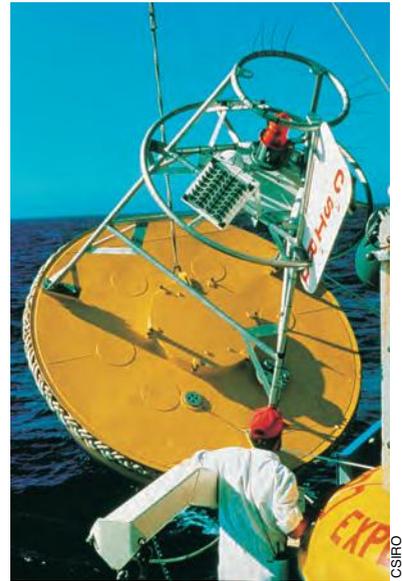


Figure 271.1 A moored buoy that measures weather conditions

*El Niño occurs when warm water stops the upwelling of cold water off Peru causing a lack of hot air over Eastern Australia.*

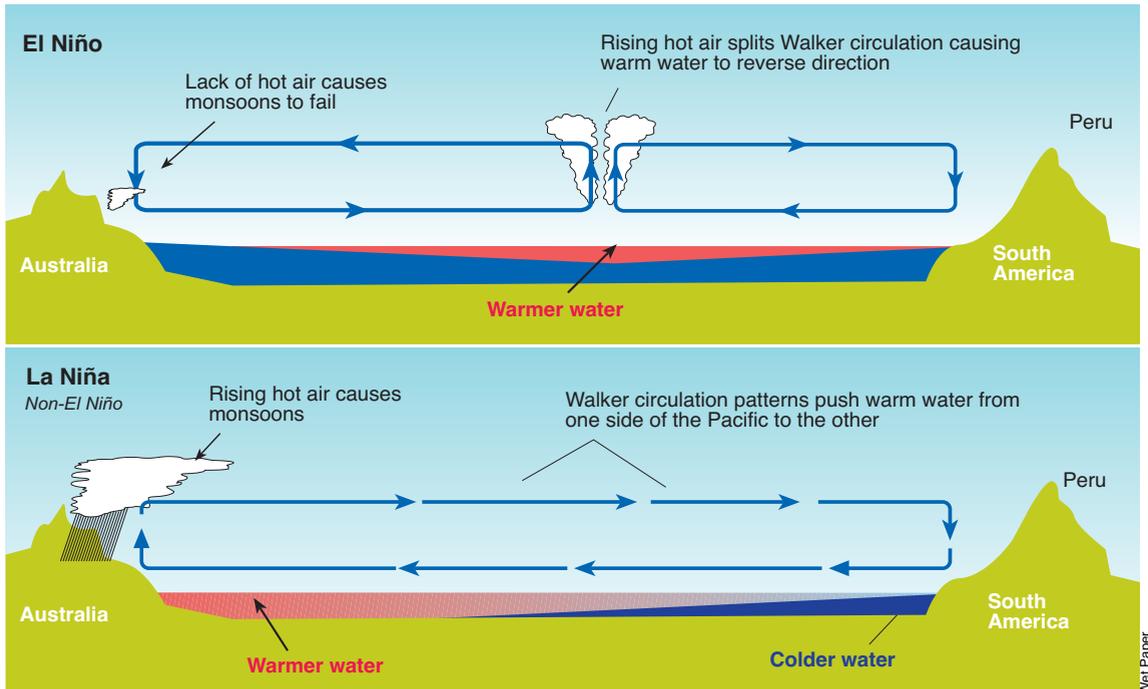


Figure 271.2 Effects of Pacific currents and weather patterns

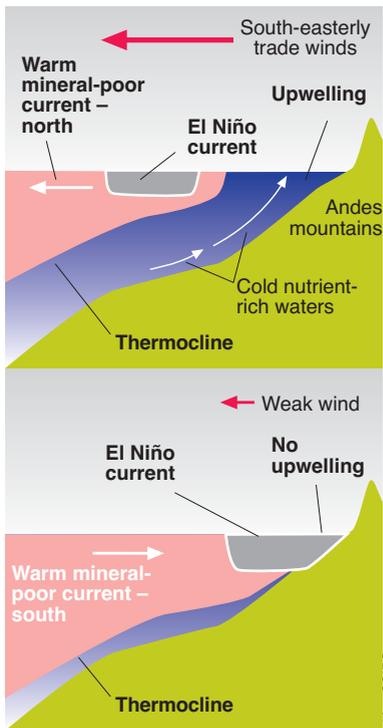


Figure 272.1 El Niño current movement and upwellings

**Questions**  
Use your textbook to find the answers

14. What are ocean currents and how are they formed?
15. What are trade winds?
16. What is the Walker circulation? Draw a diagram to illustrate your answer.
17. How is the Southern Oscillation Index calculated?
18. Where is the El Niño current found?
19. Draw a diagram to show how the El Niño current can affect the Peruvian fishing industry.
20. Explain the saying *wind over tide, expect a rough ride*.

Marine scientists have said that from a human and economic standpoint, the El Niño in 1982–83 may have affected the lives of nearly half the Earth’s population. The effects of El Niño are summarised below.

### El Niño and fishing

**Thermoclines** off Peru are normally found about 50–200 metres below the surface of the ocean (Figure 272.1), where the nutrient-rich cold water flowing so close to the surface makes ideal conditions for phytoplankton, a rich food source for larger fish. (Thermoclines are discussed in Chapter 9.)

However, in an El Niño event, Pacific Ocean sea levels can fall by as much as 20 centimetres off Indonesia and rise by up to 15 centimetres off South America. Warmer water drifts back towards Peru, thus cutting off the upwelling.

Plankton production drops dramatically because of the lack of food which then causes huge losses to the fishing industry and marine life in general.

### El Niño and cyclones

In El Niño events, ocean temperatures can drop, changing cyclone paths so that cyclones have been recorded as far south as northern New South Wales. In normal (non-El Niño) conditions, sea surface temperatures are about 8 degrees hotter in the west with rain and cyclones a normal part of the seasons.

Marine scientists can predict that in normal times, atmospheric pressures in Darwin will be 16 times higher than in the eastern Pacific and that cyclones will have a predictable path.

We are only just beginning to understand how El Niño affects cyclones. Oceanographers from around the Pacific may one day be able to predict the paths of cyclones in all conditions.

### El Niño and bushfires

During El Niño events, less wind blows across Australia, so less rain falls and summer temperatures can soar. This makes the risk of bushfires extremely high. Who would have thought that people living in the Australian outback would be affected by an ocean current thousands of kilometres away off Peru? Scientists can already predict when rainfall is going to be average or abnormal by tracking the SOI over a significant period.

### Oceanographers unite

Scientists still don’t know what causes the El Niño effect, and have set up a system to record oceanic data. By amassing enough data on Pacific currents and wind patterns, scientists hope to become more confident about their theories.



Alter Cresswell, 1995, CSIRO

Figure 273.1 Australian currents in autumn

## Coastal currents

Scientists have been studying the major currents around Australia and New Zealand for many years. These currents are shown in Figure 273.1. Tracking instruments are constantly helping oceanographic analysts to discover many smaller local currents around our coastline.

We must understand currents to understand oceans. Oil spills in the North West Shelf can affect the tuna fishing off South Australia, pollution off Brisbane could affect the upwellings and fishing grounds in New South Wales, and a study of Bass Strait oceanic sediments can reveal new resources for Australian industry.

## East Australian current

The East Australian current was first discovered by a European when Captain James Cook was just east off Byron Bay in 1770. An excellent navigator, Cook found that for two days he was actually sailing backwards. He realised that he had sailed into a strong current from the north. Flowing south from the Coral Sea, the East Australian current carries up to 10 million litres of water/second (or 10 times the amount of water in Sydney Harbour) and is up to 500 metres deep and 200 kilometres wide.

However, the East Australian current does not travel in one direction. CSIRO scientists have discovered that large circulating bodies of water called **eddies** are formed as the Eastern Australian current runs over the continental shelf.

The eddies can last for up to a year and can drift up and down the coastline. The satellite photograph in Figure 273.2 is an image of sea-surface temperature showing an eddy pair at the eastern end of Bass Strait. The white line is the track of the CSIRO research vessel the RV *Franklin*.

*Diving deeper*



4. Go to the CSIRO Marine Laboratory's web address [www.marine.csiro.au](http://www.marine.csiro.au) then download a list of their oceanography brochures .
5. Prepare a chart of the local currents in your area. Write an essay on how they affect local industries.
6. Find Tahiti on a map. Why were the South Pacific islands so concerned about French nuclear testing?
7. Research the trade winds and find out how they played an important part in your local maritime history.
8. Prepare a summary poster on El Niño using the colour diagrams in this chapter.
9. Look up the [www.bom.gov.au](http://www.bom.gov.au) weather bureau and find how the Southern Oscillation Index (SOI) affects your area.
10. Set up a model longshore drift experiment like the one on page 277.

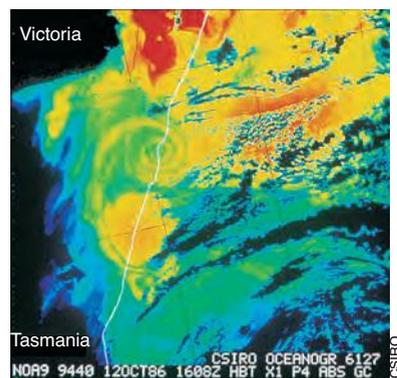


Figure 273.2 Eddies off Victoria and Tasmania

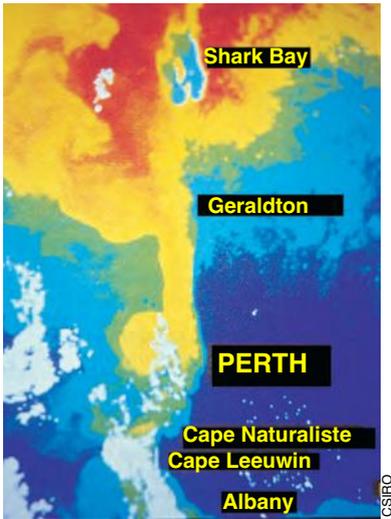


Figure 274.1 The Leeuwin current

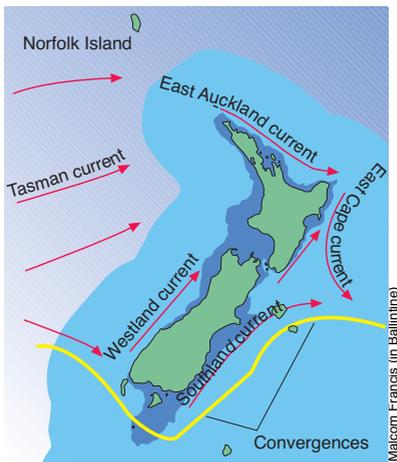


Figure 274.2 New Zealand currents

## Western Australian current

Figure 274.1, from the Western Australian Institute of Technology, shows the Leeuwin current extending down the Western Australian coast during winter.

This current is the main current influencing Western Australia and starts in the warm, low-salinity waters off the north-west coast. It flows southward to Cape Leeuwin and east across the Great Australian Bight.

The Leeuwin current intrudes between the coast and the south-west branch of the West Australian current. The current's movement depends on the time of year: it moves south from February to June, and is found off Perth in April.

### Why fish need currents

Currents affect the lives of all the fish which live in them, and thus the livelihood of everyone working in the fishing industry. The Leeuwin current, for example, brings juvenile southern bluefin tuna south along the coast of Western Australia from their spawning ground off the north-west of the continent.

Another species of fish which depends on the Leeuwin current is the Australian herring. **Herring** larvae grow up in the warm waters around Shark Bay and then, within a few months, are found almost one-third of the way around Australia in the ocean off Adelaide and Melbourne (Figure 274.3).

As the current slows, the larvae make their way into estuaries and bays where they grow into juveniles and feed off the rich plankton waters in the Southern Ocean. When they are mature, they migrate back to Western Australia. Without the Leeuwin current, the Australian herring would not be able to survive.

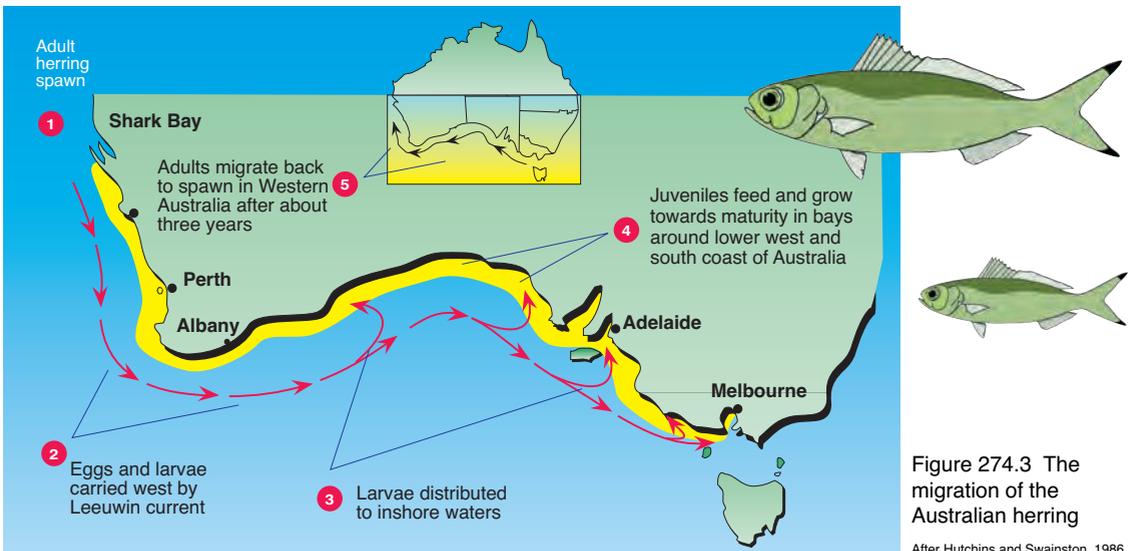


Figure 274.3 The migration of the Australian herring

After Hutchins and Swainston, 1986

# Local currents

## Longshore currents

If waves approach a beach at an angle, as shown in Figure 275.1, they set up a **longshore current** close to the beach. These currents move sand along the coastline (discussed in Chapter 20).

## Rip currents

The bigger the waves coming onto a beach, the bigger the backwash current away from the beach. Where the backwash can find an easy channel back out to sea, rip currents can form (Figures 275.1 and 275.2).

**Rips** are areas without waves where the water runs back fast towards the open sea. Swimmers who are caught in rips can be unexpectedly carried out beyond their depth.

Rips are not always dangerous, they can be useful if you know what you are doing. Surfers use rips as an easy route back to the sea after they have surfed into the shore. They enter the rip at the mouth and are quickly swept out through the neck and then past the breakers at the head of the rip. The Australian and New Zealand Surf Life Saving Associations have identified four types of rip:

- permanent, where the current remains in the same place for months, even years;
- fixed, where a gutter or depression in beach sand keeps a rip in place for months;
- flash rips, where a depression suddenly occurs in a beach profile; and
- travelling, where a rip moves up the coast.

These associations recommend that you swim on patrolled beaches and between the red and yellow flags.

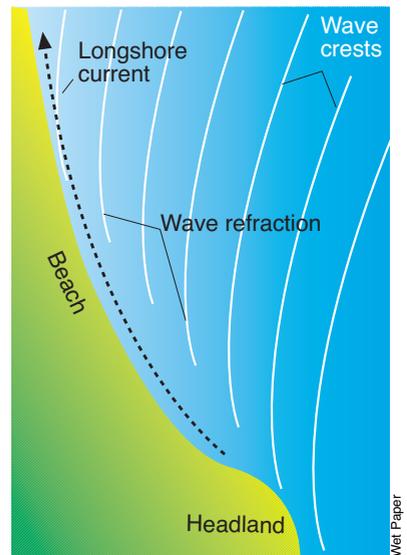


Figure 275.1 Longshore currents

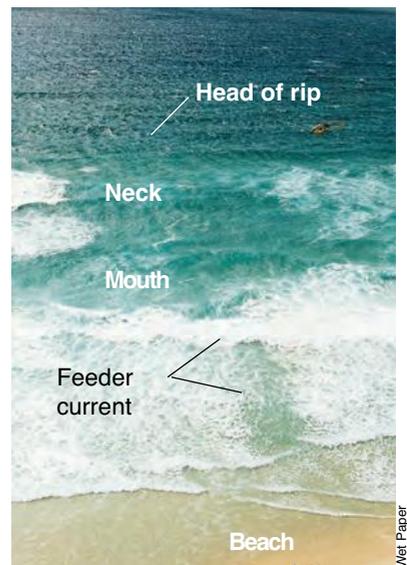


Figure 275.2 Rip currents on a beach

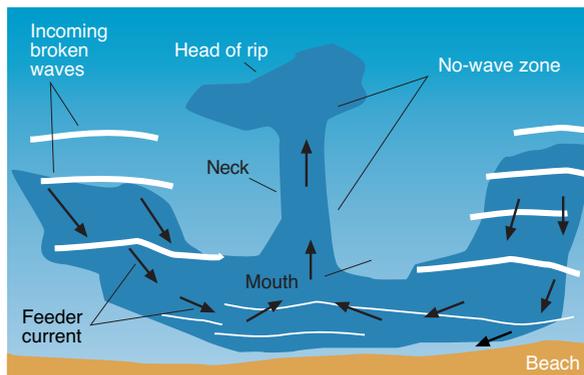


Fig 275.3 Rip currents

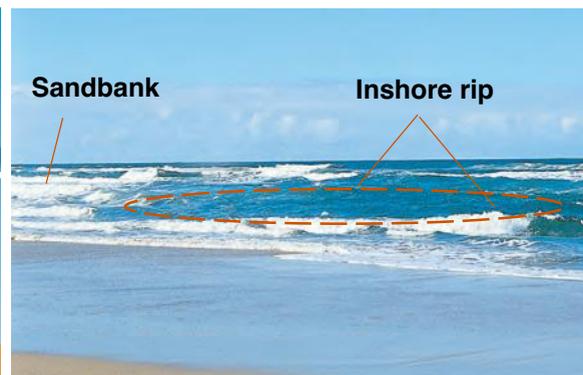


Figure 275.4 Rips can form very close to shore

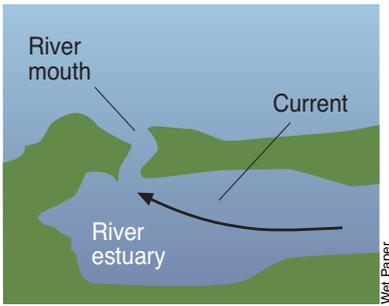


Figure 276.2 Rips can form in an estuary.

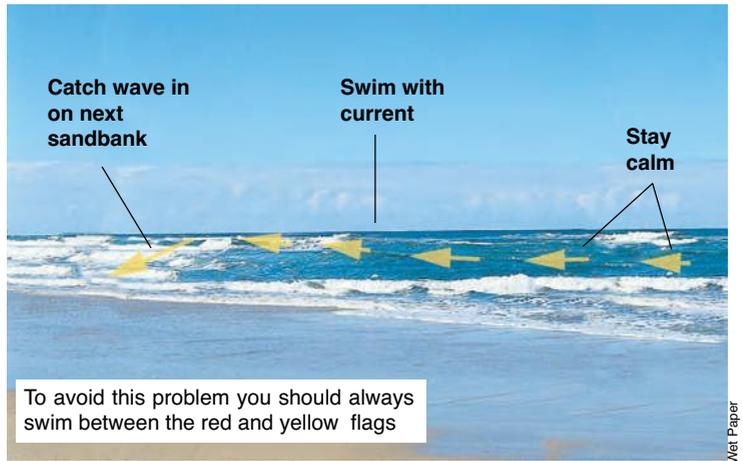


Figure 276.1 How to get out of a rip on a small surf day

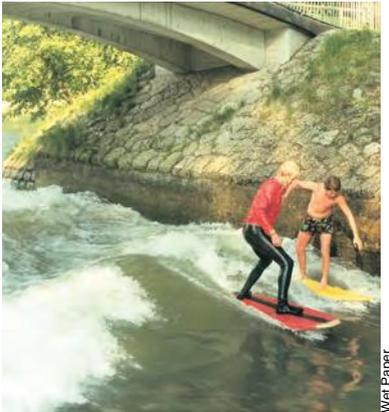


Figure 276.3 Waves formed by a river current

### How to get out of a rip

If you are on a patrolled beach and are caught in a flash rip, make sure you stay calm and assure others caught in the rip too that help is on the way.

- Raise one hand, signal for help and wait for help to arrive. Fear and panic are one of the most common forms of drowning in these situations.
- Alternatively, swim sideways (Figure 276.1) till you reach a sandbank and then catch the next wave in further up or down the beach.
- If the surf is rough and you want to go for a swim, make sure you stay in waist deep water.

### Estuarine currents

Rips can also form in **estuaries** (Figure 276.2). As the tide comes in or goes out, the water currents mix rapidly causing strong rips and dangerous situations.

Strong surf running at the mouth of the river causes dangerous currents. Avoid river mouths if you are boating, sailing, swimming or snorkelling.

### River currents

River currents form when rainfall in the catchments increases the water speed. Training walls that confine the water can even cause waves to form in the river because, as the tide goes out, the current gets faster.

If you are fishing in a small boat or snorkelling in these areas you could easily be swept out to sea. This is why every boat should carry an anchor and emergency signalling equipment (see Chapters 1 and 7).



### Questions

Use your textbook to find the answers

21. How does an El Niño event affect cyclones?
22. Name any four ocean currents found around Australia or New Zealand.
23. What are *eddies*?
24. What is the main current that influences the coast of Western Australia?
25. How can tidal currents form?
26. What type of currents form in river mouths that have been constrained by training walls?

## Key words

Buoys, centripetal force, current, eddies, El Niño, estuaries, gravitational attraction, gyres, latitude, longshore current, neap tide, perigee, pressure, rip, southern Oscillation Index, spring tide, storm surge, thermoclines, tide, trade wind, upwellings, walker circulation, wind over tide.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- The tides are caused by the [1] \_\_\_\_\_ of the Moon and the Sun on the Earth.
- The force of the Moon's gravity pulls out a [2] \_\_\_\_\_ of sea water on one side of the Earth. Another tidal bulge forms on the other side of the Earth because of the [3] \_\_\_\_\_ of the Earth's spin.
- [4] \_\_\_\_\_ occur where the Earth, Moon and Sun are in a straight line. The [5] \_\_\_\_\_ pull of the Sun and the Moon are combined and the tides are at their highest.
- The [6] \_\_\_\_\_ is the difference in height between high and low tides for a given place on the Earth's surface.
- In boating if the wind is blowing into the [7] \_\_\_\_\_ of the tide it creates uneven waves which lead to the saying "[8] \_\_\_\_\_ - expect a rough ride".
- The predicted tidal height is based on an average barometric pressure and if the atmospheric [9] \_\_\_\_\_ decreases, the [10] \_\_\_\_\_ level increases.
- Local currents, such as [11] \_\_\_\_\_ currents on surfing beaches, have claimed many lives. Strong currents caused by [12] \_\_\_\_\_ flows continually create marine hazards. They even damage our marine [13] \_\_\_\_\_ as ships and pleasure boats drag their [14] \_\_\_\_\_ over reefs and coral outcrops.
- When the pressure in [15] \_\_\_\_\_ is high, the pressure over [16] \_\_\_\_\_ is low and the pressure oscillates between the two. This is called the Southern Oscillation and an index called the [17] \_\_\_\_\_ (SOI) is calculated from pressure differences between the two.
- If caught in a rip on a [18] \_\_\_\_\_, all you have to do is to stay calm, [19] \_\_\_\_\_ under the waves as you are taken out to sea, and [20] \_\_\_\_\_ help when you are past the breakers.
- River currents form when rainfall in the catchments [21] \_\_\_\_\_ the water speed.



- What is an *overflow current* and how can it form?
- What is a *longshore current* and how is it formed?
- Draw a fully labelled diagram of a rip current that forms on a beach.
- If you are caught in a rip current, what should you do?
- Download this article and make a summary:  
[www.marine.csiro.au/LeafletsFolder/pdfsheets/37eac.pdf](http://www.marine.csiro.au/LeafletsFolder/pdfsheets/37eac.pdf)



Figure 277.1 Model current tray experiment

# Chapter 25 Small sea creatures



## Web references

[www.reefed.edu.au](http://www.reefed.edu.au), [www.csiro.gov.au](http://www.csiro.gov.au), [www.dpi.qld.gov.au](http://www.dpi.qld.gov.au), [www.fisheries.nsw.gov.au](http://www.fisheries.nsw.gov.au), [www.fish.wa.gov.au](http://www.fish.wa.gov.au), [www.dpif.tas.gov.au](http://www.dpif.tas.gov.au), [www.pir.sa.gov.au](http://www.pir.sa.gov.au)



Figure 278.1 Using a plankton net



Figure 278.2 Studying plankton

Some animals spend only part of their lives as small sea creatures, for example a baby barnacle begins life in the sea but migrates back to the shore to live as an adult. Some animals, such as jellyfish<sup>1</sup>, spend their lives drifting in the sea.

## What are plankton?

**Plankton** is the name given to the microscopic plants and animals that float or swim in the surface layers of oceans, rivers and lakes.

Almost all marine organisms with the exception of mammals, reptiles and some fish spend part of their life cycle as plankton. They feed on other plankton, grow and move with the currents as they disperse to other regions of the water column.

Phytoplankton (plants), form the basis for life on Earth. They provide more than 70% of the oxygen we breathe and remove most of the carbon dioxide we breathe out.

They form the basis of marine food chains - their numbers exceeding all other producers on Earth. Zooplankton (animals), comprise larvae of marine animals as well as a whole range of microscopic individuals that do not change, forming the next step in the marine food chain (see Chapter 5).

Baby prawns, some algae and baby fish are examples of plankton which can be caught with a plankton net (Figure 278.1). As the net is dragged through the water, floating animals that are greater than the net size are caught in the bottle at the end of the net.

Do this for about 10 minutes before hauling the net on board, unscrewing the bottle, putting the plankton on a **petri dish** and studying them under a **microscope** (Figure 278.2).

## Temporary plankton

Temporary plankton are animals and plants which spend part of their babyhood in the sea.

<sup>1</sup> Some people these days refer to jellyfish as sea jellies

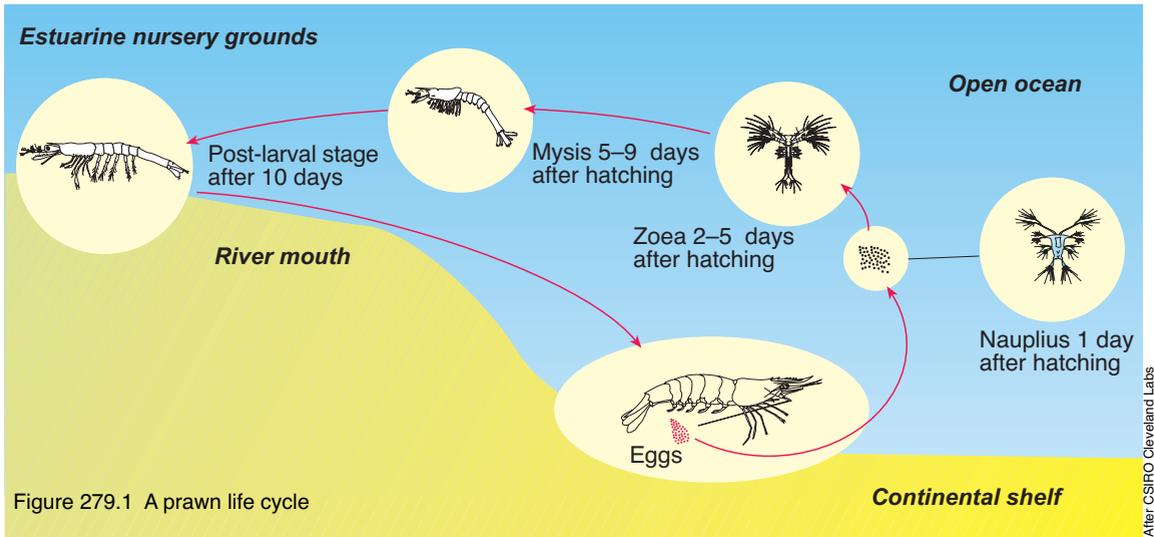


Figure 279.1 A prawn life cycle

After CSIRO Cleveland Labs

## Prawns

The prawn is an excellent example of an animal which has a planktonic part to its life cycle.

Mature prawns live on the continental shelf close to river entrances (see Figure 279.1). The fertilised eggs shown in Figure 279.2 are released into the sea by female prawns, float to the surface and start their lives as plankton. Within 24 hours, they hatch to become the first larval stage called a nauplius, which is very similar to the barnacle.

After two days, the larva moves into a second larval stage called a **zoea** (Figure 279.3), an animal about 1.5 millimetres long. This larval stage changes yet again after 59 days to a final larval stage called a **mysis**.

This mysis has legs and has developed swimmers so that it can migrate quickly through the river mouth to the estuarine nursery grounds (Figure 279.4). After 10 days, in this nursery, it has grown to about 4 millimetres long and becomes a post-larval stage or baby prawn. The prawn then changes its planktonic habits and takes up a bottom-dwelling life in the mangroves for a few months. Young adults then migrate to the open ocean to grow to maturity.

Prawns pass through the nauplius, zoea and mysis stages quickly to make sure as many survive as possible because death rates among plankton are very high.

Research by marine scientists into understanding these stages and behaviour patterns has allowed the aquaculture industry to develop rapidly. Large prawns sell for up to \$200 each in some Asian countries and culturing prawns for export is a fast-growing industry.

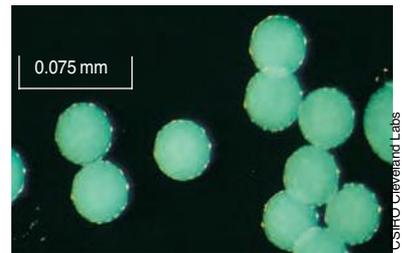


Figure 279.2 The eggs of a prawn

After CSIRO Cleveland Labs

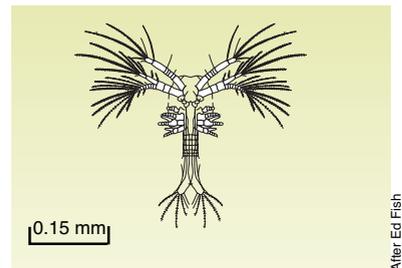


Figure 279.3 Zoea stage of prawn

After Ed Fish



Figure 279.4 Mysis stage of a prawn

CSIRO Cleveland Labs

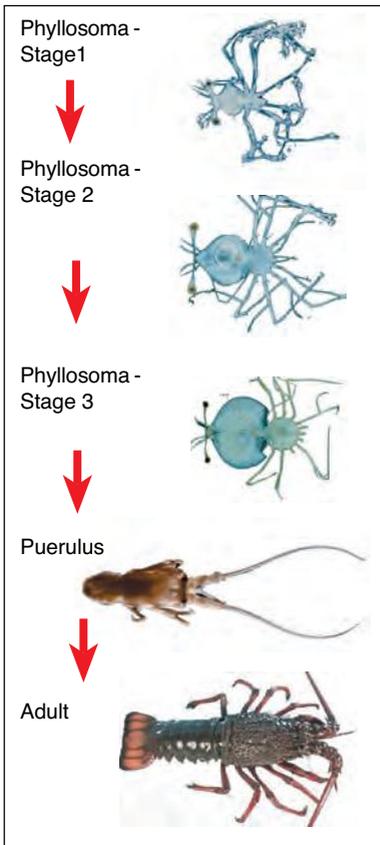


Figure 280.1 Lobster development  
 Courtesy www.science-in-salamanca.tas.csiro.au  
 Hobart Tasmania Photographer Russell Bradford.

## Lobsters

Female lobsters and crayfish hold their fertilised eggs in their abdomen before they hatch into small larvae.

These larvae are planktonic and can drift for many months over thousands of kilometres during which time most of them are eaten by **predators**. Those left, sink to the bottom and grow to be adults. Of the 80 000 eggs produced by each adult female, only about two will grow to maturity.

### Western rock lobster

Female lobsters generally spawn at about 6-7 years of age, between September and January as shown in Figure 280.2.

Most of their eggs have hatched by the end of February, and the tiny **phyllosoma** larvae (Figures 280.1 and 280.2) are carried up to 1500 kilometres out to sea on wind driven surface currents. Here they spend between 9 and 11 months feeding on the plankton, and evolve through a series of stages. Many larvae die on their ocean journey, but the survivors eventually return to the coast, carried again by ocean currents.

The last stage of the lobsters' larval development are tiny 25 millimetres long **puerulus**, which look like miniature adult lobsters. The puerulus swim many kilometres across the continental shelf with the help of winds and currents to settle on inshore reefs and feed in the shallow waters. It takes about 4 to 5 years for the juveniles to grow to adults.

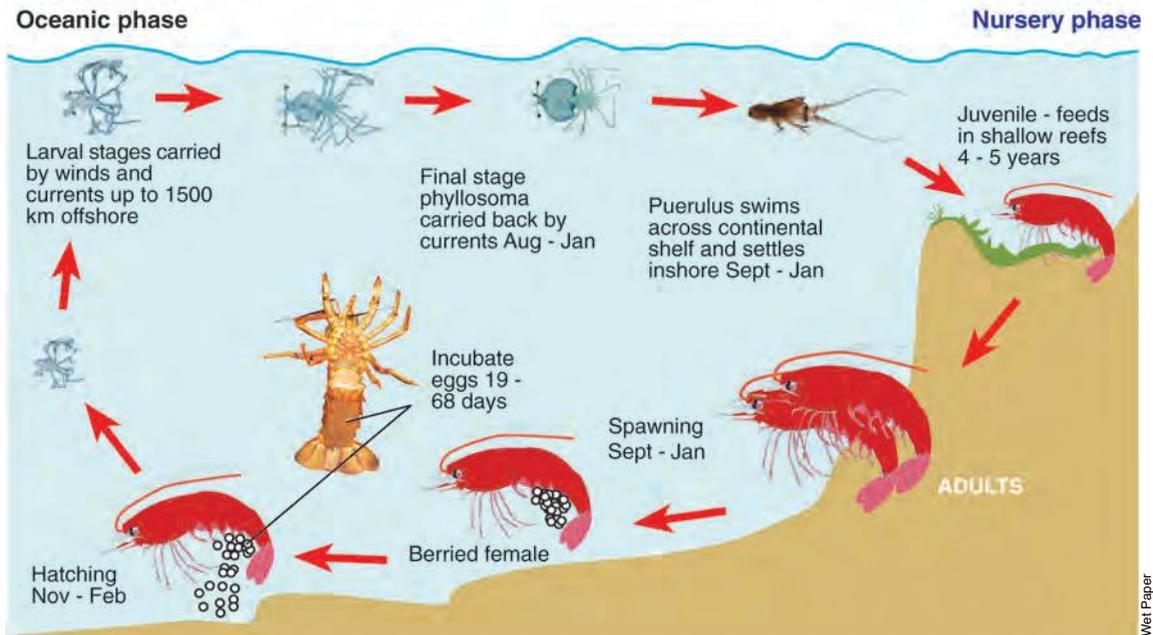


Figure 280.2 Western rock lobster life cycle (after WA Fisheries)

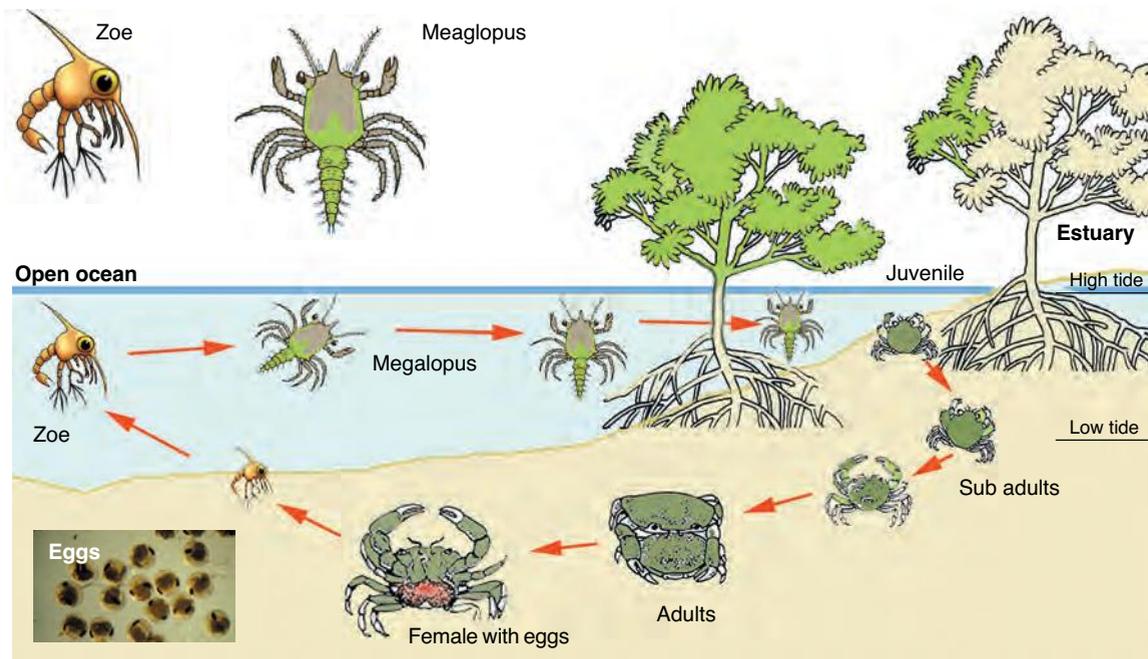


Figure 281.1 Crab life cycle (After Qld fisheries)

## Crabs

Crabs are bottom-living animals like lobsters and crayfish and an example of how a marine animal uses a low energy shoreline nursery such as a mangrove ecosystem (Figure 281.1).

Crabs have a hard outer skeleton (**exoskeleton**). When the female has just shed her shell and her new shell is still soft, the male produces a sperm packet which he deposits under one of her legs connecting to her egg pouch.

The female then swims out to sea and releases her eggs with her partner's sperm into the plankton.

The eggs are fertilised and quickly grow into a microscopic larval stage called a **zoe**.

The zoe undergo several changes called a **metamorphosis** and change into a **megalopus** which is carried back towards the mangroves or salt marshes where they settle out of the plankton and take on their **juvenile** form (like tiny adults).

Juveniles feed off the rich life in the mangroves and grow quickly. They can also hide amongst the roots and logs in the mangrove habitat. They grow into adults and make burrows in the nursery areas to find a mate and start the cycle again.

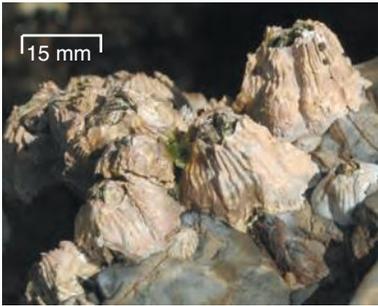
Without the protection of mangroves, the crabs would have no habitat to live and reproduce. This is why you often see bumper stickers which say - *no mangroves, no fish*.



1. What are plankton?
2. Plankton can either be temporary or permanent. Give examples of temporary and permanent plankton.
3. Why are there so many planktonic animals?
4. What are the sex cells of a lobster called?
5. Name the first larval stage of a rock lobster after fertilisation, and draw it.
6. Why are mangroves important to crabs?
7. Draw a fully labelled diagram to show the behaviour of the juvenile settling behaviour of a crab.
8. Where do adult prawns live?
9. What does the mysis stage of the prawn do 5–9 days after hatching?

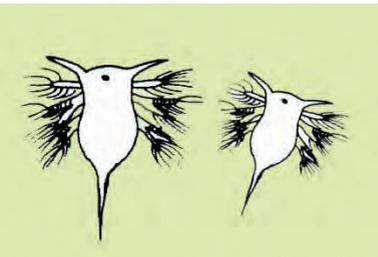


Wet Paper



Wet Paper

Figure 282.1 Barnacles on a rock



Wet Paper

Figure 282.2 First larval stage of a barnacle — the nauplius

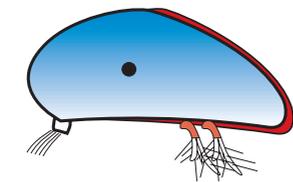


Figure 282.3 Cypris larva  
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## Barnacles

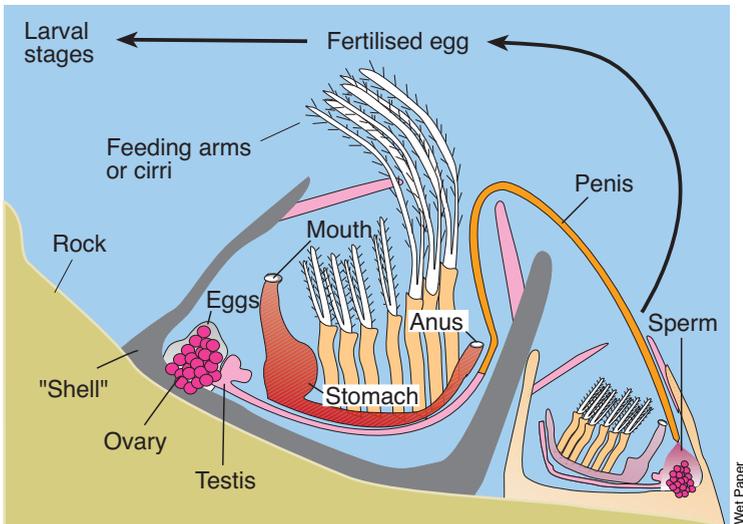
Shore barnacles live on rocks (Figure 282.1) or places like pylons within the **tidal zone** and can be found attached to most hard surfaces in the sea. To reproduce, each barnacle has a male reproductive organ called a **testis** which makes **sperm** and a female reproductive organ called an **ovary** to make eggs (Figure 282.4). Because both male and female organs are found in the one animal, the barnacle is called an **hermaphrodite**. Sperm and eggs are called the **reproductive cells** of the **adult stage** of an animal and **fertilisation** is where sperm and eggs join to form a **fertilised egg**.

Even though they have both female and male organs, barnacles do not fertilise themselves. Each barnacle has a **penis**, which can be up to 20 millimetres long, that transfers its sperm to the eggs of its neighbour barnacle (a rather impressive feat considering some barnacles are only about 10 millimetres long).

When tide and time are right, the fertilised eggs are released from the ovaries and float to the surface of the sea to become plankton. The fertilised barnacle eggs quickly divide to form many more cells.

This is called a **larval stage**. A larval stage is the baby stage of an animal. To distinguish between the different stages, marine scientists use different terms.

The first larval stage of a barnacle is called the **nauplius** (pronounced naw-plee-us) and is shown in Figure 282.2. It is characterised by its microscopic size, two horns and external feeding arms or cirri. The barnacle grows rapidly and changes into a cypris (sip-ri-us) larvae (Figure 282.3).



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Figure 282.4 A cross-section of a barnacle

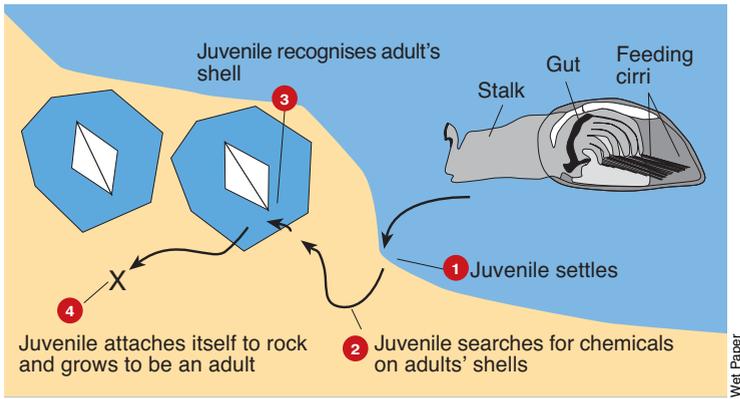


Figure 283.1 Juvenile settling behaviour

This larva finds its way to shore or onto a solid object by using a remarkable chemical sensory organ which guides it back towards land even though at this stage it is less than 1 millimetre long and has no eyes.

Shortly before settling on to a solid object, the barnacle changes again, this time into a post-larval stage called a juvenile (Figure 283.1).

This juvenile stage lands on the rocks and crawls around until it finds other barnacles. Its stalk then helps it attach itself to the rocks and grow to the adult stage.

### Other invertebrates

Worms have a trochophore larvae (Figure 283.2) which swims by beating cilia. Marine snails such as the trochus shell have a veliger larvae which forms just after the fertilized egg. Molluscs can have trochophore and/or veliger larvae.

### Fish

See also Chapter 27 page 308

There is extreme variation in fish reproduction. Sexual reproduction involves the production of sperm and eggs from gonads. Masses of sperm called milt come from the **testis** and masses of eggs or **roe** come from the ovaries.

Fertilization can be external or internal in fish but all results in an embryo. The embryo divides many times to form a larval stage with a vertebral column and digestive system. This stage contains the yolk sac and are known as fish fry (Figure 283.4). They feed on this yolk until they are able to find their own food, which is usually other plankton.

Fish fry and juveniles need the safety of protected habitats such mangroves (Figure 283.5) and seagrasses. The massive root systems found in these ecosystems provides a haven from larger predators.

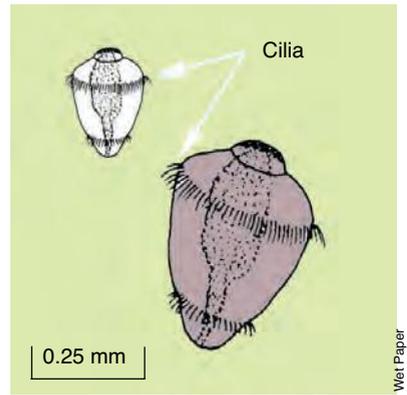


Figure 283.2 Trochophore larvae



Figure 283.3 Marine snail larval stage —the veliger

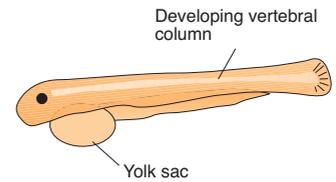


Figure 283.4 Fish fry

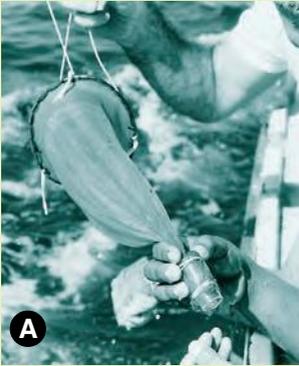


Figure 283.5 Mangrove roots

## Diving deeper



1. What is fish poisoning and how is it caused?
2. Make a simple plankton net from some stockings, a coat hanger and some household venetian blind cord as shown by the photograph A below.



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3. Make a test tube microscope to study plankton as shown by photograph B below.



Wet Paper

4. Find out what brine shrimp are and make a culture.
5. Make a poster of a lobster life cycle.
6. Make a model coral showing where the zooxanthellae are located.

## Permanent plankton

Permanent plankton are animals and plants which spend their whole life floating in the sea.

### Phytoplankton

Phytoplankton are the plant plankton from which all life in the sea derives its energy. The best-known plant plankton are the diatoms shown in Figure 286.1. These plants have two shells and a chlorophyll spot which helps them make their own food by using sunlight in photosynthesis (see Chapter 6).

The main plant types that can be classified as phytoplankton are **cyanobacteria** (red tide and blue-green algae), **dinoflagellates** and **diatoms** (golden algae).

### Cyanobacteria

#### Blue-green algae

Blue-green algae (Figure 285.3) are an advanced form of bacteria which have chlorophyll in their cells. In **estuaries** that have become polluted with sewage and stormwater runoff, these algae grow very quickly and form an **algal bloom**.

These blooms can cover huge areas of water, often restricting light from penetrating into the photic zone.

This can reduce oxygen levels, killing fish and other marine life. Blue-green algae can also be poisonous to humans and signs are erected during blooms to warn swimmers.

If your skin comes into contact with blue-green algae through swimming, water-skiing and other activities, your skin may become itchy and rashes may form, your lips may swell up, your eyes and ears may become irritated, you may get a sore throat, and show signs of hayfever and symptoms of asthma.

If you drink water with blue-green algae in it you may get nausea, vomiting, abdominal pain, diarrhoea, liver problems and muscle weakness. The more blue-green algae you drink, the sicker you may become.

If there is a blue-green algal bloom in a lake or a waterway nearby you should avoid contact with the water, touching any scum around the bank, drinking the water and paying attention to any signs that may have been put up to warn people of the algal bloom.

#### Red tide

In many reef waters, another species of cyanobacteria called *Trichodesmium* blooms during summer months and is often confused with coral spawn or oil spills.

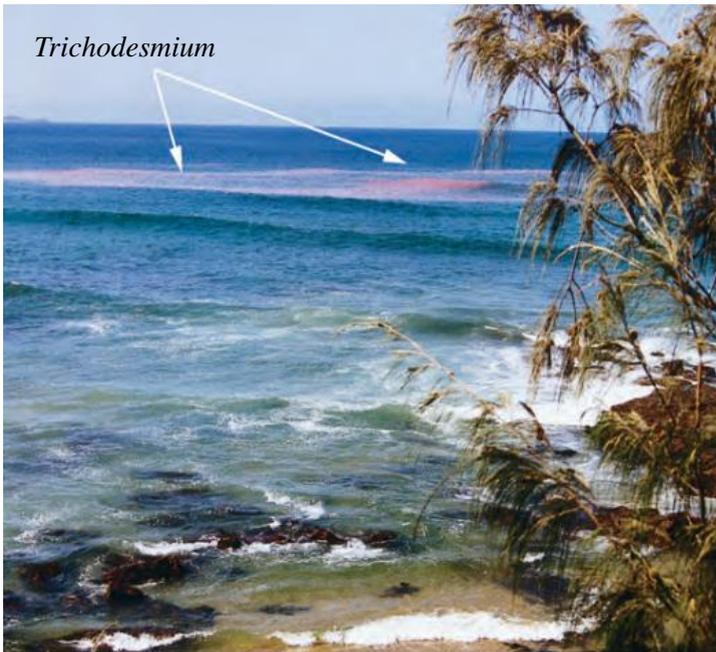


Figure 285.2 Red tide, Bonny Hills NSW

The bloom is a rusty brown and is relatively harmless unless you swallow large amounts. *Trichodesmium* floats on the surface of the sea because parts of its cell structure are filled with gas (Figures 285.1 and 285.2).

## Dinoflagellates

Dinoflagellates are single-celled organisms with armoured plates containing flagella that help the plant stay afloat (Figure 285.4).

## Zooxanthellae

**Zooxanthellae** (zoo-zan-thellie) are single-celled dinoflagellates which live in the tissues of marine animals such as clams and corals, taking in the Sun's rays and making sugars by photosynthesis (Figure 285.5). The relationship between zooxanthellae and corals is also discussed in Chapters 5 and 26.

A recent problem in world reefs is **coral bleaching**. This occurs when the temperature rises and corals eject their zooxanthellae resulting in the coral dying.

Some dinoflagellates have the ability to give out light, known as **bioluminescence**, which can be quite spectacular at night. In the right weather, these bioluminescent phytoplankton bloom to produce a blue-green light which shows up as a wave breaks or as a boat moves through disturbed water. We do not know why phytoplankton produce this light.

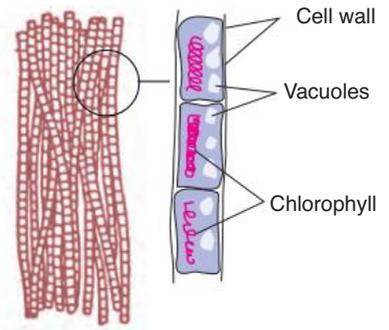


Figure 285.1 *Trichodesmium* structure



Figure 285.3 Blue-green algae



Figure 285.4 Blue-green algae

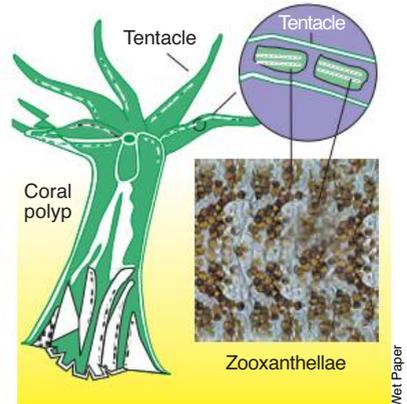


Figure 285.5 Blue-green algae

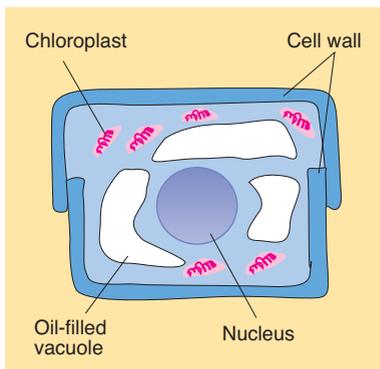


Figure 286.1 Diatom structure

Wet Paper

## Diatoms

Diatoms are tiny, one-celled plants that contain a strong transparent case made of **silica**.

Diatoms come in many shapes which are quite beautiful when viewed through a microscope. The glass-like cell wall consists of two parts which fit together like a lid fits a box or a petri dish (Figure 286.1). These extremely small greenhouses of the sea produce enormous amounts of oxygen.

Another big role they play is trapping nutrients washed into the ocean and passing these materials on in the food chain. Untrapped, these nutrients would merely settle on to the ocean floor.

Some diatoms attach themselves to rocks where they form a brownish slime. Foam spilling from a wave is often coloured yellowish-brown by millions of diatoms.

After the diatom plant dies the plates accumulate on the bottom of the ocean and contribute to the formation of ocean sediments, carbonate oozes, and rocks such as limestones and chalks. The remains of diatoms is the major component of the white cliffs of Dover. Diatomaceous earth is also used in swimming pool filters.



Figure 286.2 Copepod

Jack Marsh

## Zooplankton

**Zooplankton** are animal plankton which eat phytoplankton and form the basis for food chains in the sea. The most common free-swimming zooplankton are the copepods shown in Figure 286.2. These animals come in a variety of shapes and sizes but are all still small - about 0.5 millimetres long.

Other common zooplankton are sea jellies (Figure 286.3) and by-the-wind sailors (Figure 286.4). Sea jellies are an example of permanent zooplankton and large numbers can easily be seen with the naked eye, floating with the currents and tides in our estuaries and seas. Other sea jellies are called medusa, which are part of the life cycle of sea animals such as corals. Dangerous sea jellies, such as the sea wasp, are discussed in Chapter 3.

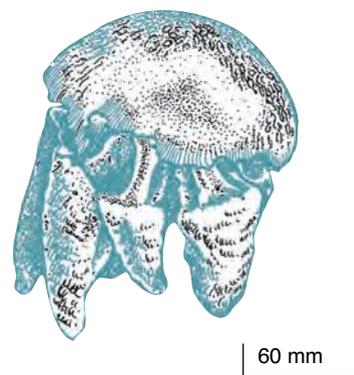


Figure 286.3 Sea jelly

Wet Paper

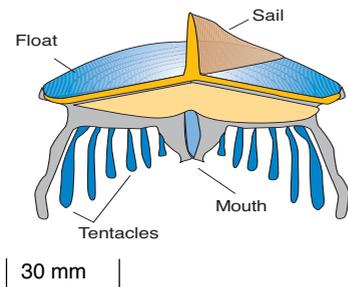


Figure 286.4 By-the-wind-sailor

## Plankton adaptations

The examples of barnacles, prawns, marine bacteria and the copepod show how well adapted some organisms are to living in the marine environment. For example, barnacles produce many eggs of which only very few live long enough to become adults.

## Adaptations

An **adaptation** is something which helps the animal or plant survive. It is a characteristic of all life on Earth because organisms that are poorly adapted die before they can reproduce. Plankton are no exception and have developed a number of adaptations to help them stay afloat and drift.

### Colour

Nearly all plankton are clear which makes them very difficult to see. Others are blue, so they blend in with the sky when viewed from below. This protective camouflage helps them avoid being eaten by predators.

### Size

Most plankton are small which helps them float and makes them difficult to see. Figure 287.1 shows a prawn larva on a piece of plankton net with a mesh width of only 0.25 millimetres. Many plankton are even smaller.

Small size also means that larvae can ingest and excrete straight through their body wall so they do not need a complicated digestive system which would add weight to the body.

### Shape

Many plankton make use of their shape to stay afloat. A long, flat, winged arrow worm can glide through the water using its winged shape (Figure 287.2). The surface area to volume ratio is also very large allowing them to float easily in the sea.

A bell-shaped jellyfish can fill its bell with air or a buoyant material to help it float. By adjusting the air, it can control its movement up or down to make the most of the weather conditions. Blue-green algae also use air — their long chains of cells are filled with air sacs.

### Swimming

Many plankton, such as copepods, use long swimming projections outside the body to stay afloat. These are called **appendages**. If viewed under the microscope, these can be seen to beat frantically to move the animal forward.

### Vertical migration

Many plankton in the top 100 metres of water spend their daylight hours in deeper water and move towards the surface at night in a process called **vertical migration**. This is why you will catch more plankton at night. Figure 287.3 shows that more copepods are caught at night compared to daytime.

Phytoplankton tend to stay near surface waters because they require sunlight and lack the swimming mechanisms of the copepods or arrow worms.

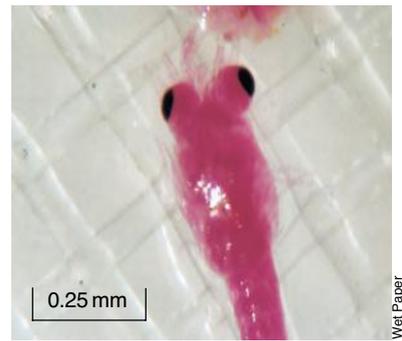


Figure 287.1 The mesh size of this net is 0.25 mm or 250  $\mu$ .

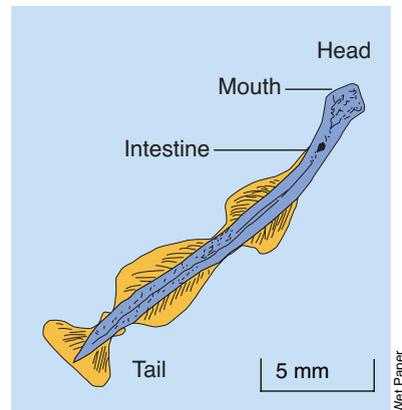


Figure 287.2 Arrow worm

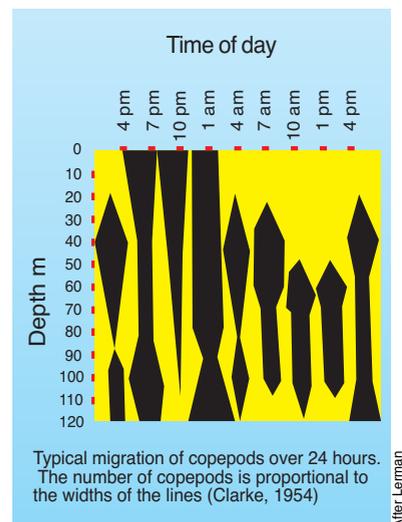


Figure 287.3 Vertical migration of plankton

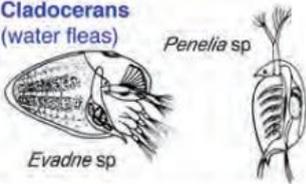
# Plankton identification

If you look under a microscope, you may see some of the plankton illustrated on this page. *Illustrations drawn by Dr Jack Marsh, Dr David Tulip and Dr Bernie Cook, reproduced with permission.*

<p><b>Diatoms</b></p> <p>Disc-like plankton <i>Coccolithidiscus</i> sp</p> <p>Star-shaped plankton <i>Asterionella</i> sp</p>		<p><b>Phytoplankton</b></p> <p><i>Biddulphia</i> sp</p> <p>Needle shaped plankton <i>Rhizosolenia</i> sp</p> <p><i>Chaetoceros</i> sp</p> <p><i>Thalassiothrix</i> sp</p>		<p><b>Dinoflagellates</b></p> <p><i>Noctiluca</i> sp</p> <p><i>Ceratum</i> sp</p>	
<p><b>Protozoa</b></p> <p>A foram <i>Globigerina</i> sp</p> <p><i>Radiolaria</i> sp</p>		<p><b>Zooplankton</b></p> <p><b>Cnidaria</b></p> <p><i>Pleurobranchia</i> sp</p> <p><i>Mnemiopsis</i> sp</p>		<p><b>Coelenterata</b></p> <p><i>Liriope</i> sp</p> <p><i>Diphyes</i> sp</p>	
<p><b>Annelida</b></p> <p>Trochophore larva</p> <p>Nereidae post larva</p> <p><i>Sagittella</i></p>		<p><b>Mollusca</b></p> <p>Gastropod larvae</p> <p>Bivalve larva</p>		<p><b>Hemichordata</b></p> <p>Totnaria larva</p>	
<p><b>Chaetognatha</b></p> <p><i>Sagittella</i> sp</p>		<p><b>Echinodermata</b></p> <p><i>Ophiopluteus</i> larva</p>		<p><b>Chordata</b></p> <p>Fish larva</p>	
<p><b>Urochordata</b></p> <p><i>Oikopleura</i></p> <p><i>Fritillaria</i></p>		<p><b>Chelicerata</b></p> <p>Salp</p> <p><i>Doliolid</i></p> <p>Sea spider</p>			

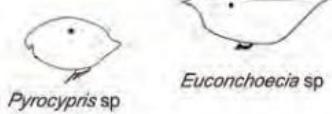
**Zooplankton (cont'd)**

**Cladocerans**  
(water fleas)



**Crustacea**

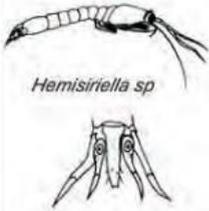
**Ostracods** (mussel shrimps)



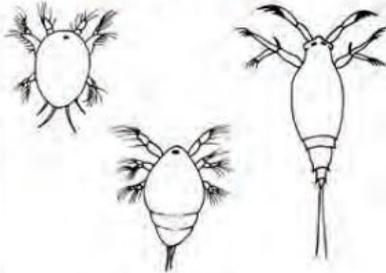
**Cirripedes** (barnacle larva)



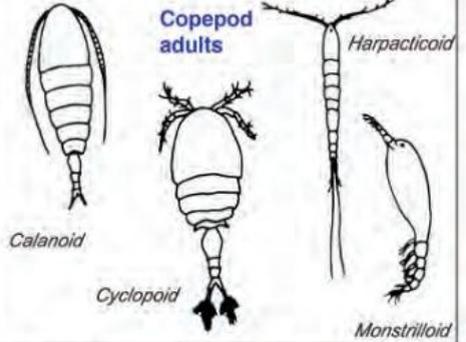
**Mysid shrimp**



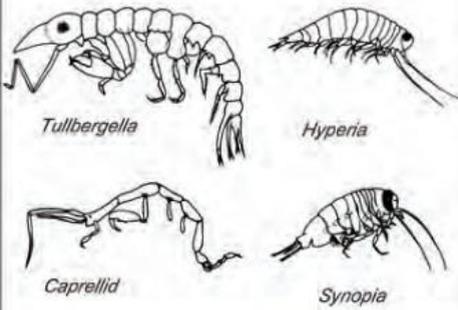
**Copepod larva**



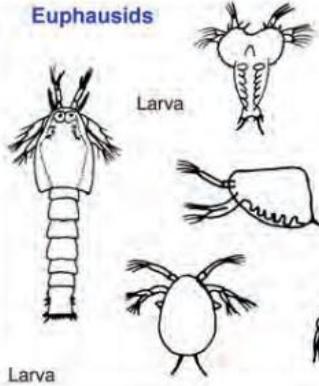
**Copepod adults**



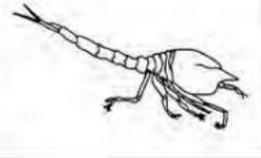
**Amphipods**



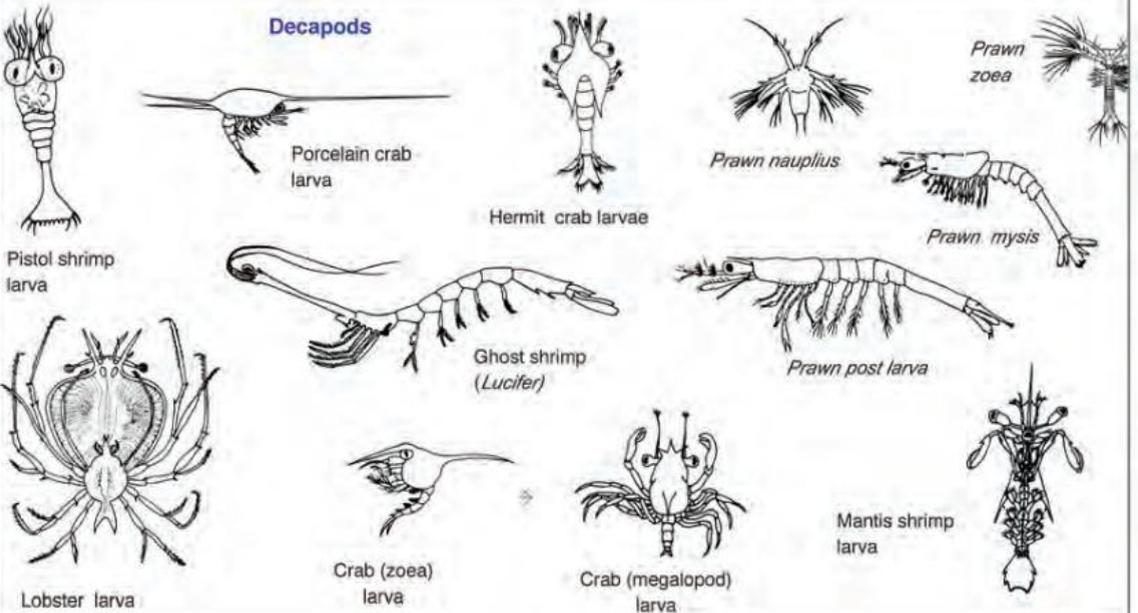
**Euphausiids**



**Cumacean**



**Decapods**



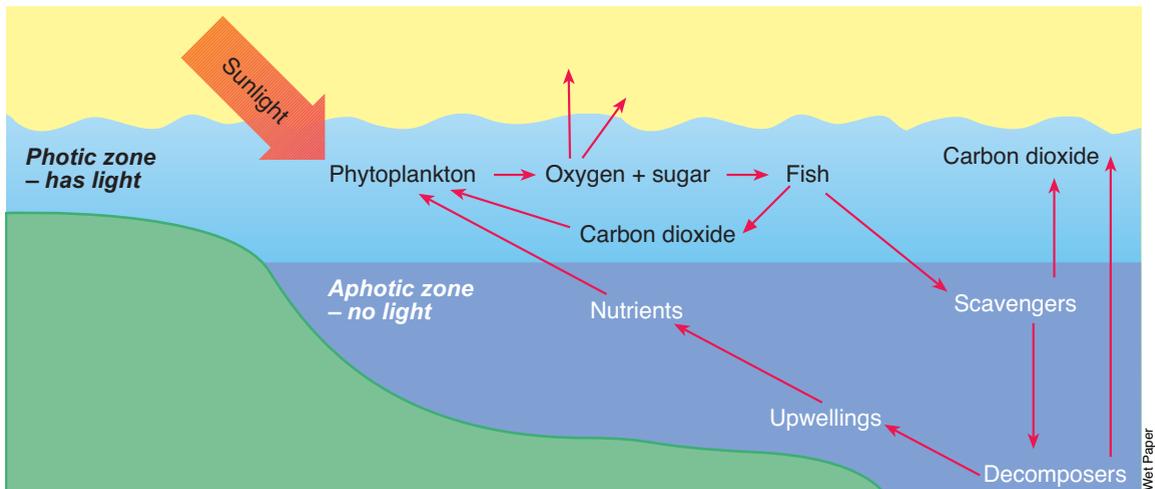


Figure 290.1 The photic zone

## Plankton and the photic zone

Reference: See also Chapter 5

See also pages 64 - 65

The **photic zone** is the depth of water that light can penetrate into the sea (Figure 290.1). This is where phytoplankton live because they need the sunlight for photosynthesis. Organisms in this zone are affected by how clean the water is because dirty water will not allow light to penetrate as far as clear water does.

### Upwellings

When it rains, water runs over the land picking up dirt, leaves and other materials, carrying it into the rivers and estuaries. As these materials move down the river they are pulverised. This organic and non-organic material sinks to the sea bottom to become marine sediments.

**Upwellings** are currents that bring marine sediments to the surface and are very rich in nutrients which fertilise the phytoplankton (see Chapter 12). Phytoplankton grow to very high numbers here, providing an enormous amount of food for marine animals.

## Plankton and the food chain

### Producers and consumers

See also Chapters 5, 20 and 21

**Producers** are plants which make their own food using photosynthesis to convert the Sun's energy to sugars. All the algae on pages 284 - 285 can do this. In the sea, phytoplankton are the primary producers and provide the food for bigger animals feed.

**Consumers** are animals that consume other organisms — plants, animals or both — to obtain their energy needs. All the zooplankton on pages 288 - 289 can do this.



10. Name two zooplankton.
11. What is the main difference between *phytoplankton* and *zooplankton*?
12. Name two planktonic adaptations, giving reasons for your answers.
13. What happens to plankton as night falls?
14. What is the *photic zone*?
15. Why are upwellings important to phytoplankton?
16. Locate and draw examples of the following plankton from pages 288 - 289.
  - Cypus larvae
  - Disc like plankton
  - Gastropod larvae
  - Barnacle larvae
  - Crab zoe
  - Megalopus
  - Fish fry
  - Sea spider



# Key words

Adaptation, adult stage, algal bloom, bioluminescence, estuaries, fertilisation, hermaphrodite, juvenile, larval stage, megalopus, metamorphosis, microscope, mysis, nauplius, ovary, penis, photic zone, phyllosoma, phytoplankton, predators, producers, puerulus, reproductive cells, sperm, testis, tidal zone, vertical migration, zoe, zooplankton, zooxanthellae.

# Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

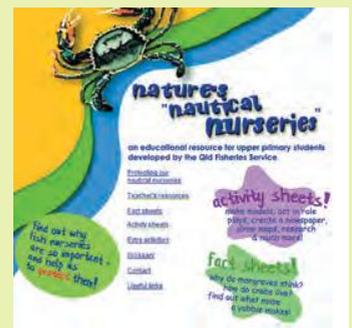
- a. [1] \_\_\_\_\_ (plants), form the basis for life on Earth. They provide more than 70% of the [2] \_\_\_\_\_ we breathe and remove most of the [3] \_\_\_\_\_ we breathe out.
- b. Mature [4] \_\_\_\_\_ live on the continental [5] \_\_\_\_\_ close to river entrances. The fertilised eggs are released into the sea by female prawns, [6] \_\_\_\_\_ to the surface and start their lives as plankton. Within 24 hours, they [7] \_\_\_\_\_ to become the first larval stage called a [8] \_\_\_\_\_, which is very similar to the barnacle.
- c. Female [9] \_\_\_\_\_ generally [10] \_\_\_\_\_ at about 6-7 years of age, between September and January. Most of their [11] \_\_\_\_\_ have hatched by the end of February, and the tiny [12] \_\_\_\_\_ larvae are carried up to 1500 km out to sea on wind driven surface [13] \_\_\_\_\_.
- d. Crabs have a hard outer skeleton ([14] \_\_\_\_\_). When the female has just shed her shell and her new shell is still soft, the male produces a [15] \_\_\_\_\_ which he deposits under one of her legs connecting to her egg pouch.
- e. Shore barnacles live on rocks or places like pylons within the [16] \_\_\_\_\_ and can be found attached to most hard surfaces in the sea. To reproduce, each barnacle has a male reproductive organ called a [17] \_\_\_\_\_ which makes [18] \_\_\_\_\_ and a female reproductive organ called an [19] \_\_\_\_\_ to make eggs.
- f. Blue-green algae are an advanced form of bacteria which have chlorophyll in their cells. In [20] \_\_\_\_\_ that have become polluted with sewage and stormwater runoff, these algae grow very quickly and form an [21] \_\_\_\_\_.
- g. The [22] \_\_\_\_\_ is the depth of water that light can penetrate into the sea. This is where phytoplankton live because they need the sunlight for [23] \_\_\_\_\_.

**Diving deeper**

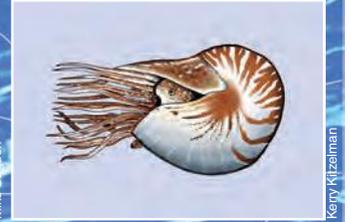


- 7. Research coral bleaching and the effects on the Great Barrier Reef. Make a wall poster.
- 8. Research the origin of the white cliffs of Dover.
- 9. Make a poster of a crab life cycle.
- 10. Draw a diagram showing the difference between male and female crabs and regulations protecting them.
- 11. Make a model copepod to show how it moves.
- 12. Write a play that depicts the vertical migration of plankton. Choose a music selection to illustrate.
- 13. Draw a flow chart to show the reproductive cycle of a prawn.
- 14. Carry out a survey to see who understands the difference between red tide and coral spawning.
- 15. Complete any two crab activities from the nature's nautical nurseries web site.

[www.dpi.qld.gov.au/extra/nnn](http://www.dpi.qld.gov.au/extra/nnn)



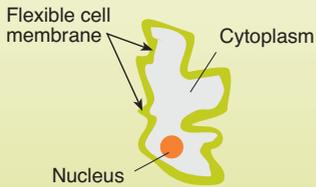
# Chapter 26 Animals without backbones



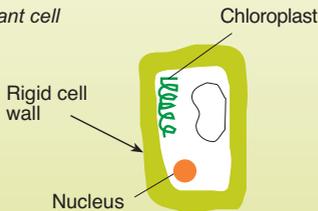
## Web references

[www.reefed.edu.au](http://www.reefed.edu.au), [www.csiro.gov.au](http://www.csiro.gov.au)

### Animal cell

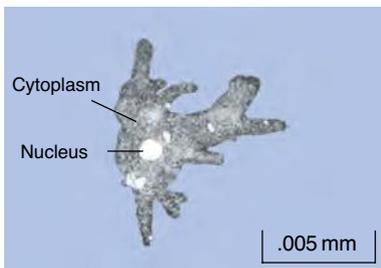


### Plant cell



Wet Paper

Figure 292.1 The difference between animal and plant cells



Jack Marsh

Figure 292.2 Amoeba is a single celled animal but cannot make its own food.



Bob Moffatt

Figure 292.3 Periwinkles

## Differences between plants and animals

Plants are **autotrophs** because they can produce their own food using the energy from sunlight and inorganic materials.

Animals are **heterotrophs** because they obtain their food from other organisms, such as the amoeba shown in Figure 292.2. Other heterotrophs may eat whole animals or parts of animals or graze off algae like periwinkles in Figure 292.3. Animals that eat both plants and animals are called **omnivores**. Another major difference between plants and animals is the cell structure. Plant cells contain **chloroplasts**, the cell components used for photosynthesis, and are surrounded by a rigid cell wall containing **cellulose** (Figure 292.1). This structure gives plant cells a more regular shape than animal cells.

In general, marine animals can move around, they respond more rapidly to stimuli than plants, and they have a more flexible cell membrane.

An enormous number of creatures live in the sea and marine scientists need some way to classify them.

## Classifying living things

All living things can be classified on the basis of their similarities with other organisms. The animal kingdom can be divided into **phyla**, each phylum into classes, each class into **orders**, each order into **families**, each family into **genera**, and each genus into **species**.

Systems of classification are usually based on **structural characteristics** of organisms, such as body skeleton or skin type. This is so that specimens can be classified when they are dead or even from photographs or drawings. Figure 293.2 shows a general classification of marine life based on the five kingdoms.

(In this chapter, the structural characteristics of the group of animals being discussed is given in *italics* under the group's name.)

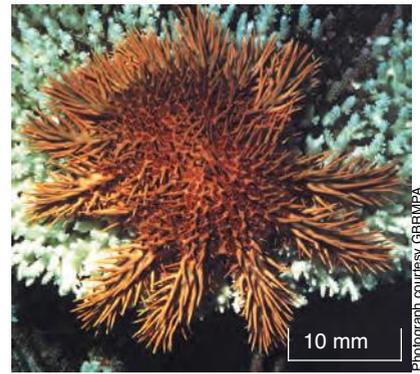
- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

## Naming marine animals and plants

Scientists use rules to give scientific names to plants and animals. Each species is given two names: the name of the genus and the name of the species. It's like having a family name and a given name.

The **genus** name comes first and always has a capital letter. The species name comes second and never has a capital. Both names are written in italics or underlined. This system has been used ever since it was first devised by the Swedish botanist **Carolus Linnaeus** in 1730. An example of a scientific name is *Acanthaster planci* for a **Crown of Thorns starfish** (see Figure 293.1). Scientists all over the world can use this name to talk about this species of Crown of Thorns without confusion.

The Latin name for our species is *Homo sapiens*. Animals without backbones are referred to as **invertebrates** and include the phyla Protozoa, Porifera, Ctenophora, Annelida, Arthropoda, Echinodermata and Mollusca.



Photograph courtesy GBRMIPA

Figure 293.1 *Acanthaster planci*- the Crown of Thorns starfish

### Note

*Vertebrates are discussed in the next chapter. Marine plants are discussed in Chapters 5, 13, 20, 21, 25.*

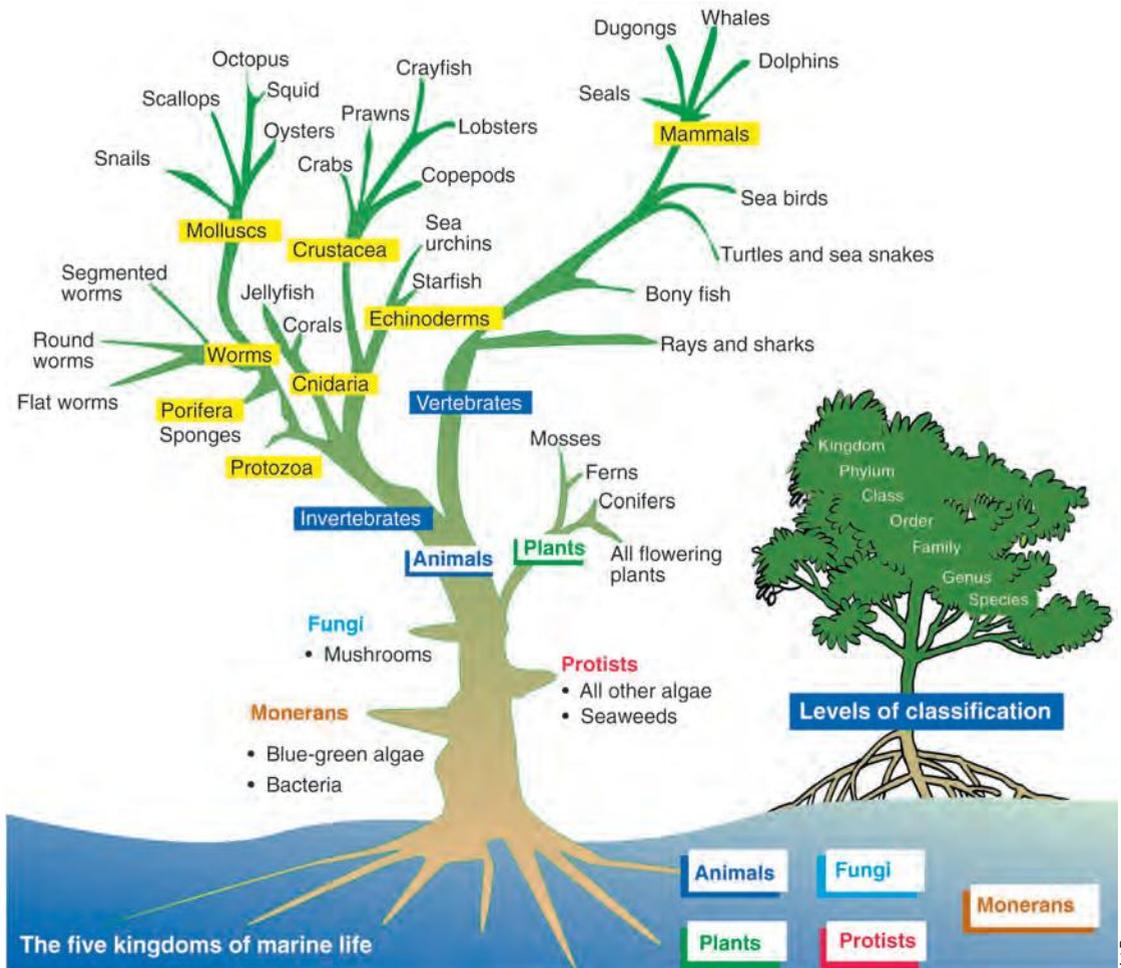


Figure 293.2 Tree of marine life

Wet Paper

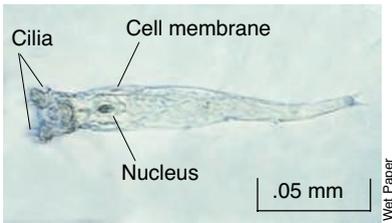


Figure 294.1 Marine protozoan

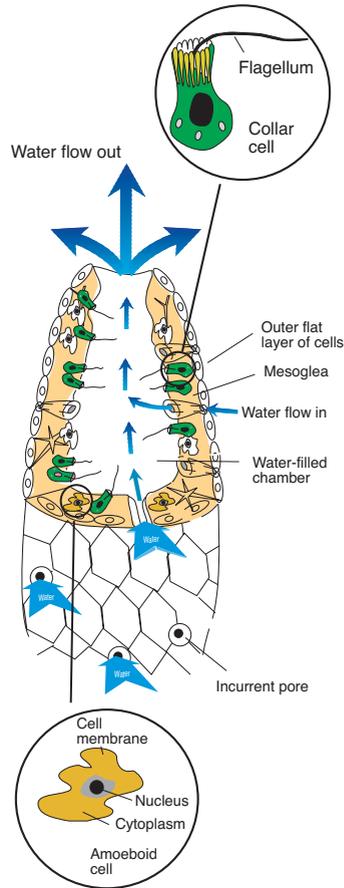


Figure 294.2 Cross-section of a sponge

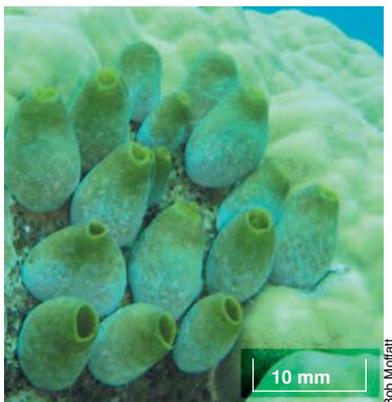


Figure 294.3 Sponges on coral

# Protozoans

## Phylum Protozoa

*Microscopic, single-celled animals.*

These microscopic animals are found in all parts of the sea, living on other animals or plants. Some protozoans called radiolarians secrete a calcium carbonate shell called a test which remains intact when the animal dies, sinks to the ocean floor and becomes part of the deep sea ooze.

When the ooze is lifted up onto the land, it forms chalk and silicone beds. The white cliffs of Dover are the dead remains of marine protozoans.

Some protozoans have special hairs called **cilia**, which beat to move food towards their cell membrane (Figure 294.1).

# Sponges

## Phylum Porifera

*Animals with many pores and many cells but no organs or tissue, attached to the sea floor.*

Adult **sponges** grow attached to rocks, sea plants, the shells of marine animals and to artificial structures. They can be found at all depths from the inter-tidal zone to the deepest parts of the sea. Live sponges are often brightly coloured.

Unlike other groups of animals, sponges show little or no **symmetry**. Their 'bodies' are made up of canals through which water is 'pumped' by ciliated cells. Water is pumped in through small holes and out through larger holes (see Figure 294.2).

This water is filtered to provide the sponge with food at a remarkable speed. The water in some sponges can be changed completely in as little as 20 seconds. A sponge the size of a coffee cup could filter over 4000 litres of water a day.

Sponges are supported by a series of small **spicules**, made of lime or silica, and by tough fibres. These structures are the parts of dead sponges which are washed up onto beaches, and are sometimes used for loofahs, cosmetic sponges and so on. In some parts of the world, divers make a living collecting sponges for these purposes.

Some sponges bore their way into coral reefs. The pieces that break off form coral sand.

One of the most bizarre characteristics of sponges is that they are able to put themselves back together if they have been broken up. No other group of animals is able to do this.

# Jellyfish, corals and anemones

## Phylum Cnidaria

*Sac-like animals with body plan arranged in a circle and a sac at one end, two cell layers, stinging cells.*

**Cnidarians** are **radially symmetrical**, with a simple body in the form of a sac or **coelenteron** with one opening or mouth (Figure 295.1). This mouth is surrounded by a ring of tentacles on which special stinging cells called nematocysts are found. These cells are for feeding and defence. In some species of jellyfish, these stinging cells can be dangerous to humans (see Chapters 2 and 3).

## Jellyfish

These animals can get together to form colonies of specialised individual cells such as the Bluebottle shown in Figure 295.2. Each group of cells performs a different function: feeding, digestion of food, reproduction. Even the float is a group of cells designed for floating. Some are free swimming, like the by-the-wind sailor or the Box jellyfish.

## Corals

The only living thing that can be seen from outer space is the Great Barrier Reef which was formed by corals.

**Corals** produce a limy skeleton that remains behind when the animal dies. This skeleton is the structure which new corals grow on. After long periods of time, they can build up to produce structures such as those which make up the Great Barrier Reef and other coral reefs around the world. There are soft and hard corals. The Great Barrier Reef Marine Park Authority has classified hard corals by their appearance as either boulder, branching, plate, table, vase, bushy or solitary. Some of these are shown in Figure 295.3.

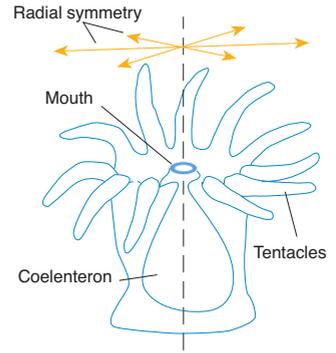


Figure 295.1 Radially symmetrical marine animal  
Wet Paper

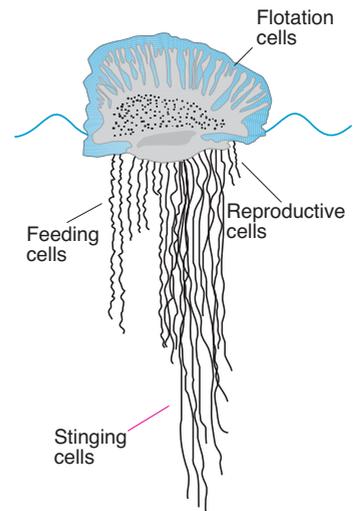


Figure 295.2 Bluebottle  
Wet Paper

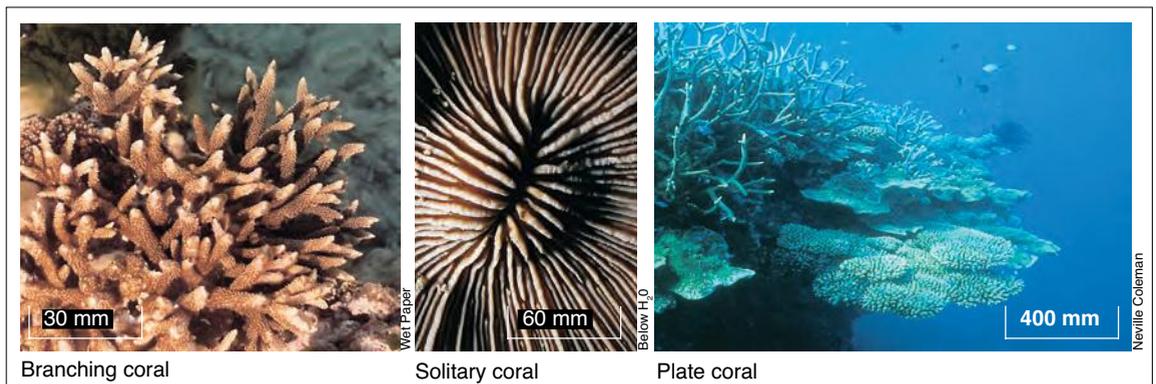


Figure 295.3 Some types of coral

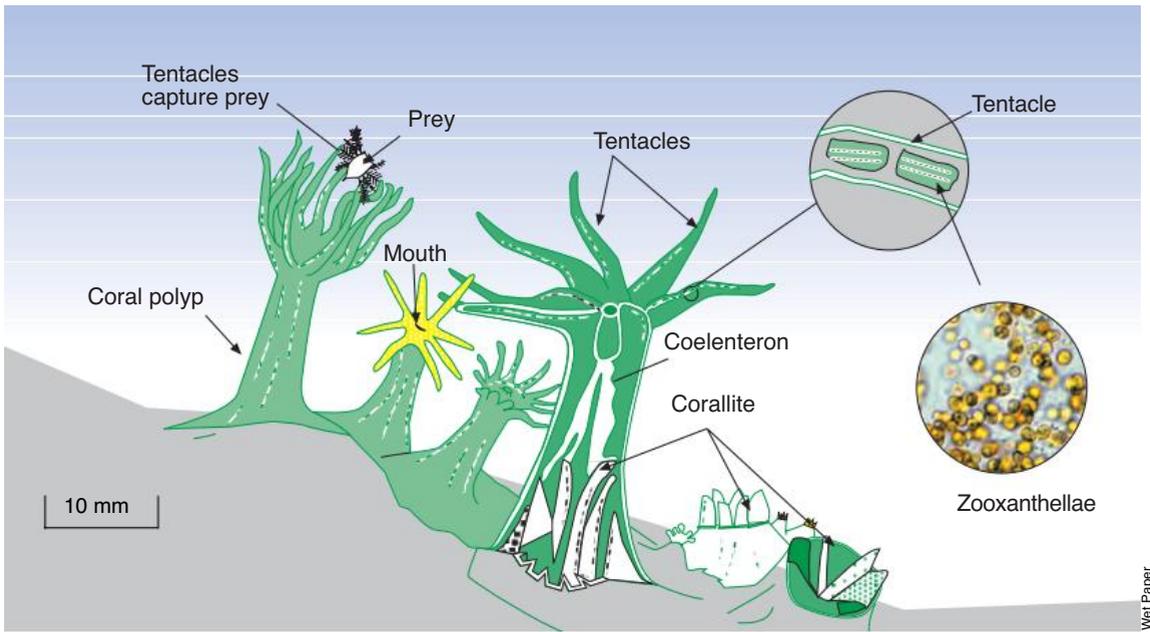


Fig 296.1 How corals feed



Figure 296.2 Sea anemone

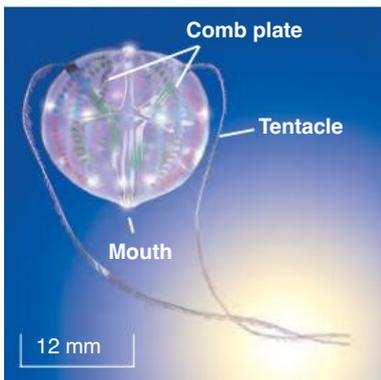


Figure 296.3 Comb jellyfish structure

While corals are animals, and therefore heterotrophic, many are also able to obtain nourishment from single-celled algae embedded in their tissues. These zooxanthellae (see Chapter 25) and corals share a symbiotic relationship, as shown in Figure 296.1. The coral has a mouth, tentacles which capture food, and a hollow gut or coelenteron. At their base they have a special structure which takes in calcium carbonate from the surrounding waters and secretes a coral skeleton.

### Sea anemones

Sea anemones (see Figure 296.2) illustrate some of the features of the phylum Cnidaria. The body plan is arranged in a circle with two cell layers and stinging cells on the tentacles. The tentacles are connected to a mouth which leads down to a hollow gut (the coelenteron) which is where food is digested. Wastes are then ejected out of the mouth. Sea anemones can move by sliding on their basal disc or by somersaulting from place to place. They reproduce by growing small buds on their sides or by producing eggs and sperm from inside their gut.

### Comb jellies

*Radially symmetrical, similar to jellyfish with eight rows of comb plates called ctenes.*

These animals are similar to jellyfish but have rows of cilia which beat in a comb-like manner as shown in Figure 296.3. They are free swimming, are part of the plankton family and are very common in tropical waters.

# Worms

## Phylum Annelida

*Worm shape, segments mostly with bristle appendages, distinct head with eyes and tentacles which are reduced in tube-dwelling forms.*

Annelids are segmented worms. Their bodies are made up of many sections. These animals have four distinct parts: the anterior (front), posterior (back), dorsal (top) and bottom (ventral). Most marine annelids are bristle worms which have leg-like bristles along their length. They may be free swimming, live in burrows in the mud or they may construct tubes to live in (Figure 297.1).

A common worm without a reduced head is the Christmas tree worm (Figure 297.2). The larvae of this worm settle among coral polyps and stimulate the coral to grow around them as the worms grow to maturity. If you put your hand close to them, they will retract into their tubes with lightning speed.

Other worms form tubes such as the one shown in Figure 297.3. These are very sensitive to sounds and if you click your fingers near one when snorkelling, you can see how fast they retreat into their tube.

## Animals with jointed legs

### Phylum Arthropoda

*Segmented animals with an external skeleton called an exoskeleton. Bilaterally symmetrical with an open circulatory system, a one-way digestive tract and a ventral nerve cord.*

This phylum of animals is by far the largest animal phylum. The number of arthropod species outnumbers all of the others put together. All arthropods have an exoskeleton made of a substance called **chitin**, which must be shed by the animal as it grows. Arthropods are **bilaterally symmetrical** which means that if you cut one in half, one side looks like the other. For example, if you cut the crab in Figure 297.4 in half, one side would be the same as the other.

All arthropods have jointed legs which are adapted for functions such as digging, sensing, grasping, mating or egg carrying.

One interesting gap in the groups of arthropods in the sea is the class Insecta (or insects). This is the single largest class of animals in the world, yet there are very few true marine insects. This is possibly due to their inability to cope with the high levels of salt in sea water.

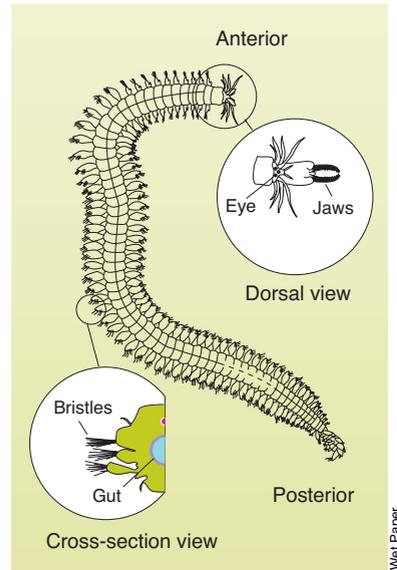


Figure 297.1 Segmented worm



Figure 297.2 Christmas tree worm in coral clump

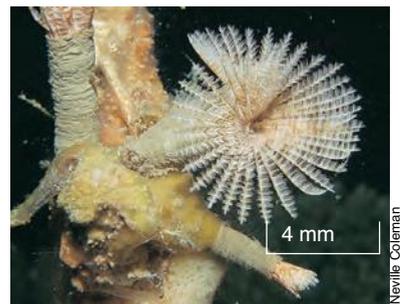


Figure 297.3 Tube worms

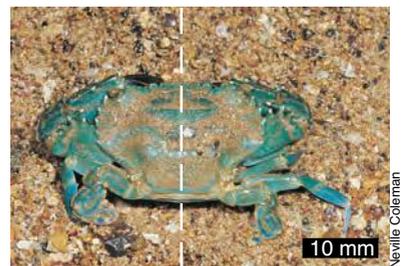


Figure 297.4 A crab - bilaterally symmetrical



## Questions

Use your textbook to find the answers

1. What is a *heterotroph* and how is it different from an omnivore?
2. What are the levels of classification of animals?
3. What is the major difference between animal and plant cells?
4. Name the five kingdoms of marine life.
5. Name the structural characteristics of protozoa.
6. How are sponges different from protozoans?
7. Name the structural characteristics of cnidarians.
8. All marine worms have one thing in common. What is it?



Figure 298.2 Barnacle feeding

Wet Paper

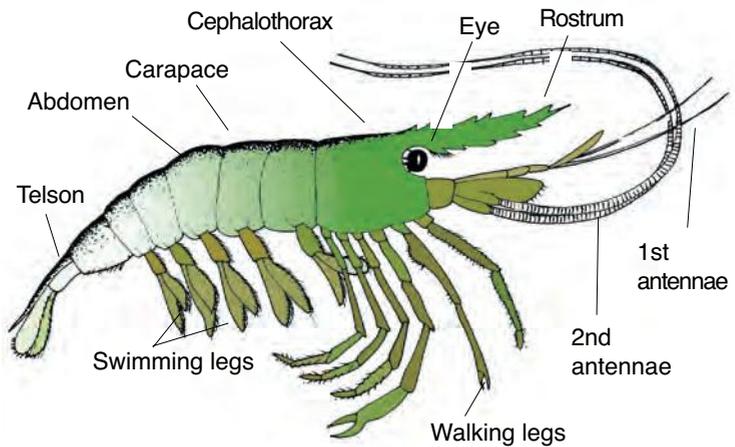


Figure 298.1 General features of the Class Crustacea  
Wet Paper

## Class Crustacea

See also Chapter 25 for life cycles of barnacles, crabs, lobsters and prawns

This class includes crabs, shrimps, prawns, sea lice and barnacles. Figure 298.1 shows the general features of this class.

Barnacles are unusual crustaceans because the adult is **sessile**, growing attached to rocks, ships and the like (Figure 298.2). The shell of barnacles has been modified into a protective coating that helps to anchor the barnacle to a surface. A barnacle uses its legs to wash food into its mouth. Barnacles are very common on rocky coasts and are able to survive being battered by waves in these exposed positions. The Goose or Stalked barnacle is most often found in the open ocean attached to driftwood.

Crabs, prawns, lobsters and ‘bugs’ are important commercially. These animals have a cephalothorax called the ‘head’ (Figure 298.1), an abdomen and a telson or ‘tail’. In crabs, the **abdomen** is reduced to a small flap tucked away under the cephalothorax as shown in Figure 298.3. The abdomen has special appendages that enable the female to carry her eggs. This rounded abdominal flap makes it easy to sex crabs. Female crabs should not be taken for food.

Crustaceans play an important role in the food chain because they scavenge for dead and decaying matter. They clean up the sea floor, keeping bacterial and algal growth to a minimum. One problem with having a hard exoskeleton is that it is difficult to mate. The animals have to wait till they **moult** or shed their skin. The reproductive tissues are then soft and sperm can be transferred to the female’s eggs. Sperm are usually produced in a bundle and one of the male crab’s walking legs is usually modified to place the sperm packet in the female’s reproductive opening that leads to her egg chamber.

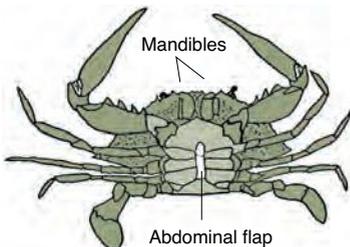


Figure 298.3 Crab from underneath  
Wet Paper



Figure 299.1 Western rock lobster

Most crustaceans hold their eggs beneath their bodies until they hatch and young larvae are released into the plankton. The young grow and develop, as discussed in Chapter 25, returning to a bottom-dwelling existence as adults.

Crustaceans have many forms of defence but none more impressive than the lobster (Figure 299.1). Their claws, rostrum and antennae are all sharp and the lobster uses them to ward off predators.

## Spiny-skinned animals

### Phylum Echinodermata

*Radially symmetrical, vascular system characterised by tubed feet, skeleton of calcareous plates.*

This is a large and diverse group of animals which includes sea stars, sea urchins and sea cucumbers. Apart from the sea cucumbers, **echinoderms** have a rough, spiny outer skin, and hydraulically operated tubed feet as shown in Figure 299.2. Tubed feet help echinoderms move and feed.

Echinoderms show remarkable powers of regeneration because new body parts can be created from old ones. For example, if a sea star loses one of its arms, it can grow another.

Sea stars usually have five arms but can have more. These are continuous with the central body section. Brittle stars have a distinct central disc with usually five arms growing from it (Figure 299.3). Sea urchins are more or less spherical. They are covered in long, brittle spines that can make them dangerous to touch (Figure 299.4).

See Chapter 3 for more information on sea urchins.

## Diving deeper



1. Visit a fish shop and photograph a selection of local crustaceans such as prawns or crabs. Find out where they live and how to cook them.
2. Visit a fishing boat and ask the skipper to describe how crustaceans are caught.

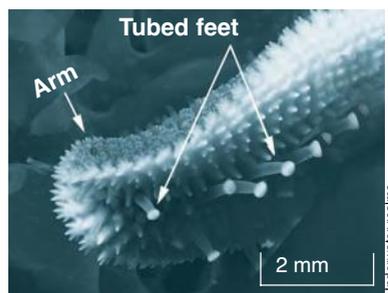


Figure 299.2 Tubed feet of a sea star

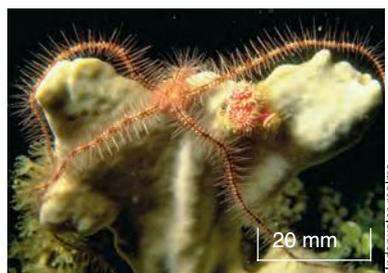


Figure 299.3 Brittle star

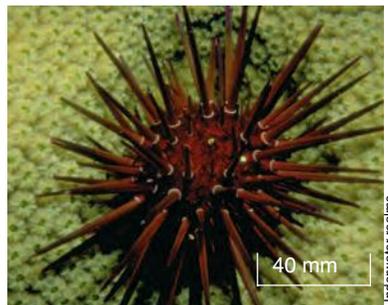


Figure 299.4 Sea urchin

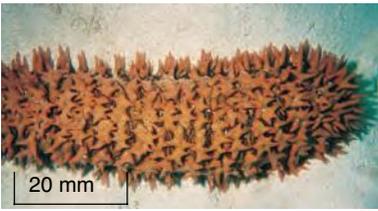


Figure 300.1 Sea cucumber



Figure 300.2 Periwinkles and a limpet

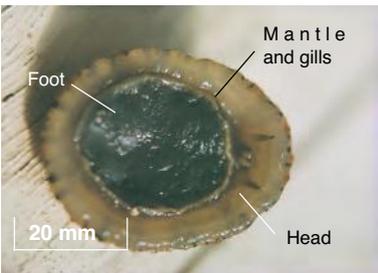


Figure 300.3 Underneath a limpet



Figure 300.4 Mudwink

Sea cucumbers, as shown in Figure 300.1, have a soft cylindrical body with a ring of feeding tentacles around the mouth. When disturbed, a sea cucumber may release sticky anal threads. If this does not deter a predator, it may squirt out its internal organs in a sticky mass! These organs are regenerated later.

## Animals with shells

### Phylum Mollusca

*Most have a soft skin, bilateral symmetry, mantle with gills, most types protected by a shell, no segmentation.*

**Molluscs** have a soft body, usually covered with a hard outer shell or shells. They breathe through gills and many have a strong foot to fix themselves to rocks for protection (Figure 301.1). The limpet in Figure 300.3 is a good example of this phylum because if we carefully prize it off the rocks and turn it over we can see the head, foot and mantle cavity.

Molluscs also have a modified mouth piece called a **radula** which scrapes food off rocks. Each periwinkle in Figure 300.2 is feeding with this radula, scraping algae from the rock surface.

There are six classes of molluscs. Four of these are common, one is only seen rarely and the sixth class is only known through fossils and a few specimens dredged from the ocean depths.

### Class Gastropoda

The **gastropod** molluscs are the snails and slugs. This is the largest class and is characterised by a spiral shell, although some slugs no longer have this.



In this group are whelks, limpets and periwinkles. The most commercially important is the abalone.

The mudwink (Figure 300.4) lives in mangrove mud and feeds off plankton and other dead remains. The mouth is ventral and surrounded by an inner and outer cap which can be closed with an operculum.

In this class we also find the dangerous cone shell. Cone shells are also discussed in Chapters 2 and 3.

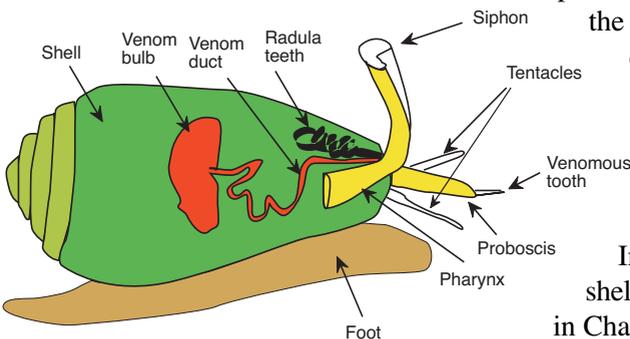


Figure 300.5 Cone shell

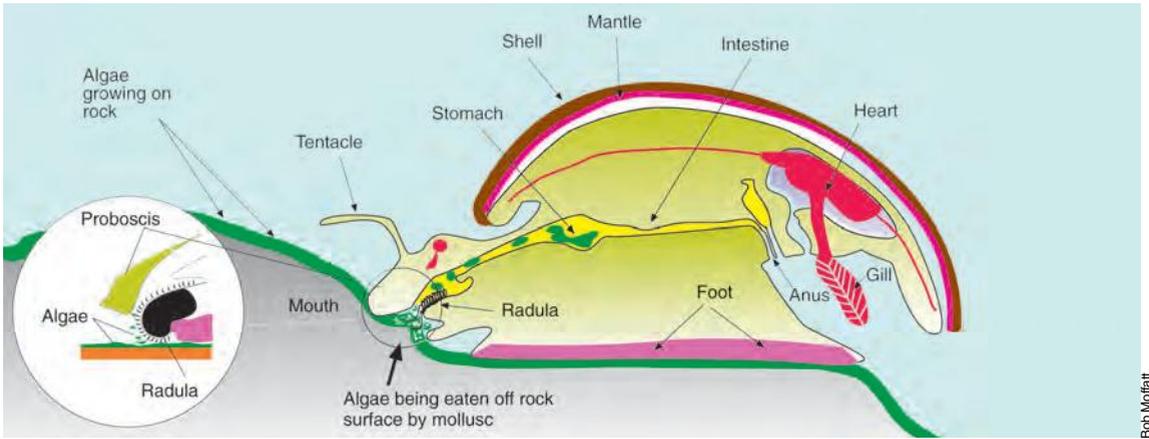


Figure 301.1 The interior of a mollusc

Other gastropods include the **nudibranchs** (Figure 301.2) which have a shell when they are young but shed it when they grow up.

They are beautifully coloured and move so gracefully they have often been called spanish dancers.

The abalone is a commercial gastropod prized by people who live in Asia for its medicinal powers. The life cycle involves both a veliger and trochophore larva (Figure 301.3).

**Class Bivalvia**

Molluscs with two shells are known as **bivalves** (or sometimes as Pelecypoda). The two shells are hinged and can be opened and closed by muscles attached to the shell (Figure 301.4). Pippies and scallops are two common bivalves.

Scallops are dredged commercially by trawlers and are a much prized seafood item in restaurants. Tasmania is famous for its scallops.

Other bivalves attach themselves to rocks or burrow into the sand, like cockles and pippies (Figure 301.4). Many bivalves are commercially important such as scallops and oysters.



Figure 301.2 Nudibranch (Steven Byers and Kerry Kitzelman)

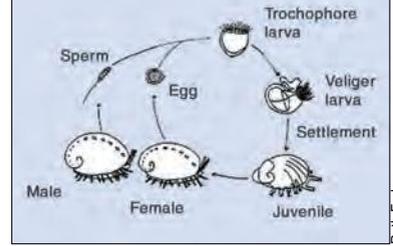


Figure 301.3 Abalone and life cycle



Figure 301.4 Bivalves



Figure 302.1 Chiton  
*Acanthoplera sp*



Figure 302.2 Octopus



Figure 302.3 Cuttlefish

## Class Amphineura

These are a little like long limpets with eight sections to their shells. They are found clinging to rocks, often in the surf zone. The **chiton** (Figure 302.1) is an example of an amphineuran. Male and female chitons release their sperm and eggs into the water. Fertilization is at sea and larval stages swim back to shore where they find rocks and settle to grow as adults.

## Class Cephalopoda

The most spectacular group of molluscs is probably the cephalopods. This is the class which contains the squids, octopuses (Figure 302.2), cuttlefish (Figure 302.3) and nautilus (Figure 302.4). In this class, the foot is modified into a group of tentacles surrounding the mouth.

Cephalopods have highly developed eyes and a relatively large brain. The Blue-ringed octopus can be a very dangerous animal if handled incorrectly, as discussed in Chapter 3. Generally, humans are more danger to cephalopods than the other way around. Squid, octopus and cuttlefish are all captured and eaten by humans in large quantities. The largest of the invertebrate animals is the giant squid, which can grow to at least 18 metres long. It is found in the open ocean at depths of 300 metres or more and is prey for sperm whales. The giant squid is sometimes washed onto beaches or found dead floating on the sea surface. It is probably this creature which gave rise to myths of sea monsters which were supposed to devour ships and seafarers. It is unlikely that any cephalopod other than the Blue-ringed octopus is a threat to humans.

### The Nautilus

The Nautilus is active at night feeding on crabs and fish and rests during the day. Whether it is swimming or resting its gas filled chambers keep the shell buoyant and upright. Swimming relies on the ejection of water through a siphon by the contraction of muscles. If threatened it can retract its head into its shell.

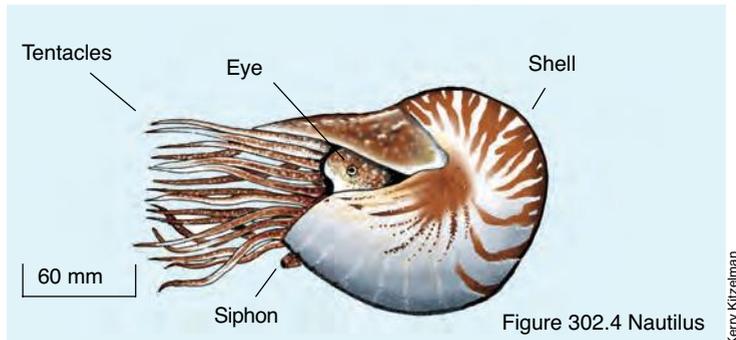


Figure 302.4 Nautilus

# Key words

Amphineura, annelida, arthropoda, autotrophs, barnacle, bivalve, Carolus Linnaeus, cellulose, chitin, chloroplast, cilia, coelenteron, crustacea, cuttlefish, echinoderm, exoskeleton, family, gastropod, genera, heterotrophs, invertebrate, mollusc, moult, Nautilus, nudibranch, omnivore, order, phyla, protozoan, radially symmetrical, radula, sea urchin, sessile, species, structural characteristic.

# Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. Plants are [1] \_\_\_\_\_ because they can produce their own food using the energy from sunlight and inorganic materials. Animals are [2] \_\_\_\_\_ because they obtain their food from other organisms. Other heterotrophs may eat whole animals or parts of animals or graze off algae like [3] \_\_\_\_\_. Animals that eat both plants and animals are called [4] \_\_\_\_\_.
- b. Plant cells contain [5] \_\_\_\_\_, the cell components used for photosynthesis, and are surrounded by a rigid cell wall containing [6] \_\_\_\_\_.
- c. The [7] \_\_\_\_\_ name comes first and always has a capital letter. The species name comes second and never has a capital. Both names are written in [8] \_\_\_\_\_ or underlined.
- d. Cnidarians are [9] \_\_\_\_\_, with a simple body in the form of a sac or [10] \_\_\_\_\_ with one opening or mouth.
- e. [11] \_\_\_\_\_ produce a limy skeleton that remains behind when the animal dies. This [12] \_\_\_\_\_ is the structure which new corals grow on. After long periods of time, they can build up to produce structures such as those which make up the [13] \_\_\_\_\_ and other coral reefs around the world.
- f. All arthropods have an exoskeleton made of a substance called [14] \_\_\_\_\_, which must be shed by the animal as it grows. Arthropods are [15] \_\_\_\_\_ which means that if you cut one in half, one side looks like the other.
- g. Apart from the sea cucumbers, [16] \_\_\_\_\_ have a rough, spiny outer skin, and hydraulically operated tubed feet.
- h. Molluscs with two shells are known as [17] \_\_\_\_\_.
- i. The [18] \_\_\_\_\_ molluscs are the snails and slugs.
- j. Scallops are dredged [19] \_\_\_\_\_ by trawlers and are a much prized seafood item in restaurants. [20] \_\_\_\_\_ is famous for its scallops.



- 9. Why have insects failed to conquer the marine world?
- 10. What are *tubed feet* and of what phylum are they a structural characteristic?
- 11. An animal has soft skin, bilateral symmetry, a gill membrane, no segmentation and most types are protected by a shell. To what phylum does it belong?
- 12. What do divers like about tube worms?
- 13. What do crustaceans do when they moult?
- 14. Give an example of one animal that uses regeneration as part of its adaptation to underwater life.
- 15. What is the largest invertebrate animal?
- 16. What is a *radula* and how is it used by molluscs to get food from rocks?
- 17. To what class do abalone belong?
- 18. What is the scientific name for the Crown of Thorns starfish.
- 19. Draw a diagram for an abalone life cycle.
- 20. Calculate the approximate sizes for all the animals in this chapter from the scale given in each Figure.

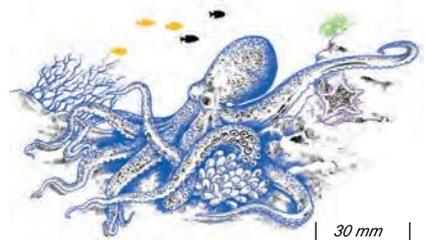


Figure 303.1 Octopus and eggs  
Illustration Sharyn Madder Courtesy MESA

# Chapter 27 Marine vertebrates



## Web references

[www.reefed.edu.au](http://www.reefed.edu.au), [www.csiro.gov.au](http://www.csiro.gov.au),  
[www.mesa.edu.au](http://www.mesa.edu.au)



Figure 304.1 Cunjevoi from a rock pool

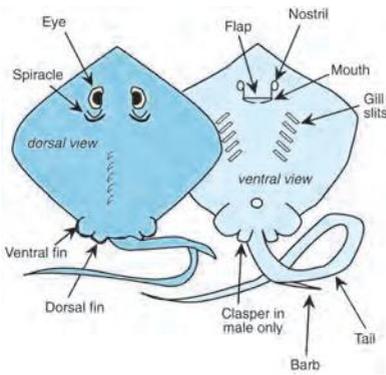


Figure 304.2 Features of rays  
Rose Bedford

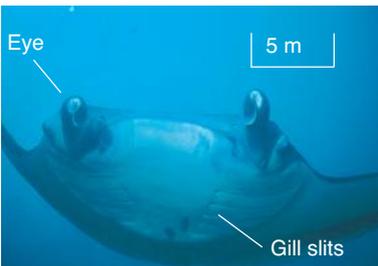


Figure 304.3 Manta ray

The evolution of a backbone protecting a spinal cord allowed animals to become more complicated. Improved and extended nervous systems enabled animals to conquer the land, become bigger and more agile. Marine mammals returned to the sea with all these characteristics, the birds became masters of the air while the sharks have remained basically the same over millions of years. Marine vertebrates belong to the Phylum Chordata which has the following characteristics.

*Skeleton made of cartilage or bone, gill slits in the throat at some stage of its life cycle, dorsal nerve cord that extends the length of the animal and a posterior tail.*

## Class Ascidiacea

A representative of this group of animals is the **cunjevoi** which grows in the inter-tidal zone of rocky reefs and pools as shown in Figure 304.1. This animal does not have a true backbone, but does have a **notochord** which is the part of the vertebrate embryo which develops into the backbone. Cunjevois are just one of an enormous number of ascidians that live in shallow waters worldwide.

## Class Chondrichthyes

Sharks and rays have a skeleton composed of cartilage rather than bone. **Cartilage** is a type of gristle similar to that found in your nose. Sharks and rays do not have typical fish scales. If you run your hand one way along a shark's skin it will feel smooth but try to run it back the other way and you soon realise that the skin is sharp. Their fins are rigid and they have no swim bladder so sharks and rays need to keep swimming to maintain their level in the water. Rays are flattened while sharks are more cylindrical and streamlined (Figures 305.2 and 304.3). Sharks and rays do not have the gill cover, the **operculum**, which is found in bony fish. While most rays and sharks lay eggs, some sharks give birth to live young.



Shark egg case  
Bob Moffatt

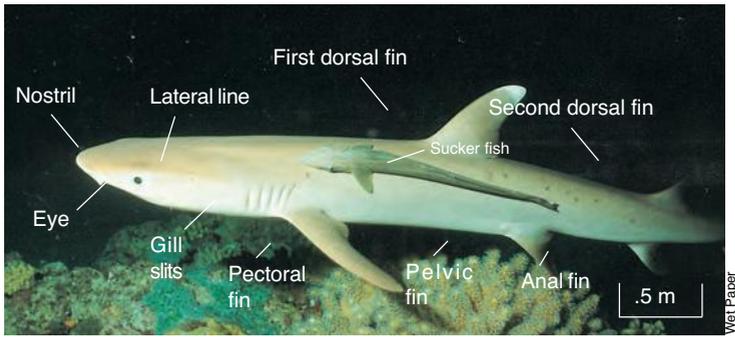


Figure 305.1 Generalised features of a shark

The largest of all fish is the Whale shark (Figure 305.2) which grows to 15 metres or more. This shark is a harmless filter feeder, unlike the Great White shark which can grow to at least 6 metres long and has certainly been responsible for attacks on humans (see Chapter 3). The Great White does not deserve its evil reputation, and in many places it is protected from humans who would hunt and kill it.

Sharks are important because they help control population sizes in the food chain. They also weed out the sick and injured as well as scavenging for food. Sharks are so nondiscriminating in their diet that some have been found to have old oil drums in their stomachs.

### Shark meshing

Major beaches in some Australian states are protected by shark nets and drum lines as shown in Figures 305.3 and 305.4. Drum lines are made up of a baited shark hook on a chain running up to a float on the surface. The float is attached by a rope to a heavy anchor on the sea-bed so it remains in place. The hooks are baited and sharks are attracted and caught as they bite at the bait. **Drum lines** are checked for sharks on a regular basis and are baited if required (Figure 305.4). Nets are anchored to the sea floor by tow anchors at either end of the net. Marker buoys identify the end of the net and a series of white floats keeps the net hanging on the surface. Sharks are caught as they swim into the net and are hauled on board a special shark boat usually under contract to the government.

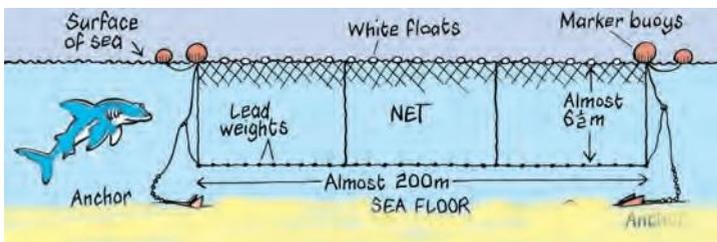


Figure 305.3 Shark net

Illustration courtesy Paul Lennon Courtesy Qld Fisheries Service

## Diving deeper



1. Use the library to compare drawings of fish scales and shark teeth.
2. How do sharks reproduce?
3. What impacts have humans had on shark numbers worldwide?
4. Research the use of shark repellent devices.



5. Check out the MESA Seaweed 2005 shark web site [www.mesa.edu.au](http://www.mesa.edu.au)

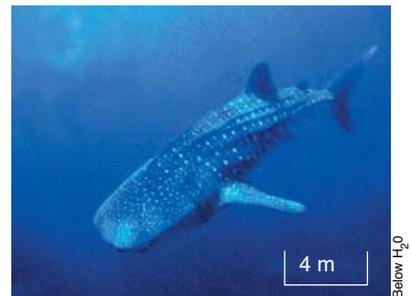


Figure 305.2 Whale shark

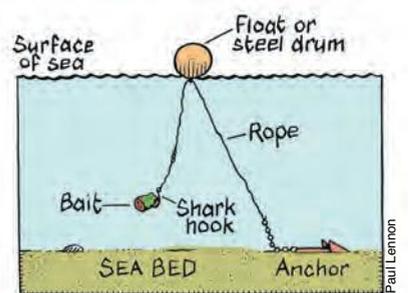


Figure 305.4 Shark drum line



Figure 306.1 Puffer fish

Mike Sugden



Figure 306.3 Common sea dragon

Mike Sugden



Figure 306.4 Colour disguise in fish

Below HQ



Figure 306.5 Moray eel

Underwater realms

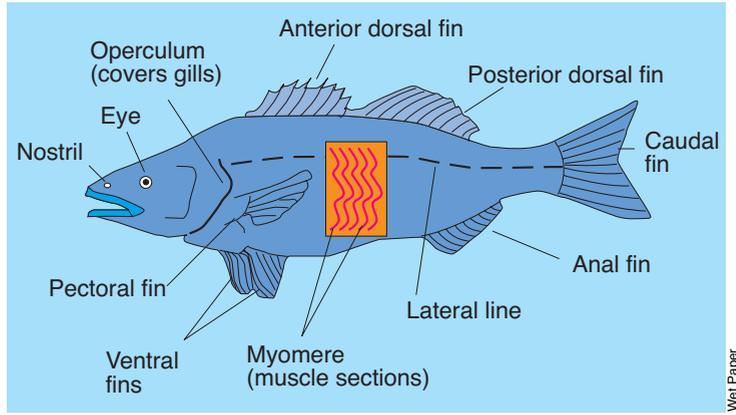


Figure 306.2 Generalised fish

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## Class Osteichthyes (bony fish)

Bony fish have true scales, a bony skeleton, a single pair of gill openings and an **operculum** which covers the gills (see Figure 306.2 and 307.1). Like sharks, fish have a **lateral line** system which enables them to sense vibrations in the water. Their eyes and sense of smell are also well developed. Fish are the world's main source of animal protein for humans.

Bony fish have paired fins, a term that refers to fins that are the same on either side of the body. Fish have two types. **Pectoral** fins help the fish go up, down and sideways and the **ventral** fins are used in steering the animal as it propels itself forward by its caudal fin.

Rays or spines stiffen these fins because they are mostly used for swimming. Some fish have fins modified into feelers or suckers. Other types of fish, such as the Moray eel shown in Figure 306.5, live in burrows where they can dart out and catch passing fish. The burrow also gives the Moray eel protection from predators.

Some fish inflate their bodies to protect themselves from their enemies (for example, the Puffer fish in Figure 306.1) whereas others disguise themselves as plants (for example, the sea dragon in Figure 306.3).

Colour has become an important part of fish anatomy. Some fish even disguise their heads with stripes (Figure 306.4) so that predators cannot distinguish them from the homes where they live.

### Feeding

Fish have a one way digestive system. Food enters the mouth and passes by muscular contraction to the oesophagus located in the gill region.



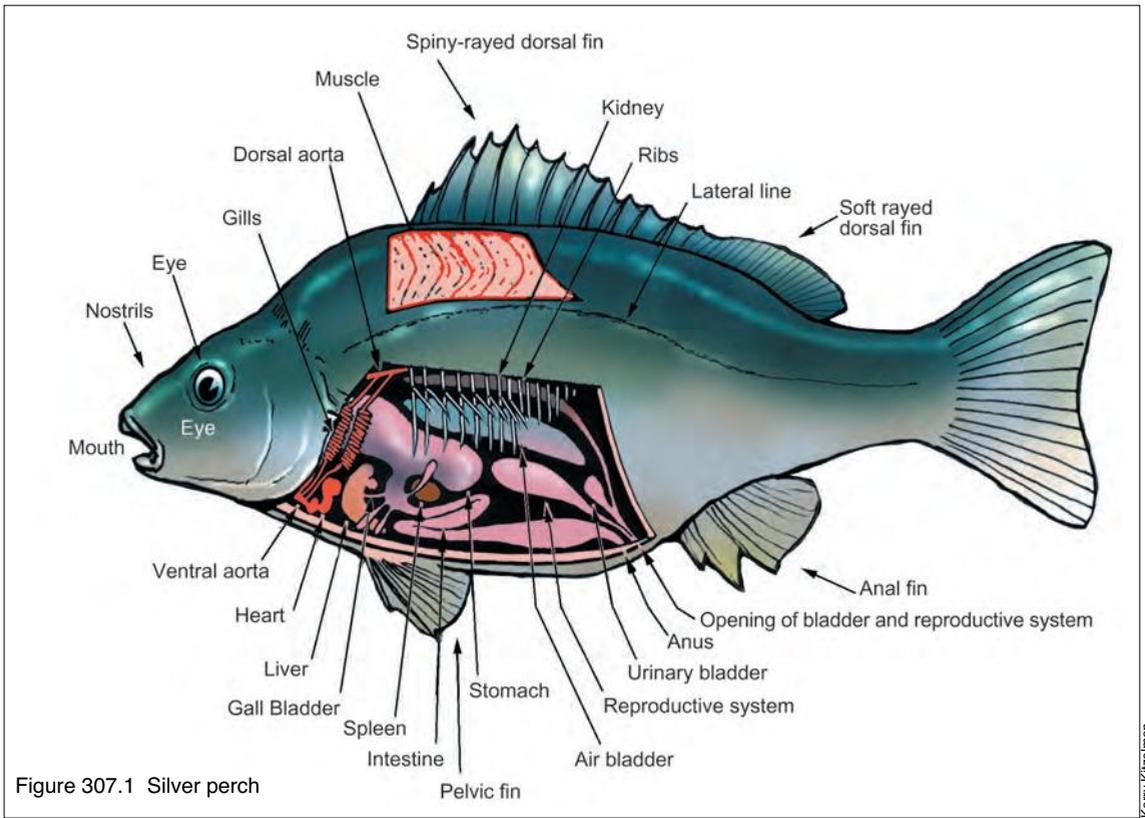


Figure 307.1 Silver perch

Kerry Kitzelman

It connects the mouth to the stomach as shown in Figure 307.2. The stomach (or gullet) is the place where much of the digestive process takes place. As a general rule, fish with short intestines are carnivorous and those with long intestines are herbivorous. Digested wastes are then eliminated from the intestine through the anus.

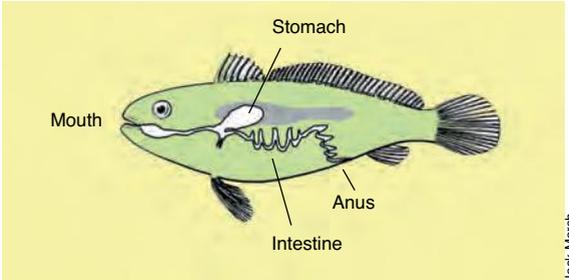


Figure 307.2 Digestive system

Jack Marsh

**Circulation**

Bony fish breathe through gills, which are best observed by lifting the gill cover, the operculum, and peering under it, but can also be seen from the mouth.

Water passes through the mouth and over the **gills** where some of the oxygen dissolved therein is removed.

Blood is circulated by a two-chambered heart as shown in Figure 307.3, and passes through the gills, where it receives a fresh supply of oxygen before coursing through the remainder of the body.

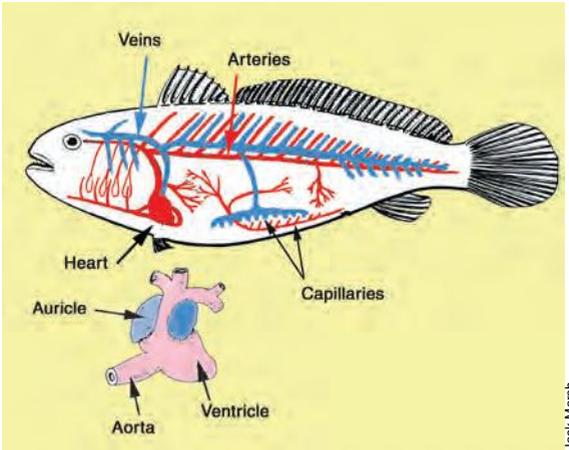


Figure 307.3 Blood system and heart

Jack Marsh

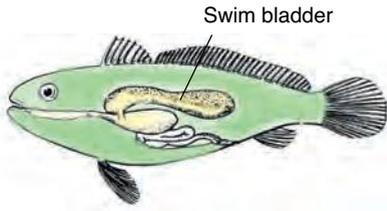


Figure 308.1 Swim bladder

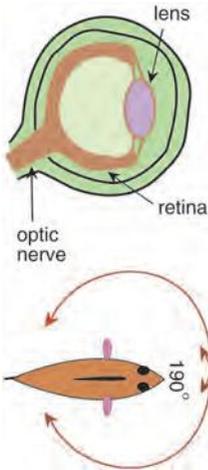


Figure 308.2 Fish vision

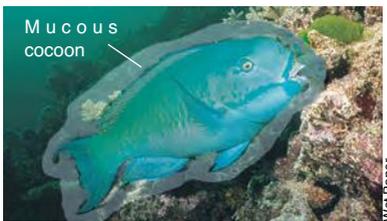


Figure 308.3 Parrot fish and cocoon

## The swim bladder

The swim bladder, a thin-walled sac, also aids breathing in some fish as well as keeping the fish buoyant. In some cases the air bladder is connected to the oesophagus and in others it is a separate organ (see Figure 308.1).

## Vision, hearing and balance

Hearing and balance in fish is controlled by the interaction of inner ear, lateral line and **swim bladder**. Fish eyes with an almost 360° vision, are one of the adaptations that help the fish see in almost every direction (Figure 308.2).

## Smell, taste and chemical adaptations

Smell and taste are controlled by specialised cells called **chemoreceptors**. Smell receptors are located in the nostrils while taste receptors are located in the skin and around the mouth. Chemical senses are responsible for a wide range of behaviours in courtship, schooling, sexual identification, migration and mating. Some fish secrete a chemical bubble (called a mucous cocoon), to keep predators away at night (Figure 308.3).

## Fish reproduction

There is extreme variation in reproduction of fish. Sexual reproduction involves the production of sperm and eggs from gonads. Masses of sperm called milt comes from the **testis** and masses of eggs or **roe** come from the ovaries. Fertilization can be external or internal in fish but all results in an embryo. Breeding can also be controlled by water temperature, daylight length, salinity or tide heights. The timing of reproduction is important to enhance the chance of fertilization.

## Fertilization and development

In most fish **fertilization** is external (Figure 308.4) with sperm and eggs fusing and dividing many times to form an embryo. In some cases males develop into females (see Chapter 12).

The larval stages contain the yolk sac and are known as **fish fry**. They feed on this yolk until they are able to find their own food, which is usually other plankton (see Chapter 25).

The fry develop into **juveniles** which need shelter in estuaries or mangroves to avoid larger predators. In some fish species, it is often hard to tell the difference between males and females.

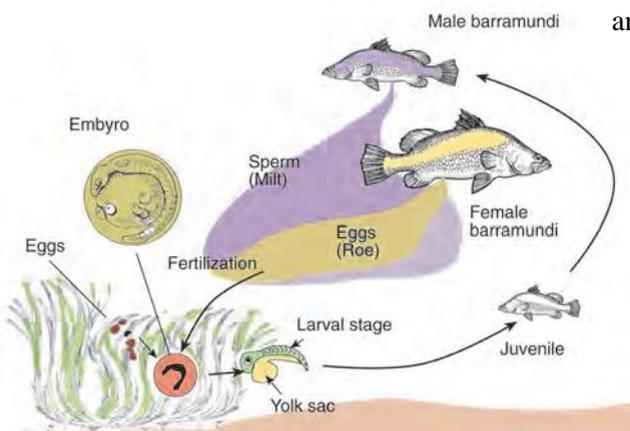


Figure 308.4 Barramundi reproduction

# Class Reptilia

Most reptiles lay eggs that, unlike the eggs of fish and amphibians, resist drying out. Reptile hearts have three chambers, though the crocodile heart is almost completely divided into four chambers just like the hearts of mammals and birds. Reptiles breathe with lungs but, because they do not have diaphragms, they can only inflate their lungs by moving their ribs. Reptiles have scaly, waterproof skin. Marine reptiles are equipped with salt glands which remove excess salts.

## Crocodiles

Crocodiles are found in the northern-most parts of Australia. The Australian saltwater crocodile is the largest of all reptiles, at least 9 metres long, and is an extremely dangerous animal. For more information on crocodiles, see Chapter 3.

## Sea-snakes

Sea-snakes are found in shallow tropical waters of the western Pacific and Indian Oceans. Generally they feed on fish but can live on land in many South Pacific Islands. They are extremely venomous but their jaw and tooth structure makes it difficult for them to bite humans (see Chapter 3).

## Turtles

Turtles have shells and flippers rather than feet. All turtles have to leave the water to lay their eggs.

Less than 1% of newborn turtles will survive their first year. Most are taken by predators soon after they hatch. They can also be disturbed by human-made lights shining when they hatch which causes them to get lost when they are trying to reach the sea. Domestic dogs and cats and feral animals like foxes are also a threat. Because watching turtles lay their eggs is a popular tourist attraction, steps are taken around turtle breeding beaches for their protection.

Turtles have been exploited for their meat and shells in many parts of the world so some species are becoming rare or endangered. All marine reptiles, including turtles, are totally protected in Australia but turtles cross international boundaries and are exploited in other countries where they may be turned into soup, jewellery, shoes or handbags. The Australian Customs Service imposes heavy fines on people importing turtle products from other countries.

Turtles are also threatened by litter such as plastic bags that are thrown into the sea. Turtles eat jellyfish and often mistake plastic bags for food. When they eat plastic bags they die a slow, painful death.



Figure 309.1 Saltwater crocodile

Ian Morris



Figure 309.2 Loggerhead turtle

Neville Coleman



Figure 309.3 Green turtle

Bob Moffatt



1. Name any four characteristics of the phylum Chordata
2. Draw a diagram of a shark, naming all the fins.
3. Draw a diagram of a shark drum line and explain how it is used.
4. What is *cartilage*?
5. What is an *operculum*?
6. How are reptile eggs different from fish eggs?
7. What are *salt glands* and how do they help reptiles?
8. Why are plastic bags dangerous to turtles?
9. Which animals have a four-chambered heart?



Figure 310.1 Noddy terns

Bob Morfitt



Figure 310.3 Pelicans

Murray Waite



Figure 310.4 Cormorants

Wet Paper



Figure 310.5 Osprey and nest

Bob Morfitt

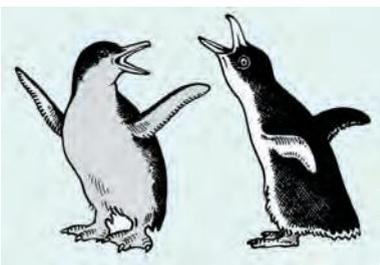


Figure 310.6 Fairy penguin

Sharyn Madder

## Class Aves

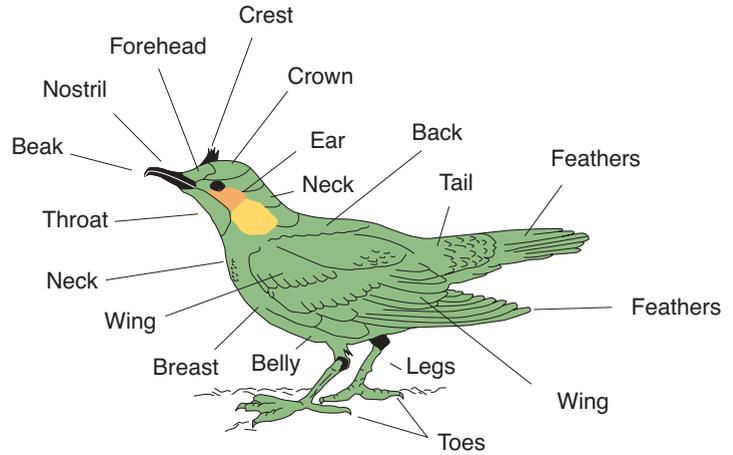


Figure 310.2 General bird features  
Wet Paper (After Vernon)

### Features of birds

Birds have a number of distinct features as shown in Figure 310.2. If you are describing a bird, you often describe some or all of these features. Birds can also be described by their flight patterns or how they hold their wings in flight. Fast-flighted birds have long pointed wings, soarers have broader wings and feather tips and fishing birds (such as pelicans in Figure 310.3) have large wings to help manoeuvre them during landing.

Where birds live is often reflected in their features. For example mud flats will attract waders with long legs and bills adapted for hunting local available food. Spoonbills and herons are good examples.

Wading birds are possibly the easiest to observe but the hardest to identify because some species look alike. Look for differences in bill and wing shape, leg length and feather colour. A good reference book is an invaluable tool.

### Adaptations

Seabirds are found from the poles to the equator and are masters of their environment. The cormorants in Figure 310.4 are found worldwide as well as in New Zealand and Australia. Crested terns (Figure 310.5) are found throughout the Indian Ocean and south-east Asia as far north as Japan, where they dive for food in coastal waters. **Penguins** (Figure 310.6) are found in temperate and polar waters all year round where they swim underwater to feed on fish in freezing conditions. So what is it that gives birds the ability to master the sky and ocean?

Pages 311 - 312 provide some answers to this question.

## Feeding

The sea is a three-dimensional space which makes hunting for food difficult. On land, a prey can only move along one plane, however a fish can move up, down and sideways. Seabirds must be adapted to flying in the air and hunting under the water.

Terns select their prey while hovering, then bomb dive using their wings for entry speed, closing the wings at the last moment before entering the water. (Figure 311.1).

## Sight

Seabirds must be able to see well both in air and under the water. Birds that see well in air have binocular vision to help them dive from great heights to pounce on fish under the surface. Other seabirds swim on the surface and dive for long periods to hunt their prey. To help them, many have developed an extra **eyelid** which is semi-transparent to help them focus and catch fish underwater.

## Water conservation

Seabirds have to have different body systems from land birds because they need to conserve water. Seabirds drink salt water and process it into drinking water by getting rid of the excess salt through their nostrils and excreting a water-free and very white waste called **uric acid**. This is often seen on shoreline structures and is very hard to clean off.

## Staying afloat – buoyancy

Seabirds have light bones to help them take flight and to float on the water when they land on the sea. Their bodies contain a lot of fat and oil and have special glands near their tails which secrete an oil known as **preen**. Seabirds constantly apply this preen to the rest of their body by rubbing their beaks in the oil and spreading it over their feathers. The preen coats the feathers, repels water and traps a layer of air against the birds' bodies which helps them float.

## Keeping warm

Birds are warm blooded and their temperature ranges between 39 – 41°C. To maintain this temperature, they need to insulate their bodies from the cold. Birds trap air beneath their feathers in the same way that a doona keeps you warm on cold nights.

## Behaviour

If you go to the beach with some food, seagulls usually gather around. At first they group but soon display a variety of behaviours designed to keep the group together. Alarm calls (Figure 311.2) remind the group of danger, dominant birds will signal their powers (Figure 311.3) while others down the peck order will show their submission (Figure 311.4).

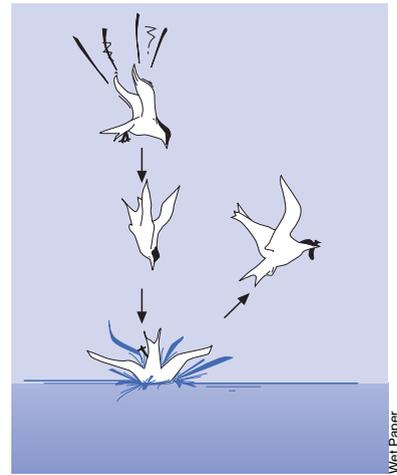


Figure 311.1 Tern feeding pattern

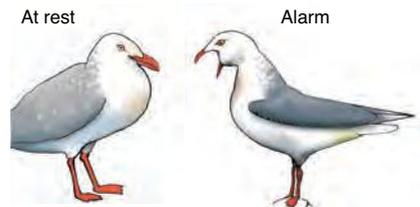


Figure 311.2 Seagull behaviours  
(Kerry Kitzelman)



Figure 311.3 Signalling territory  
(Kerry Kitzelman)



Figure 311.4 Submission behaviour  
(Kerry Kitzelman)

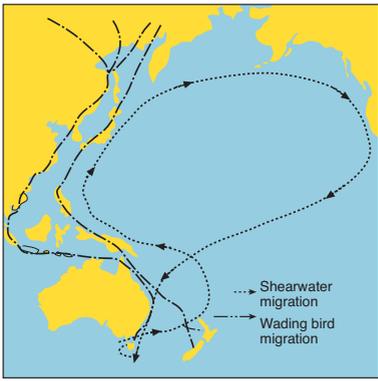


Figure 312.1 Migration patterns



Figure 312.2 Wandering albatross chick

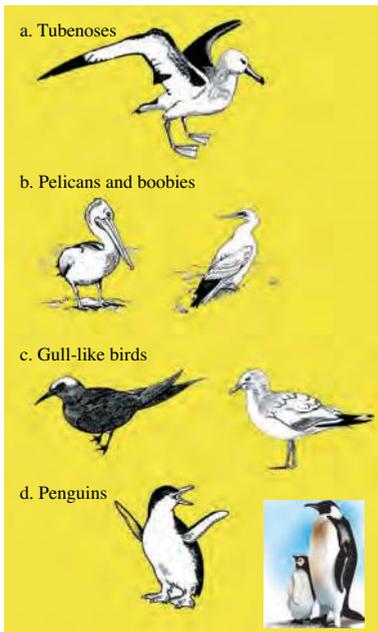


Figure 312.3 Four groups of birds  
(Illustrations Steven Byers and Sharyn Madder)

Behaviours such as these are adaptations to group life preventing physical injury to weaker or less dominant birds.

### Migration patterns

The general pattern of bird migration is to breed in high latitudes (near the poles) and then move to places where food is plentiful. Often the migrations are timed to occur when food supplies are large or plankton bloom. Many scientists believe that young birds learn navigation skills while flying with their parents.

The longest flight recorded was by an Arctic tern which nested in the Arctic and then flew to within sight of the Antarctic for the winter (summer in the Southern Hemisphere) a round trip of 38 000 kilometres!

Most seabirds feed on small squid, fish, krill, egg masses and the dead remains of other animals. Many can **migrate** for long distances and travel from one hemisphere to another. Migratory birds cannot nest at sea but must return to land to breed and raise their young. The places where they breed are therefore special places and require careful **management**. This is why island national parks have been created and international conventions agreed to secure breeding places for migratory birds. One such convention is the **Ramsar** convention which protects places in different countries where birds can rest or breed.

### Different types of seabird

Four groups of birds shown in Figure 360.3 a-d are commonly recognised as tubenoses; pelicans, boobies, frigates and related species; gull-like birds and penguins.

#### Tubenoses or ocean birds

*Albatross, petrels, storm petrels, diving petrels and shearwaters.*

These birds, including albatrosses (Figure 312.2) and gannets, spend most of their life out at sea and only return to shore for brief periods to mate and raise their young. The wandering albatross is 1.5 metres long and has the longest wingspan in the world — up to 3 metres. These great birds, which can glide for long distances, are often observed following fishing boats off the cooler southern coasts of Australia and New Zealand.

#### Pelicans, boobies, frigates and relatives

*Pelicans, gannets, boobies, cormorants, darters and frigate birds.*



Frigate bird

The pelican is a popular bird, found all over Australia and lives in estuaries. They can be seen diving for fish, filling their beaks and then returning to their nest to feed the young chicks from their mouth.

Some birds fly over the water, skimming the surface for fish (Figure 313.1). When they touch a fish, they use their wings to brake as their head turns backwards, and they swallow their fish whole.

This group includes the petrels, some of which are also good divers. In fact, the white-bellied storm petrels are often considered a nuisance by people fishing because they dive to take bait from lines. Cormorants and terns are divers (Figure 313.2) and spend much of their time at sea locating schools of fish.

### Gull like birds

*Gulls, auks, terns and skuas.*



Tern



Skua

Few gulls are oceanic and a number of species can be found far inland. Graceful flyers, they use their legs for paddling and are buoyant birds who seldom dive beneath the surface. Probably one of the most familiar seabirds of this group is the silver gull, commonly called seagull.

Terns are more marine and may travel the ocean for long periods in search of food. They feed on plankton and small fish catching them with their characteristic plunge dive. Skuas are large Antarctic birds and feed off penguins.

### Penguins

Penguins are a group of flightless birds that have adapted to living in cold climates. On the land they walk with difficulty but are great underwater swimmers when they tuck their wings and legs in close to their bodies to become streamlined.

### Birds of prey

Two of the most efficient hunters among the seabirds are the sea eagles and ospreys (Figure 313.5) that are found all around our coastline.

### Observing

The best way to observe birds is with the sun behind you and at high tide. A pair of binoculars will help you get a close look at some of the behaviour patterns associated with animal space and territory.

### Significance of seabirds

Seabirds are scavengers of dead fish, predators of squid and fish or plankton feeders.

They are responsible for transferring seeds from island to island and provide a way for plants to reproduce. Their droppings are important for plants because they heap fertiliser on island soils which would otherwise be very poor in nutrients.



Kerry Kitzelman

Figure 313.1 Skimming



Kerry Kitzelman

Figure 313.2 Diving



Bob Moffatt

Figure 313.3 Wading



Kerry Kitzelman

Figure 313.4 Gliding



Bob Moffatt

Figure 313.5 Bird of prey



Figure 314.1 Sea lion



Figure 314.2 Elephant seal

## Class Mammalia

Mammals have four-chambered hearts. They are warm blooded and have hair or fur at some stage of their lives. The word 'mammal' comes from the Latin word for breast because all mammals suckle their young. In some parts of the world, all marine mammals are protected and many areas have marine protected regions designed to protect species.

### Order Carnivora

These are the seals, sea lions and walrus which are closely related to dogs and cats. They are similar in some ways to otters because their legs have been modified into flippers. Sea lions can turn their front limbs forward for walking on land but seals and walrus cannot. Seals and their relatives must leave the water to breed. Their young are raised in colonies on rocky shores. Seal colonies are found around the southern coasts of Australia.

#### Australian sea lion and fur seal

**Australian sea lions** live for about 25 years. Found only on mainland Australia and offshore islands they prefer sandy beaches or smooth rocks as breeding or haul-out sites. They feed on fish, octopus and lobsters and are very social animals and gather in large groups, particularly during the breeding season. They are hunted by sharks, particularly great white sharks. There are presently only 3 000-5 000 Australian sea lions in existence and they are thought to be the rarest carnivore.



### Diving deeper



1. Make a fibreglass fish following the instructions from the students pages Instructions on the wet paper web site [www.wetpaper.com.au/student](http://www.wetpaper.com.au/student)
2. Set up an aquarium as discussed in Chapter 11 and keep some fish for a term.
3. Visit your local marine aquarium or zoo and study marine life there.
4. Invite a marine scientist to your class.
5. Run a marine photographic competition. Use a digital camera to capture images.
6. Calculate the approximate sizes for all the animals in this chapter from the scale given in each figure.

**Australian fur seals** were hunted to the brink of extinction last century. Population recovery has been slow, and seals are now wholly protected. The dense coat is made of woolly underfur and long, coarse outer hairs to trap air which waterproofs and insulates the seal. Like all seals, they moult each year, replacing their old fur with new growth. A layer of fat assists with warmth and streamlining.

The Australian fur seal eats mainly fish and cephalopods (squid, octopus and cuttlefish). Once a cow gives birth for the first time, she is practically in a continuous state of pregnancy/lactation for the rest of her life, with maybe only a few weeks off between weaning last season's pup and having another.

Seals are greatly affected by human activities such as deliberate persecution through shooting, fisheries bycatch and **entanglement** in plastic, non-biodegradable materials.

## Order Sirenia

Dugongs are the world's only fully vegetarian marine mammal and the only sea cow in Australian seas. Dugongs, like whales and dolphins spend their lives at sea.

Australian dugongs range from Shark Bay in Western Australia around the north to Moreton Bay in Queensland. The Great Barrier Reef Marine Park Authority estimates there are 80 000 dugongs in Australian waters, approximately 14 000 of them on the Great Barrier Reef.

Dugongs are a dolphin-like shape, with flippers and a tail and can grow up to 3 metres long and weigh up to 400 kilograms. Their nostrils are located near the front of their head allowing them to breath with most of their body beneath the surface. However dugongs cannot hold their breath under water for very long. The upper lip on their large mouth is covered in bristles which are used to find and chew seagrass. Dugongs' ears and eyes are found on the side of the head, and they swim with a slow and graceful motion.

### Reproduction

Scientists from the Great Barrier Reef Marine Park Authority estimate dugongs live for approximately 70 years. Female dugongs first breed between the ages of 6 and 16 years old. They produce calves about every 2 to 5 years. Breeding commences when the female is in oestrous (on heat). Groups of male dugongs will follow the female around and will mate only with her. The female will produce a single calf after a 14-month pregnancy. Most calves are born between September and October, and remain with their mother for around 18 months.

### Feeding

Dugongs feed mostly on small, delicate easily digestible seagrasses. A dugong can dig up an entire seagrass plant including the roots.



Figure 315.2 Sea cow or dugong



Figure 315.1 Dugong feeding



10. Draw a fully labelled diagram of the internals of a silver perch?
11. How do seabirds get rid of salt in their drinking water?
12. What is *preen* and how is it used by seabirds?
13. Are birds warm blooded and what is their temperature range?
14. What are four things seabirds do to swim underwater?
15. Describe a wading bird's feet.
16. Name one scavenging bird and one ocean bird.
17. What problems can occur when gulls or other species overpopulate an area?
18. What is the record for the longest bird flight?
19. Which bird is found in polar waters and swims underwater to feed?
20. Name any three dangers to seabirds.
21. Compare any two characteristics that distinguish of a bird of prey from a wading bird.
22. What is the RAMSAR convention and why is it important?

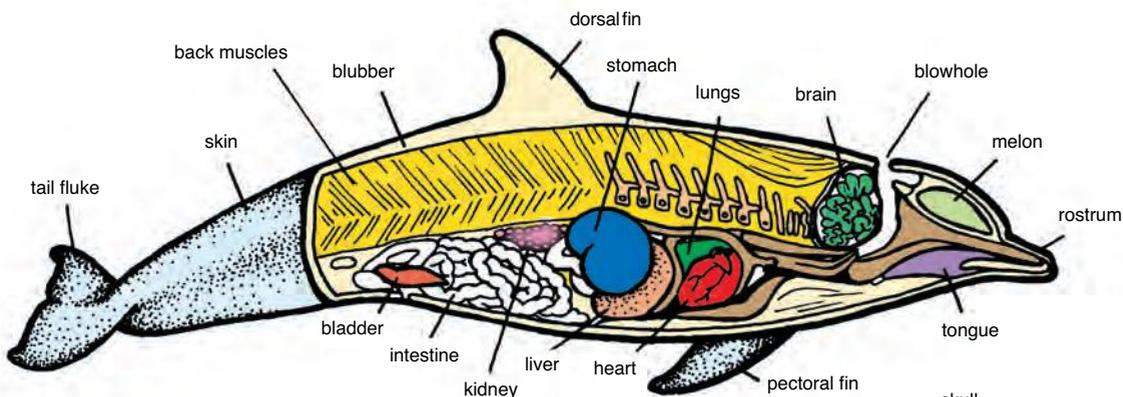
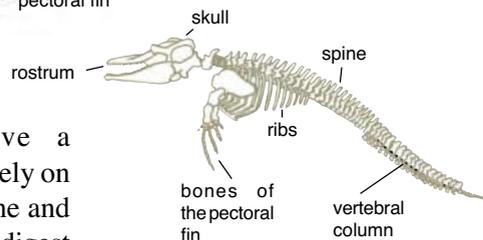


Figure 316.1 Dolphin anatomy  
(Illustration Rose Bedford)



Dugongs do not have a chambered stomach, but rely on an extremely long intestine and bacteria living within it to digest the cellulose of seagrass.

The greatest threat to dugongs is the loss of their habitat. As a result of increased siltation and nutrients from human activities on the land, such as dumping of dredge wastes, urbanisation, industry and agriculture, seagrass beds are diminishing.



Figure 316.2 Dolphin and diver

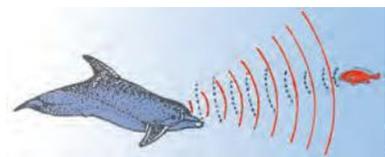


Figure 316.3 Dolphin echolocation



Figure 316.4 Killer whale

## Order Cetacea

The cetaceans are almost certainly one of the best-loved groups of animals in the sea. Dolphins and whales are highly intelligent animals. At times, they even seem to enjoy human company. Cetaceans have highly developed sonar systems for navigation and for finding food. Their communication faculties are also highly developed. Whales are thought to be able to communicate over hundreds of kilometres using very low frequency sound.

Whales have the largest brain of any animal - the brains of some whale species can weigh as much as 7 kilograms (a human brain weighs about 1.3 kilograms). The cetacean nostril or blowhole is on the top of the head. The two main groups of cetaceans are the toothed whales and the baleen whales.

### Toothed whales

Toothed whales — dolphins, porpoises, sperm whales, killer whales and narwhals — have many peg-like teeth with which they grasp their prey, usually fish or squid. These creatures often hunt in highly organised packs. Killer whales will actually beach themselves to catch seals lying on the shore. They have also been observed breaking through solid ice to catch seals and penguins.

## Baleen whales

Baleen whales - including right whales, humpback whales and blue whales - have no teeth. Instead, they have baleen plates composed of hairlike material hanging from their upper jaws (see Figure 317.1). While feeding, they gulp large amounts of sea water and small planktonic animals. When they close their mouths, the water drains out of the mouth, leaving the food behind.

Many of the baleen whales were hunted to the point of extinction. The right whale was even given its name because it was the 'right' whale to catch. They floated when shot which made them easy to haul on board the whaling ship and because they produced a good yield of oil and meat. Australia did not stop whaling until the mid - 1970s. Some countries, including Norway and Japan, still insist on hunting whales despite bans on this practice by the International Whaling Commission.

The largest of the dinosaurs was probably diplodocus or brachiosaurus. They were as long as 30 metres and weighed as much as 50 tonnes. Blue whales have been captured that were 30.5 metres long and weighed 135 tonnes. The blue whale is almost certainly the largest animal which has ever lived. Although whales were still hunted off the Australian coast just over 30 years ago, whale watching is now an important tourist industry.

When whales are migrating along the New Zealand and Australian coasts, cruise boats take tourists out on daily outings with spotter planes used to direct the vessels to where the whales are. If you go on a whale watching trip, try to go with an operator who knows not to harass or disturb the whales by going too close or making too much noise.

Humpback whales show many behaviours as shown in Figure 317.2 the most spectacular is **breaching** and **tail slapping**.

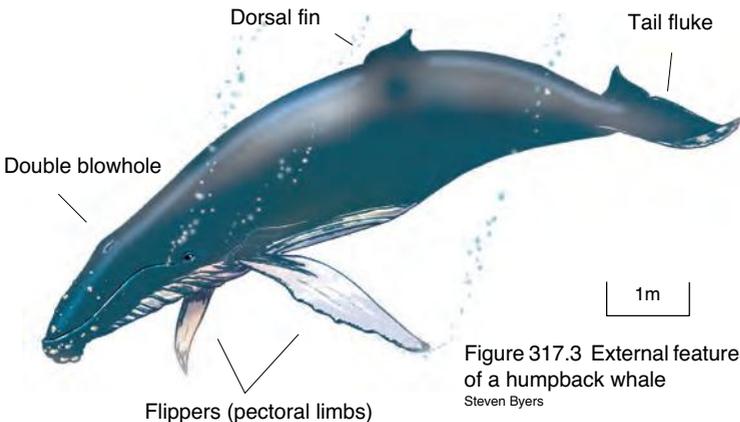


Figure 317.3 External features of a humpback whale  
Steven Byers

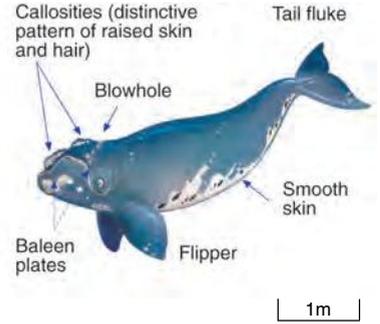


Figure 317.1 Baleen whale  
Jan Taylor



Figure 317.2 Some whale behaviours

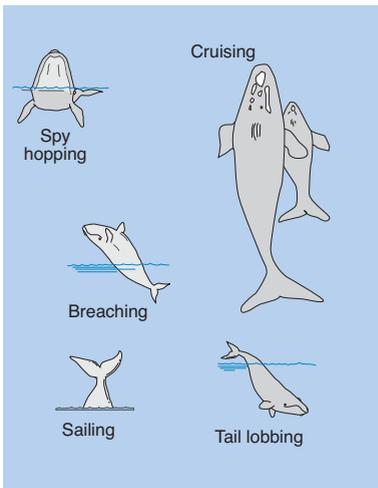


Figure 318.1 Southern right whale behaviour

After SA Whale Watch Centre

Some typical behaviour patterns of southern right whales are shown in Figure 318.1.

## Key words

Aves, baleen, breaching, buoyancy, cartilage, chemoreceptor, cunjevoi, dorsal, drum line, elder, entanglement, eyelid, fry, humpback, initiation ceremony, juvenile, lateral line, mammalia, migrate, notochord, ocean bird, operculum, pectoral, preen, puffer fish, ramsar, reptile, shark meshing, tail slapping, totem, uric acid, ventral.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- The [1] \_\_\_\_\_ of a backbone protecting a spinal [2] \_\_\_\_\_ allowed animals to become more [3] \_\_\_\_\_. The improved and extended nervous [4] \_\_\_\_\_ enabled animals to [5] \_\_\_\_\_ the land, become bigger and more agile. The marine [6] \_\_\_\_\_ returned to the sea with all these characteristics, the birds became masters of the air while the sharks have remained basically the [7] \_\_\_\_\_ over [8] \_\_\_\_\_ of years.
- [9] \_\_\_\_\_ lines are made up of a baited shark hook on a chain running up to a float on the surface. The [10] \_\_\_\_\_ is attached by a rope to a heavy [11] \_\_\_\_\_ on the sea-bed so it remains in place.
- Hearing and balance in [12] \_\_\_\_\_ is controlled by the [13] \_\_\_\_\_ of inner ear, lateral line and [14] \_\_\_\_\_. Fish eyes have an almost 360° [15] \_\_\_\_\_, is one of the [16] \_\_\_\_\_ that help the fish survive.
- A person who is given a name from the living world takes on a responsibility to care for that animal or plant and that animal or plant becomes that person's [17] \_\_\_\_\_.
- An Aboriginal child may be given the [18] \_\_\_\_\_ as their totem at their [19] \_\_\_\_\_.
- Humpback whales show many [20] \_\_\_\_\_.
- Less than 1 per cent of newborn [21] \_\_\_\_\_ will survive their first year. Most are taken by [22] \_\_\_\_\_ soon after they [23] \_\_\_\_\_.
- Seabirds have light [24] \_\_\_\_\_ to help them take flight and to float on the water when they land on the sea. Their bodies contain a lot of [25] \_\_\_\_\_ and [26] \_\_\_\_\_ and have special glands near their tails which secrete an oil known as [27] \_\_\_\_\_.

## Diving deeper



### Did you know

In some parts of the world, when people are born or initiated into a family they are given animals or plants to use as personal symbols.

A person who is given a name from the living world takes on a responsibility to care for that animal or plant and that animal or plant becomes that person's **totem**.

For example, an Aboriginal child may be given the turtle as their totem at their **initiation ceremony**.

The child is taught about the turtle by the tribal **elders** and the child looks after the turtle for the rest of its life.



Joyce Summers



**Web references**

[www.reefed.edu.au](http://www.reefed.edu.au), [www.csiro.gov.au](http://www.csiro.gov.au), [www.mesa.edu.au](http://www.mesa.edu.au), [www.ausmepa.org.au](http://www.ausmepa.org.au)

There are many ways we trash the sea. The photograph above shows accumulated rubbish in a boom net in a harbour and Figure 319.1 shows poisoning of coastal dune vegetation for a better view. Figure 319.2 shows dense algal growth on rocks caused by agricultural fertilisers and Figure 319.3 shows cars dumped in our estuaries. Unfortunately we are now living in a ‘throw-away’ society. Most of the goods we buy have specialised packaging which cannot be re-used. Many items we buy are used once and then disposed of. Manufacturers make disposable items or cheap goods which have a short life. Others run advertising campaigns telling us our old models are inadequate or obsolete and that we need to purchase their new improved model. But what are we going to do with our old model? The answer - it becomes trash.

**Trash**



Three places we can dump our rubbish are on the earth, in the air or in the water.

People once believed that the oceans were so huge they could absorb or dilute most of their wastes. They thought the wastes simply disappeared, never to be seen again. However, some wastes are now making their presence felt. Our waterways are a wonderful resource to have at our disposal, but we tend to turn the inland waters into inland sewage or drainage systems and the estuaries into convenient dump sites for a wide variety of harmful materials. Most of the waterways near our cities and ports are showing evidence of contamination.

The introduction of harmful waste substances into a natural area is termed **pollution**. The United Nations Organisation has defined pollution of the marine environment as *the introduction by humans, directly or indirectly, of substances or energy into the marine environment resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of the quality of sea water and reduction of amenities.*



Figure 319.1 Cutting down trees for a better view of the ocean

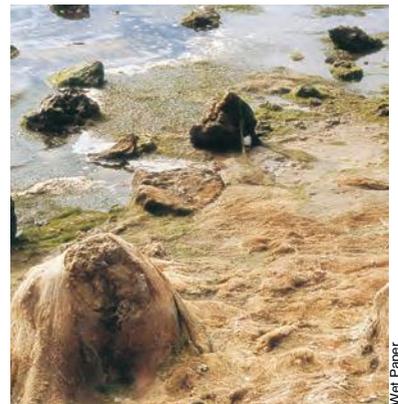


Figure 319.2 Algal pollution on rocks



Figure 319.3 Rubbish in waterways

## Diving deeper



1. Research your own contribution to pollution by finding out the answers to the following questions.
  - a. How heavy is your school bag and what weight of paper do you estimate is in it? How much paper would you estimate you would use in one year?
  - b. What materials were used to make your school pens? How many synthetic items, eg plastics, are found in your bag?
  - c. Work out the volume of wood in the classroom furniture and fittings. What other types of products have been used in the construction of the school building? How could the design of this building be improved to make it more energy efficient?
2. Estimate the volume of rubbish produced by your street during the year.
3. Some materials are said to be biodegradable. What does the term *biodegradable* mean?
4. What type of packaging is found on items bought from the local supermarket in your last shopping trip? How could the amount of packaging be reduced?
5. Debate the use of the antivandalism sign in Figure 319.1.



In August 1974 heavy metal pollution was discovered in the Derwent estuary, Tasmania. Four years earlier, people had become sick after eating oysters farmed in the lower estuary. CSIRO confirmed that zinc and cadmium levels in the oysters were a threat to human health. Excessive mercury levels were later found in certain species of fish. Waste discharges from Electrolytic Zinc at Risdon, 15 kilometres upstream were blamed for the contamination. The metal plant (Figure 320.1) was established in 1917 and is one of the world's largest producers of zinc, metals and alloys.

## Pollution — who causes it?

Most people believe that they are environmentally concerned and that what they do has little effect on their environment. They believe that it is the major factories and industries that are causing pollution problems. Few will admit to actually causing pollution themselves.

If we were really concerned about pollution, we would grow our own vegetables and food supply and live very modestly with no dishwashers, garbage disposal units or air conditioners. Most of the industries that produce these products created them to make our lives easier. If we examine the ways in which we use these products and how they affect the environment, we may have a better chance of overcoming some of the pollution problems.

## Technology

Increased waste production has come with increased technology. The wastes we produce today are full of chemical and toxic substances. Each person in our country is responsible for one tonne of rubbish each year.



Figure 320.1 Zinc metal plant, Derwent River Tasmania

The amount of garbage that a developed country throws out each year has been estimated to contain:

- 500 000 tonnes of metal;
- 700 000 tonnes of plastics;
- 2 000 000 tonnes of paper (which represents 10 million trees or a large forest); and
- 900 000 tonnes of glass, mostly in the form of soft drink and beer bottles.

Most of these wastes are dumped in landfills around our major cities, although some finds its way into our waterways. The cheapest method of disposal is burying (most landfills are left open and so become health hazards). But most city councils are running out of space for dump sites.

By the year 2020, Sydney will need an area the size of a major suburb to dispose of the millions of tonnes of wastes produced in that city every year. The average local council in a developed country spends an estimated 20% of its annual budget on waste disposal. Many landfill sites were originally unique estuarine mangrove communities located near cities that bordered coastal communities. These communities have been permanently destroyed to make way for the disposal of household waste. Plants and animals that were once found in these areas are now becoming endangered species. So how much does your local authority spend on waste disposal?

Another major problem is that technological wastes affect local fauna. Seals and turtles eat plastic bags in mistake for jellyfish (Figure 321.1). They choke on the plastic bags and eventually die. An autopsy on a sperm whale once revealed more than 40 plastic bags stuck in its throat.

The pelican in Figure 321.2 has tried to build a nest out of twigs trashed with fishing line. The bird has been choked by its own nest. Modern fishing nets that get tangled are cut adrift in the ocean by the fishing crews responsible for them and they become tangled around turtles and seals. The end result is the collar of death shown in Figures 321.3 and 321.4.

## Radioactive wastes

**Radioactive** waste, probably the worst polluting substance ever, is dumped in many parts of the Pacific Ocean. Despite being the most dangerous substance ever to be created, it is packed into drums and dumped into the sea.

The drums, which can contain highly radioactive plutonium, will eventually corrode in the sea water, allowing these substances to escape. Radioactivity will then enter food chains and eventually human bodies.



Figure 321.1 Turtles are killed by plastic bags.



Figure 321.2 Birds are killed by fishing nets.



Figure 321.3 Turtle caught in fishing net



Figure 321.4 A slow death for a seal



Figure 321.5 This whale died from plastic bags in its stomach



1. How has the United Nations defined the word 'pollution'?
2. How would you live if you were really concerned about pollution?
3. How many tonnes of metal, plastics, paper and glass does a developed country throw away each year?
4. How do plastic bags affect turtles?
5. How can fishing nets kill seals?
6. How are birds affected by fishing lines?
7. Explain why the dumping of radioactive wastes in steel drums at sea is a poor waste disposal practice.
8. How do people's attitudes affect the amount of litter dumped?
9. What is the difference between *point source* and *non-point source* pollution? Give two examples of each.
10. What is the name given to oil when it spreads over the ocean?



Figure 322.1 Rubbish dumped from a car trailer

European countries have been dumping radioactive materials from nuclear power plants in the Atlantic Ocean since 1950 because they can find no other safe disposal site. The amount rose from 3.5 curies in 1950 to more than 100 000 curies in the 1980s (**curies** and rads are the units in which radiation is currently measured). Oceans are a finite quantity so these large doses of radiation may cause problems for future generations.

Radioactive waste pollution comes from other sources. Low energy radioactive wastes are produced by hospitals, universities, atomic research facilities and certain industries. Uranium mining in British Columbia in Canada has caused radioactive pollution in that area. Uranium mines in Australia's Northern Territory are also thought to be causing problems.

**Radiation** from nuclear tests in the Pacific by the French and American governments has also led to high levels of pollution. The fallout from atmospheric tests all ended up in the ocean. Even though these tests are no longer carried out in the open air, underground tests have cracked the structure of the islands where the tests are carried out, allowing radiation to escape.

Radiation damages the reproductive organs of most animals, causing malformations of the developing young. These malformations are known as mutations. Radiation can also cause the uncontrolled growth of body cells that are known as cancers and tumours.

Very high concentrations of radiation can kill living cells, causing severe burns and death. Organisms vary in their ability to withstand radiation. Humans become sterile at 0.1 kilorads and die at 0.5 kilorads, whereas cockroaches can survive 400 times this radiation level.

## People's attitudes

Why do people dump rubbish? Figure 322.1 shows a mangrove area polluted by a person tipping rubbish out of their car trailer and into the sea. Did they dump their waste because the rubbish tip was closed or did they just not care for our environment? Were they protesting about being charged for dumping the rubbish in a council landfill under a new user pays system?

Whatever the case, modern environmental laws carry heavy fines for people who dump rubbish like this.

Even taking your rubbish to the appropriate tip can cause pollution. If you put your rubbish in a trailer but don't cover your load, the rubbish just blows out of the trailer and finds its way into the sea. Rubbish bins may sound like a good idea, but they must have lids otherwise scavenging animals search for food and, in the process, tip out the rubbish from the bin.

Food scraps sent to the tip in plastic bags are often ripped open by hungry animals such as seabirds (Figure 323.1). The plastic bags then blow into the sea.

People's attitudes therefore determine how much waste is created either by deliberate or ill-informed means. An example of deliberate littering would be throwing rubbish out of a car window. An example of ill-informed littering could be leaving your rubbish at the beach in a bin that birds could get at.

## Sources of pollution

### Point sources

**Point source** pollution is where the pollution comes from a specific point, for example hot water from a powerhouse (Figure 323.2), paint stripper from a smash repair shop (Figure 323.2), oil from pumps or **sewage** from a **waste water treatment plant** (Figure 323.4).

### Sewage

Sewage treatment can involve up to three levels of treatment: primary, secondary and tertiary. Primary treatment of sewage involves a settling and chlorination process which is very inefficient in reducing bacterial pollution of our seas because it does not remove all solid and nutrient waste.

Some sewage treatment plants still discharge primary-treated sewage directly into the sea. Obviously, nearby beaches will be affected by bacterial and other untreated wastes from the sewerage system.

Secondary treatment (Figure 323.4) removes all solid wastes and reduces the amount of the nutrients phosphorus and nitrogen in the waste. To protect our seas, tertiary treatment is necessary because it brings all waste water up to a standard we can drink or reuse in cities and towns. Sewage treatment plants are improving as people demand better ways to treat waste water from cities and towns.

### Oil

Oil pollution poses a major threat to the marine environment. The sources of this pollution are industry, spillages from oil rigs and oil refineries, discharges from ships and tanker accidents. (Oil from roadways is a non-point source of pollution, which is discussed later in this chapter). Industry is the major source of oil pollution. Oil spillages from tankers only represent 4% of the total oil pollution of the oceans. When oil spills, it spreads over the ocean's surface forming a thin layer called a **slick**.



Figure 323.1 Ibis feeds on rubbish from bag from rubbish bin.



Figure 323.2 Thermal pollution



Figure 323.3 Chemical pollution

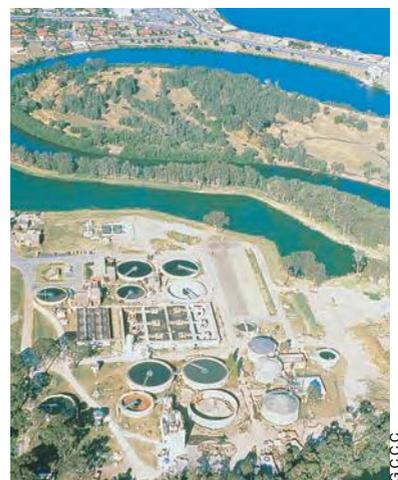


Figure 323.4 Secondary sewage treatment plant



Figure 324.1 Cleaning oil from sea birds

## Diving deeper



6. Use the library to research other sources of pollution. These include:
  - a. anti-fouling paint
  - b. contraceptives
  - c. natural pollution from volcanoes
  - d. acid rain
  - e. dredging
  - f. mining
7. Use your library to gather information on the major oil spills that have occurred in the Pacific Ocean in the last 10 years. Record details of these spills and the methods used to contain/break-up the oil spill.
8. Are there any factories or heavy industry in your local area? If so, where are they located? How might water be used in these industries and what happens to the water after use?
9. What is a marine fouling organism?
10. Research three introduced pests which are likely to be in your local marine environment.

After a major oil spill, a massive area of the sea becomes covered with oil. One litre of oil can form an oil slick covering 8000 square metres. This has a catastrophic effect on any coastline the slick contacts. The oil smothers coral reefs and mangroves. Shellfish, such as oysters and mussels, become inedible and whole fisheries can be wiped out.

Animals that live on the surface, such as birds and seals, become coated with oil and die if not cleaned quickly (Figure 324.1). Oil covers seabirds when they land on the surface and their feathers lose their waterproofing capacities. When the birds try to preen their feathers (see Chapter 27), they ingest the oil and die. They also die as a result of **hypothermia** (loss of body heat) because the insulating air layer around the body is lost when the oil slicks the feathers flat.

### Thermal pollution

Many industries use heavy machinery which generates large amounts of heat. Industries such as steel manufacturing and electricity generation use large volumes of water as coolant. This use raises the temperature of streams and rivers involved by up to 10°C causing thermal pollution. This, of course, will have a major effect on natural communities and individual organisms living in these areas.

The behaviour patterns of many aquatic animals are influenced by water temperature, for example, temperature stimulates many fish to spawn and migrate. Many fish are limited to water of a specific temperature and thermal pollution can influence migration patterns in rivers.

### Toxic compounds

Worldwide, and estimated 27 million tonnes of manufactured compounds are produced annually. Most of these eventually find their way into the marine environment. The chemicals which cause most concern are **non-biodegradable** toxic compounds. A **toxic** compound is a substance that can kill, injure or impair the functioning of an animal by its chemical action. These compounds are also dangerous to humans and must be handled with care.

Contaminated water discharges from paper mills and factories manufacturing chlorine and caustic soda can contain large amounts of mercury. Mercury accumulates in the natural food webs and can kill many animals including humans. Mercury poisoning of humans was first noted in the 1950s at Minamata Bay, Japan, where mercury was polluting the water and contaminating seafood. The fishermen of the bay and their families suffered damage to their nervous systems and over 110 people died as a direct result of mercury poisoning.

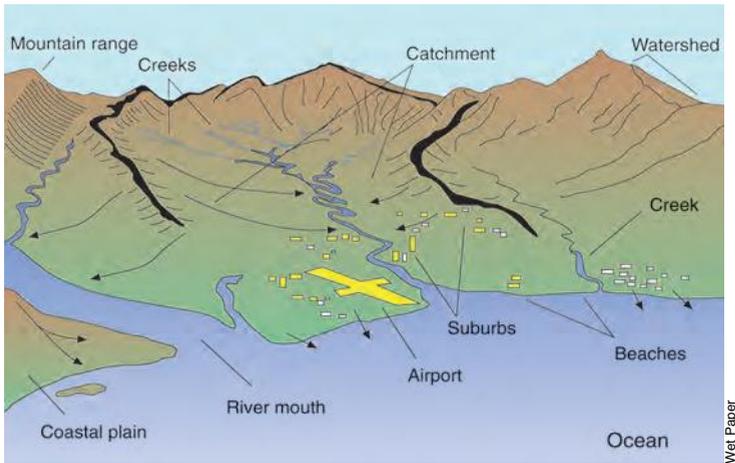


Figure 325.1 Everything in a catchment washes into the sea.

Many others were left crippled, blind and/or infertile. The fish that formed a major part of their diet contained extremely high concentrations of mercury which had been produced in a local factory making acetaldehyde. The disease became known as **Minamata disease**.

Many other toxic compounds are produced by manufacturing industries and most cannot be disposed of safely. Thousands of tonnes of lead and other heavy metals are released into the air simply by industries burning fossil fuels which contain these elements.

## Non-point sources

**Non-point sources** of pollution are sources of pollution that cannot be traced to a specific point. Non-point source pollution comes from a widespread area, for example, storm water from urban drains or agricultural runoff from a wide area.

A **catchment** is a term which describes the area of land which contributes runoff to a particular creek, river, lake or the ocean. Figure 325.1 is a schematic diagram of a catchment with a river and a number of creeks. Catchments can be very large, crossing municipal or state boundaries. Catchment boundaries may not be readily distinguishable in a settled urban area and changes that may occur to a habitat upstream of a waterway/creek may have an adverse effect on the lower reaches (downstream) of a catchment.

## Pollution from the suburbs

All storm water which washes off the catchment runs into the sea. The storm water gutters in Figure 325.2 collect dust which accumulates heavy metals such as zinc from vehicle brake pads, rubbish from the footpath and fertilisers from gardens.



## Questions

Use your textbook to find the answers

11. How does oil pollution affect birds?
12. What are the dangers involved in discharging untreated sewage into the sea?
13. Name one source of thermal pollution and describe how an increase in water temperature affects the animals living in the water.
14. How does mercury affect humans?
15. Define the term *catchment*.
16. Define the term *toxic compound*.
17. Name two other toxic compounds produced by manufacturing industries.



Figure 325.2 Storm water drain contaminants

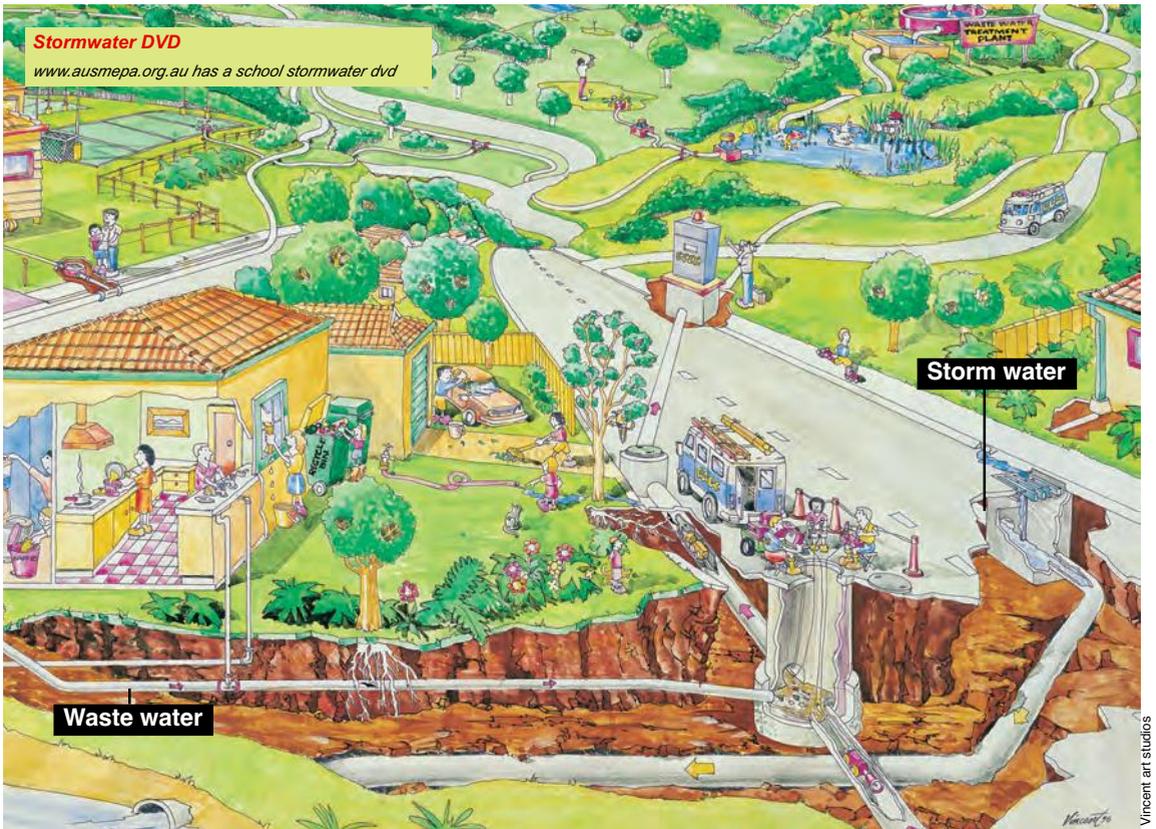


Figure 326.1 The difference between waste water and storm water systems in a catchment



Figure 326.2 Sewage pollution during storm conditions pollutes creeks and contaminates seafood.

In urban areas, rain water or storm water is prevented from infiltrating the ground by the sealed surfaces of roads, houses, driveways and so on. Instead, it is swiftly conveyed into our creeks by storm water drains. Figure 326.1 shows the difference between storm water and waste water (sewerage) systems.

When rain falls on your roof, the water goes into storm water pipes that are connected to the sea. Along the way, the storm water is joined by a whole host of pollutants such as fertilisers, pesticides, pet faeces, oil and grease, dirt, heavy metals and other organic matter, such as garden waste, which all flow towards the sea.

Storm water pipes are big pipes designed to carry a lot of water in a very quick time to prevent flooding. Sewerage pipes, as shown in Figure 326.1, are much smaller because they are designed to carry a limited amount of waste water from your sink, toilet and bathroom.

If storm water pipes are illegally connected to the sewage system, heavy rain will overload the system and waste water will flow up out of inspection holes, into the street and into the sea, polluting our beaches and creeks with bacteria.

Figures 327.1 and 327.2 show just some of the many pollutants that come out of storm water drains. Motor vehicle repair workshops are often sources of polluting oil that has been **degreased** from engines or spilled on the ground.

The silt in Figure 327.3 is topsoil that has been washed from unvegetated backyards during a recent storm. This silt is particularly dangerous to marine life because it contains heavy metals from road surfaces, fertilisers from gardens and pesticides used on fruit trees.

The impacts of polluted storm water vary but include:

- loss of aquatic life caused by poor water quality;
- weed infestations caused by garden refuse dumped in creeks;
- silted-up waterways caused by runoff from bare earth;
- lower property values caused by degraded views; and
- higher local authority rates caused by increased maintenance of waterways and public parks.

## Pollution from dredging harbours

In recent years the dredging of harbours has caused mystery illness in fish in Queensland. Figure 327.4 supplied by the Capricornia Conservation Council is an example of this.

## Pollution from agriculture

### Sediment

Trees and natural vegetation hold soil on the land and prevent it being washed away by the rain. When we clear natural vegetation from land, we increase the amount of soil eroded away by storm water. Erosion is also increased by ploughing methods that expose the soil and by planting crops such as wheat, corn and sugarcane which do not have extensive root systems to hold soil in place. Poor farm management which allows cattle and sheep to over-graze also contributes to this problem.

This eroded soil is washed into waterways where it settles to the bottom and clogs up the rivers and estuaries. The water also becomes very muddy (or turbid). This reduces the amount of light penetrating the water which in turn decreases the amount of plant life that can live in the water.

The **silt** also damages animal structures, such as the gills of fish or the feeding mechanisms of filter feeders. Too much sediment on the river bed also limits the breeding of certain species of fish, for example, the catfish which builds its nest on gravelly river beds. Discharged water from farmlands in Figure 327.5 contains water that has high phosphorus and nitrogen levels.



Figure 327.1 Oil from an industrial estate



Figure 327.2 Iron bacteria from pipes



Figure 327.3 Silt from urban topsoil



Figure 327.4 Diseased fish



Figure 327.5 Nutrient-rich discharge



Figure 328.1 The result of pollution from agriculture



Figure 328.2 Industry in the coastal zone

## Fertilisers

Most farmers add extra nutrients to the soil to increase their production. These **fertilisers** (such as phosphates and nitrates) are washed by the rain into rivers where they can produce major increases in plant growth. This huge increase in aquatic plants can clog up streams and rivers and destroy natural vegetation.

## Overstocking

Increased numbers of stock close to sheltered waterways and estuaries results in too much solid waste from these animals entering the sea. The increase in solid waste leads to increased faecal coliform levels resulting in seafood consumption bans as shown in Figure 326.2 (previous page).

## Wastes from cities and towns

Research also indicates that the Great Barrier Reef is at risk of being destroyed by waste produced by the non-point source pollution of coastal cities and towns. It is believed that the corals will be smothered by debris and plants, such as algae, which will increase in number as they break down the wastes.

## Pesticides



*DDT in the food chain is also discussed on page 337*

See also Chapter 29

Farmers often feel that insect pests are eating their crops and threatening the health of their animals. Many think that the cheapest and most effective way of reducing pest numbers is by using insecticides and **pesticides**.

These chemicals are produced by industry and can be classified into two groups:

- the chlorinated hydrocarbons or organochlorines such as DDT and Dieldrin; and
- the **organophosphates**.

An estimated 3 million tonnes of organochlorines have been used by farmers around the world since they were first made commercially available. Most of these chemicals eventually find their way into our oceans. They accumulate in food chains until they reach toxic concentrations. Their full effects are not yet known because they may only show up in the third or fourth generations, in 30 – 40 years' time.

DDT was an important pesticide used to control insects. It can last up to 20 years and is not broken down in the body. More than 2 million tonnes of DDT have been scattered across the world. DDT residues have now been found in human tissue. Unfortunately, a large amount of the chemicals sprayed by farmers never reach the intended insect or pest. Of the thousands of litres sprayed over crops, less than 500 millilitres is estimated to come in contact with the target pest.



### Questions

Use your textbook to find the answers

18. What is the difference between the storm water system and the sewerage system?
19. Why does connection of the storm water system to the sewerage system cause bacterial pollution of our seas?
20. Name five impacts of polluted storm water on a local community.
21. What are the two groups of insecticides harmful to marine life?
22. List the four sources of oil pollution. Which of these sources causes the most pollution of the ocean?
23. Explain how oil pollution affects the life in the oceans.

## Global warming and coral bleaching

Marine life has only recently been affected as the Earth's atmosphere warms the oceans and sea temperatures rise.

One example of this is **coral bleaching** when the coral host expels its **zooxanthellae** (see page 285). While some corals are able to feed themselves, most corals struggle to survive without their zooxanthellae (Figure 329.1).

The loss of these primary producers impacts on the ecosystem on every trophic level. □Some reefs may shift from coral to algal dominated systems□resulting in□biodiversity becoming severely diminished. Once this shift occurs reefs never recover.

### Coral bleaching represents a huge challenge

Coral bleaching and its effects□represent one of the greatest challenges in managing reefs systems around the world. Over 1 billion people depend on reefs as their primary food source and the income generated from tourism. Unless we address the problems of climate change, the reef, and the people who rely on it, will be at risk of an uncertain future.

## Marine pests and threats

Australia and New Zealand have been isolated from all other land masses for many millions of years. This has resulted in a wide diversity of organisms evolving here, both on land and in the water, which are not seen anywhere else in the world.

However, over the last few hundred years human activity has brought about rapid changes which have caused the disappearance of some of our unique organisms.

The main cause has been the introduction of plants and animals from other countries. The impact has been huge, for example the damage caused by cats, foxes, rabbits, prickly pear, Paterson's curse, cane toads and European carp.

### Marine pests

A **marine pest** is a species of plant or animal that seriously affects the survival of native animals and plants unique to a region. The pest can be introduced from another country or be a naturally occurring organism that increases in numbers.

The Japanese sea star in Figure 329.2 came from the Northern Hemisphere in the ballast water of ships (see over). Sea stars eat other molluscs by wrapping their arms around their prey and pulling them apart. In large numbers, they can wipe out entire populations of commercial shellfish in a matter of months.



Figure 329.1 Coral bleaching

### Did you know

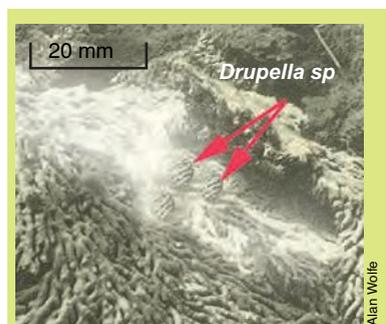
Temperature increases of only 1.5–2°C lasting for six to eight weeks are enough to trigger bleaching.

### Web references

[www.coralwatch.org](http://www.coralwatch.org)  
[www.gbrmpa.gov.au](http://www.gbrmpa.gov.au)



Figure 329.2 Japanese sea star



In Western Australia, the coral-eating snail called *Drupella* (Figure 329.3) has killed many hundreds of kilometres of reef. The snail eats the coral polyps, leaving a white trail of destruction through the entire reef system.

Figure 329.3 *Drupella* - a pest in Western Australia

## Diving deeper



- Discuss ways in which you could reduce pollution when you go boating.
- Research possible causes of fish kills.
- Join a coral watch group ([www.coralwatch.org](http://www.coralwatch.org)) and participate in live research.
- Explain why landlocked seas and lakes are likely to be affected by pollution.
- Where does most of the pollution occur in our country?
- Find out how sewage may solve some of the fuel problems of the 20th century.
- Survey the amount and types of pollutants found on a local beach.



Figure 330.1 Crown of Thorns starfish

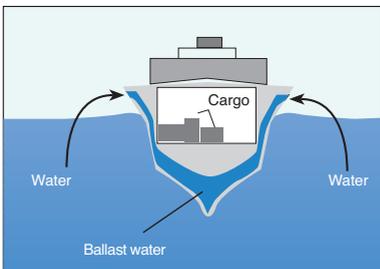


Figure 330.3 Ballast water

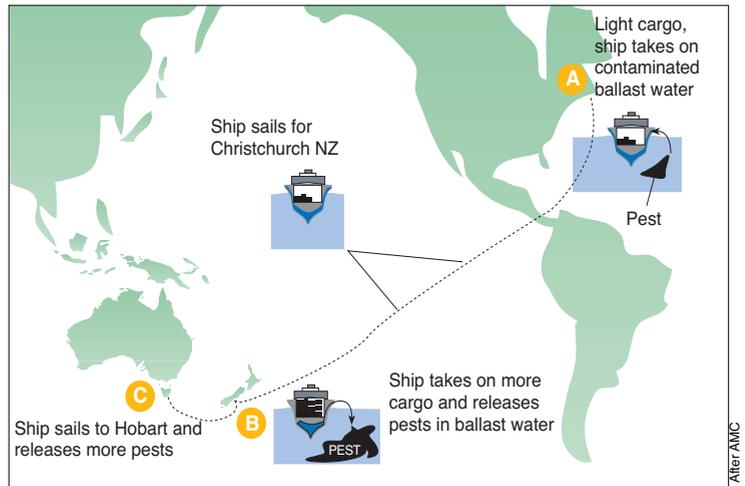


Figure 330.2 How marine pests are transferred from one port to another (after AQIS)

## Crown of Thorns starfish

Coral reefs affected by a Crown of Thorns attack (Figure 330.1) often show large areas of dead and broken coral. This widespread damage reduces the number of habitats available for marine life and this reduces the food supply for the community. The effects can be long lasting.

Animals move away or their numbers drop and the reef loses its tourism potential. The Crown of Thorns starfish plague was believed to have been caused by the removal of the triton shell - its natural predator. Triton shells sell for many hundreds of dollars and are now protected on the Great Barrier Reef.

## Marine threats

### Ballast water

When ships travel the oceans they either carry cargo or some form of ballast to keep them low in the water and thus stable. Up until the late 1870s, ships carried solid ballast. Then it became cheaper and more efficient to use the water close to or in the port as the ship was leaving, and release it on entering the new port to take on cargo.

**Ballast water** is therefore sea water taken on in overseas ports to balance large ships sailing to Australia and New Zealand with limited cargo (Figure 330.3). This water can contain pests from the country in which that water was taken on board. The potential to carry pest organisms into a country is called a **marine threat**.

Figure 330.2 shows how marine pests from the Northern Hemisphere can be transported to ports in Australia and New Zealand through ballast water discharge.

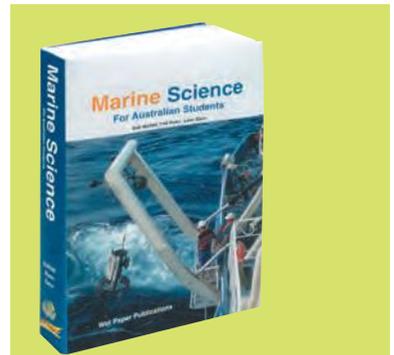
## Key words

Ballast water, catchment, coral bleaching, fertiliser, marine pest, non-biodegradable, non-point pollution, organophosphates, pest, pesticide, point source, pollution, radiation, radioactive wastes, sediment, sewage, sewerage, silt, storm water, threat, toxic compound, trash, waste water treatment plant.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- Unfortunately, we are now living in a '[1] \_\_\_\_\_' society. Most of the goods we buy have specialised [2] \_\_\_\_\_ which cannot be re-used.
- The United [3] \_\_\_\_\_ Organisation has defined [4] \_\_\_\_\_ of the marine environment as the introduction by humans, directly or [5] \_\_\_\_\_, of substances or energy into the marine environment resulting in such deleterious effects as harm to living [6] \_\_\_\_\_, hazards to human health, hindrance to marine activities including fishing, [7] \_\_\_\_\_ of the quality of sea water and reduction of amenities.
- Increased waste [8] \_\_\_\_\_ has come with increased [9] \_\_\_\_\_. The wastes we produce today are full of chemical and toxic substances. Each person in our country is responsible for one [10] \_\_\_\_\_ of rubbish each year.
- [11] \_\_\_\_\_ waste, probably the worst polluting substance ever, is dumped in many parts of the [12] \_\_\_\_\_ Ocean.
- [13] \_\_\_\_\_ \_\_\_\_\_ pollution is where the pollution comes from a specific point, for example hot water from a powerhouse, paint stripper from a smash repair shop, oil from pumps or [14] \_\_\_\_\_ from a [15] \_\_\_\_\_ \_\_\_\_\_.
- [16] \_\_\_\_\_ - \_\_\_\_\_ of pollution are sources of pollution that cannot be traced to a specific point. Non-point source pollution comes from a widespread area, for example, storm water from urban drains or agricultural runoff from a wide area.
- A [17] \_\_\_\_\_ is a term which describes the area of land which contributes runoff to a [18] \_\_\_\_\_ creek, river, lake or the ocean.
- A [19] \_\_\_\_\_ \_\_\_\_\_ is a species of plant or animal that seriously affects the survival of native animals and plants unique to a region. The pest can be [20] \_\_\_\_\_ from another country or be a naturally occurring organism that [21] \_\_\_\_\_ in numbers.



### For further reading on management and conservation of the sea

- See Chapters 17 - 22 on management and conservation from our Marine Science for Australian students [www.wetpaper.com.au](http://www.wetpaper.com.au)



24. What is *ballast water* and how is it dangerous to marine life?
25. Give an example of how an introduced pest can harm a local economy.
26. Give one example of how the disposal of wastes at sea may be beneficial to marine life.
27. What happens to sand when the coastal vegetation is destroyed by \_\_\_\_\_ coastal developments?
28. What is meant by a *throw-away society*?
29. Propose a theory for the Crown of Thorns starfish plague on the Great Barrier Reef.



# Chapter 29 Sea Water quality



Figure 332.1 Abalone

Ruth Farley

## Web references

[www.streamwatch.org.au](http://www.streamwatch.org.au), [www.waterwatch.org.au](http://www.waterwatch.org.au)

**Sea water quality** is a measure of the ability of water to support marine life and maintain public health. It is also crucial for the **aquaculture** industry (Figure 332.1). Poor water quality will, either kill fish directly or cause stress leading to reduced feeding, growth and production, inhibition of gonadal development and reproduction, and increased susceptibility to disease.

The study of sea water quality is also important because it allows us to evaluate how well we are treating our world. If we want to continue to eat seafood, we need to maintain good sea water quality.



Figure 332.2 Good management

Wet Paper

## What determines sea water quality?

*Dredging of harbours in recent years has made for poor water quality*

The quality of water in the ocean is determined by pollution from land and air as well as volcanic eruptions deep under the sea. In this chapter we will look at the quality of water in our coastal zone.

Water quality in the coastal zone is affected by human activities (such as the building of storm water drains in urban developments and **rural land use**) because these affect the state of the river catchments. A river catchment is the area of land which drains into a river (see Chapter 28). Bad quality river water will damage the quality of sea water. Good **catchment management** results in good water quality because all the forces in the environment are balanced (Figure 332.2).

The trees and plants that grow along a river are called the **riparian** vegetation. This vegetation can be rated very poor (Figures 332.3 and 332.4) to excellent, depending on the variety of vegetation, the amount and how healthy it is.

In Figure 332.2, the number of trees on the hillside would slow down the rate at which the rainwater ran off the surface and so it would soak into the ground on the hill, which would filter out dead animals and plants before the water enters the river.



Figure 332.3 Poor management

Wet Paper



Figure 332.4 Effects of poor catchment management

Wet Paper

The sea water in the coastal zone would therefore be protected from contamination from the land. Storm water that runs off new bare farmland or street systems with hard surfaces (Figure 333.1) is not filtered by the ground so everything in its path is carried into the sea. The ability of water to soak into the ground is called **infiltration**. Figures 333.2 and 333.3 compare the two infiltration rates of hard and soft surfaces. Obviously, good sea water quality will result from coastal zones that have high infiltration rates or super clean hard surfaces.

## Sea water quality tests

School students from around the world are involved in water quality monitoring programs in which they measure **parameters** of water quality such as temperature, turbidity, pH, dissolved oxygen, bacteria and nutrient levels such as nitrogen and phosphorus.

### Temperature

Water temperature influences all chemical and biological processes of all fish species and affects all aspects of their biology, including reproduction, appetite, digestion and growth. No other single factor affects the development and growth of fish as much as water temperature.

Each species has a range of temperatures in which it can live and within this range there are optimum temperatures for reproduction and growth. Temperatures reaching the upper or lower lethal limit will kill fish. Subjected to extreme, but not lethal temperatures for extended periods, growth and other biological activities will be adversely affected and mortalities will occur either directly or indirectly through starvation or stress-induced disease. Fish readily tolerate gradual changes in temperature, but a sudden change of 50°C or more may stress or kill fish, particularly if temperatures near the upper or lower limits. Water temperature can be monitored using a thermometer and /or multiprobe meters and data loggers.

### Measuring temperature

The best way to measure sea temperature is to put a thermometer in the water for about 30 seconds and then read it while it is in the water (Figure 333.4).

### Turbidity

**Turbidity** is a measure of how dirty the water is. Turbidity is caused by soil running off the land. When farmland is created, when roads or housing estates are constructed or heavy rain occurs over recently excavated land, topsoil washes into rivers, streams and estuaries and out into the sea.



Figure 333.1 Urban storm water system

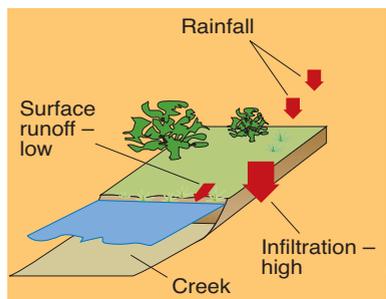


Figure 333.2 Surface and infiltration rates – soft surfaces

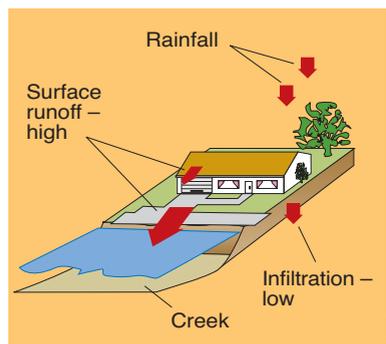


Figure 333.3 Surface and infiltration rates – hard surfaces

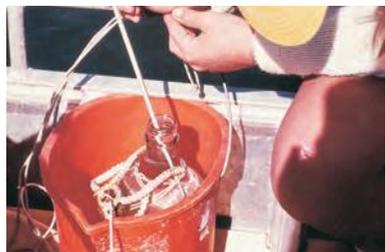


Figure 333.4 Measuring temperature



Figure 334.1 Using a turbidity tube

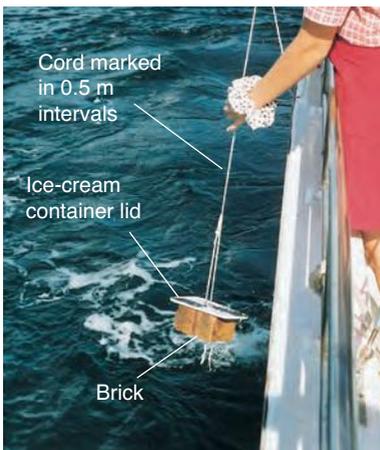


Figure 334.2 Measuring turbidity with a secchi disc



Figure 334.3 Measuring hydrogen sulfide from mangrove mud

Many invertebrates, called filter feeders, feed using very fine hairs around their mouths to trap small drifting animals like plankton. Barnacles, oysters and mussels are filter feeders. If soil enters the water, the turbidity changes dramatically and mud and silt covers these animals which often die. The turbidity also prevents sunlight from penetrating the water so phytoplankton which use this light to produce oxygen are badly affected. In addition, soil from urban environments often brings with it the heavy metals such as zinc from car and truck brake pads that accumulates in the gutters.

### Measuring turbidity

Use a turbidity tube to measure turbidity in shallow water (Figure 334.1). Collect a bucket of estuarine water and pour it into the tube until the mark at the base of the tube can no longer be seen. The tube is marked with graduations and you take the turbidity reading from the side. To measure turbidity in deeper waters, use a secchi disc made from a cord marked at metre intervals, an ice-cream container lid and a brick (Figure 334.2). Lower the instrument into the sea until the black and white sections appear to merge and measure the depth.

### Ammonia

Ammonia is the major waste product of protein or nitrogenous metabolism in fish and other aquatic organisms. It is excreted across the gills, in urine and faeces and is also produced during the aerobic decomposition of organic matter by bacteria. In water, the total ammonia-nitrogen (TAN) occurs in two forms, unionised ammonia ( $\text{NH}_3$ ) which is toxic to fish, and the ammonium ion ( $\text{NH}_4^+$ ) which is relatively non-toxic, except at extremely high concentrations. Ammonia levels can be measured using aquasonic ammonia testing kits and / or multiprobe meters.

### Carbon dioxide

Carbon dioxide ( $\text{CO}_2$ ) although not very toxic to fish, high levels antagonise the uptake of oxygen. Most species can tolerate levels up to 60 milligrams per litre, but usually avoid levels of 5 milligrams per litre and above. Carbon dioxide levels, can be monitored using multiprobe meters.

### Hydrogen sulfide and sulfide

Hydrogen sulfide ( $\text{H}_2\text{S}$ ) is produced by bacterial decomposition of organic material under anaerobic conditions. Concentrations less than 1 milligram per litre are lethal to fish, eggs and larvae. In aquaculture ponds, toxic levels may be reached during harvesting when gas is released as the thick layer of degenerating material on the pond bottom is disturbed.

## Acidity or alkalinity (pH)

Sea water tends to be slightly alkaline, ranging between pH 7.8–8.4 (Figure 335.1). Most marine animals have a very narrow range of tolerance to changes in pH so industrial spills involving acids can greatly affect animals and plants living in coastal estuarine environments. Bacteria, on the other hand, can withstand very large changes and can live in just about any marine environment.

### Measuring pH

You can use a simple pH meter like the one shown in Figure 335.2. Once the instrument is **calibrated** (placed in known pH solutions before use and the readings matched), it can be placed in the sea water sample and the reading taken from a **digital** display.

A cheaper and often more reliable method is to use special **indicator paper**. Immerse the paper into the water sample for 30 seconds and then compare the colour with a known range of pH.

### Dissolved oxygen

Oxygen is vital for all marine life and plant plankton in the sea supply over 70% of it. They make the oxygen in their cells during the day using sunlight, releasing it to the air. At night, they use the oxygen to make carbon dioxide. Because more oxygen is made by plants than they use, we have air to breathe on our planet. The amount of oxygen in the air is measured in **parts per million** or ppm.

In sea water, the average amount of oxygen is 7 ppm which shows that marine life has been able to survive on a very small amount. The balance is delicate and if there are too many plants (as during an algal bloom) the oxygen made during the day can quickly be used up at night and drop to below 4 ppm.

Dissolved oxygen is the most critical and limiting factor as fish cannot live without oxygen. Oxygen is only slightly soluble in water and this small amount is vital to all aquatic life forms.

### Measuring dissolved oxygen

Take a sample of sea water using a **dissolved oxygen bottle** as shown in Figure 335.3. Chemicals are added to convert the dissolved oxygen gas in the water into a solid form which can be tested with a chemical solution called **sodium thiosulphate**. The sodium thiosulphate is then added drop by drop until a colour change occurs.

The number of drops are then recorded because this is a measure of the oxygen levels in parts per million.

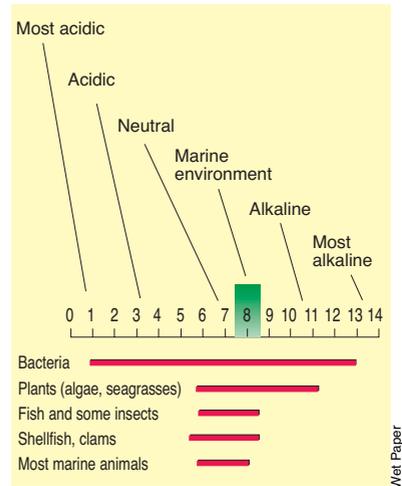


Figure 335.1 pH ranges and tolerance of marine organisms



Figure 335.2 Students using a digital pH meter and colourimeter

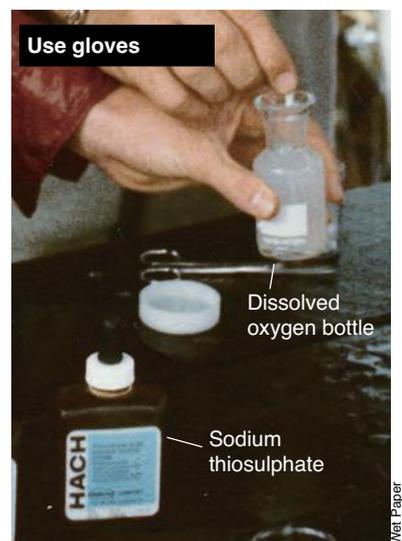


Figure 335.3 Measuring dissolved oxygen



Figure 336.1 Students collecting water samples from a coastal river



Figure 336.2 Testing for bacteria

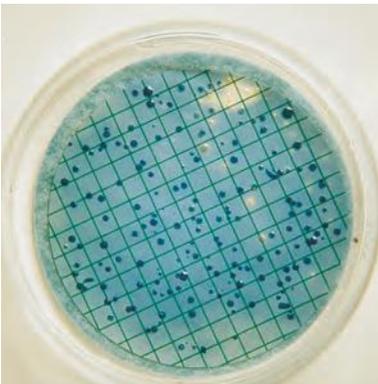


Figure 336.3 Results of faecal coliform tests



Figure 336.4 Testing for nutrients

## Bacteria and viruses

It is important to know the water quality of our surfing and swimming beaches and regular tests need to be done on storm water drains to see if the surf is healthy to swim in. Under natural conditions, when land animals defecate on the land the waste products are filtered by the soil and the riparian vegetation before they enter the sea. In urban areas, the wastes from our bodies, kitchens, laundries and showers are connected to a **sewerage** system. In many places this sewerage system is linked to a waste water treatment plant which removes the harmful wastes before discharging the water into the sea.

If the system fails or **storm water** becomes contaminated with waste water, harmful bacteria, such as those which cause **cholera**, grow rapidly in the water. A person who swims in contaminated water which comes from these pipes takes the chance of absorbing these germs into their body. Eating oysters from polluted water can cause a liver disease known as hepatitis because oysters and other molluscs concentrate these germs in their own bodies and pass them onto people who eat them uncooked. Water-borne bacteria can also cause skin and ear infections.

### Testing for bacteria

Collect a water sample as shown in Figure 336.1. Filter the sample through a very fine piece of filter paper called a **membrane filter** (Figure 336.2). Put this membrane filter on a small dish with a special bacterial food and incubate it for 24 hours. Harmful bacteria which are present will grow into blue spots (Figure 336.3). Count the number of blue spots. If there are more than 150 spots per 100 millilitres of water sample, the water is not safe to swim in or take food from.

## Nutrients

The sea maintains a delicate balance of the nutrients **nitrogen** and **phosphorous**. The riparian vegetation on land in natural coastal environments also keeps this balance in check. However, if levels of these nutrients rise in the water, algae can grow rapidly and form blooms (see Chapter 28).

### Testing for phosphates and nitrates

Chapter 11 discussed how nitrate levels affect the survival of fish in your aquarium and you may have used a simple nitrate test kit to work out the parts per million of nitrate present in your aquarium water. You can use a similar kit, involving a chemical reaction, to use up or convert all of the nitrate or phosphate present in your sea water sample into a distinct colour. The student in Figure 336.4 has just finished a nitrate test and is comparing her colour with that of a known sample.

She is turning a colour wheel until the colours match. When they do, she will take the nitrate reading from the wheel. More sophisticated colourimeters like the one shown in Figure 335.2 can be used to get very accurate measurements of nitrate and phosphate levels in sea water.

### DDT in the food chain

Waste water or sewage is not the only killer of waterways. In the mid-1940s, a miracle chemical called DDT was discovered which wiped out mosquitoes and so eradicated malaria from many countries. However, the DDT did not break down over time but concentrated itself in the food chain as animals ate each other (Figure 337.1). The problems showed up when it was discovered that the DDT in the system of the osprey, a large predatory seabird, prevented the egg shells from forming properly so that they cracked before the baby birds had a chance to hatch. Osprey population numbers dropped and governments from around the world have subsequently banned DDT. Other reasons for the banning of DDT were that it was found in human breast milk and in the bodies of animals as far away as Antarctica. Continued use of this chemical would have had severe repercussions for life on our planet.

## Macroinvertebrate sensitivity tests

These tests come from a fresh water system however in the years to come it is hoped to have invertebrate tests for sea water so as to reduce the number of chemicals used in testing for pollution.

### Determining a water quality index

Checking for the presence of types of invertebrate animals can be used to determine water quality. This form of testing is more **environmentally friendly** than some of the ones described previously in this chapter because it does not use chemicals.

Using this method, collect animals with a net from a stream. Record what invertebrates you have caught and use these records to assess the quality of the water.

The water invertebrates are classified into four different groups depending on how sensitive they are to pollution. These groups are very sensitive, sensitive, tolerant and very tolerant.

Each water invertebrate is given a rating according to how sensitive it is to pollution. Very sensitive animals are given high numbers and very tolerant animals low numbers.

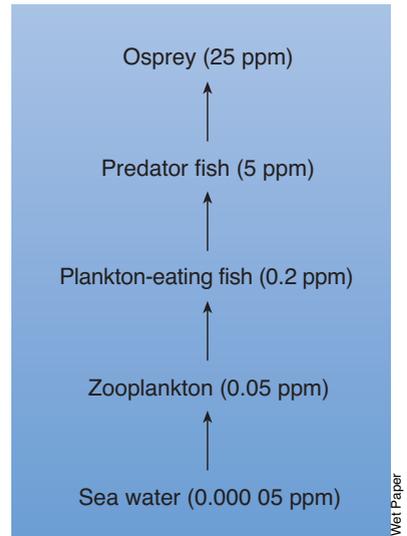


Figure 337.1 DDT concentration in a food chain

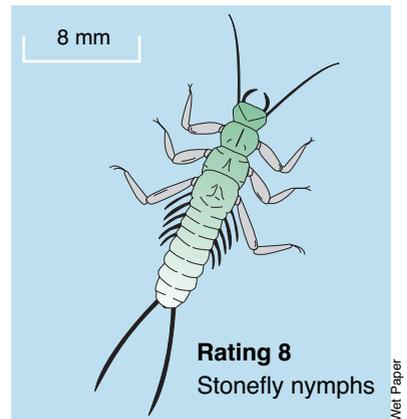


Figure 337.2 Very sensitive water bugs

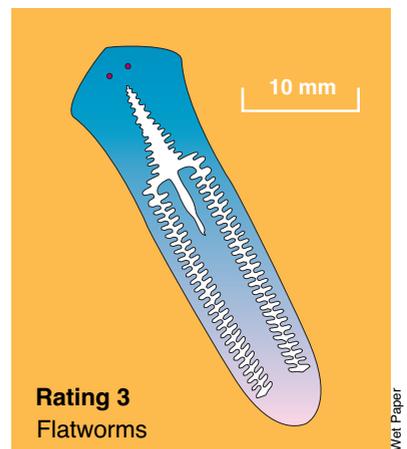


Figure 337.3 Very tolerant water bugs



1. What is sea water quality?
2. How should the temperature of a water sample be read?
3. What is *turbidity* and how is it measured in the sea?
4. What is a possible source for mercury pollution in estuaries?
5. What is the average range of pH in sea water?
6. What happens when a pH instrument is calibrated?
7. Which organisms can withstand a wide range of pH?
8. How are dissolved oxygen levels measured?
9. What is the average dissolved oxygen level for sea water?
10. Below what dissolved oxygen level do fish die?
11. What is the name of the system that carries waste water from our homes?
12. Above what level of bacterial counts per 100 mL is it dangerous to swim in sea water?
13. Name two nutrients that are delicately balanced in the sea.
14. How can we use invertebrate animals to test for water quality and give an example of how a pollution index is calculated?
15. Make a list of any three poor water quality parameters.

Stonefly nymphs are very sensitive (Figure 337.2). Flatworms belong to the very tolerant group (Figure 337.3). So the stonefly bug is given a rating of 8 and the flatworm a rating of 3.

The more sensitive the animals found in a stream, the less polluted the water quality is likely to be. To calculate the water quality of a stream, add the numbers to get a **pollution index**. Rate the stream according to the index number you get. If there were lots of very-tolerant-to-pollution animals and no very-sensitive-to-pollution animals, then the water quality would be poor.

Scientists from programs called Streamwatch, WaterWatch and from CSIRO have developed the following pollution table:

Pollution index	Stream quality rating
20 or less	Poor
21 - 35	Fair
36 - 50	Good
51 or more	Excellent



An example of how the scientists can measure water quality using water invertebrates is as follows:

Very sensitive	Sensitive	Tolerant	Very tolerant
Yabbies (7)	Dragon flies (6)	Leech (3)	Mosquito (1)
May flies (7)	Mussels (6)	Beetles (6)	Bloodworm (1)
	Shrimp (6)	Snails (3)	
Totals (14)	+	(18)	+
Pollution index = 45 (Stream quality rating = good)			

### Poor sea water quality

The parameters for good and bad sea water quality depend on local areas and conditions.

Over time, animals and plants adapt to their particular environment.

The list of parameters for poor quality listed below are only generalisations.

- Temperature - big differences in degrees in place and time (say 10 degrees).
- Dissolved oxygen - less than 60% saturation and fish gasping for air or not present.
- Turbidity - one week turbid, the next clear.
- Nitrate levels - greater than 0.01 ppm.
- Phosphate levels - greater than 0.01 ppm and algal blooms occurring.

- Bacterial levels - greater than 150 colonies/100 millilitres and signs warning swimmers not to bathe in place.
- **Biodiversity** - would have changed. Old timers would tell stories of the abundance of animal and plant life in the past but current scientists would report of few species today.
- Riparian vegetation - non-existent. Polluted storm water flows into rivers and streams and there are few or no trees or mangroves beside creeks, rivers or estuaries.

Chapter 30 discusses ways we can improve sea water quality and reduce the pollution of our seas.

## Key words

Biodiversity, calibrated, catchment management, cholera, digital, dissolved oxygen bottle, environmentally friendly, evaluate, indicator paper, infiltration, membrane filter, nitrogen, parameters, parts per million, phosphorous, pollution index, riparian, rural land use, sea water quality, sewerage, sodium thiosulphate, storm water, turbidity.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- Water quality in the coastal zone is affected by human activities such as the building of [1] \_\_\_ drains in urban developments.
- The trees and plants that border a river are called the [2] \_\_\_ vegetation.
- If soil enters the water, the [3] \_\_\_ changes dramatically and mud and silt covers these animals.
- Sea water tends to be slightly [4] \_\_\_ , ranging between [5] \_\_\_ 7.8–8.4.
- In [6] \_\_\_ areas, the wastes from our bodies, kitchens, laundries and showers are connected to a [7] \_\_\_ system.
- The sea maintains a delicate balance of the nutrients [8] \_\_\_ and [9] \_\_\_ .
- In the mid-1940s, a miracle chemical called [10] \_\_\_ was discovered which wiped out mosquitoes and therefore eradicated [11] \_\_\_ from many countries.
- Many types of [12] \_\_\_ animals can be used to determine water quality.

This form of testing is more [13] \_\_\_ because it does not involve the use of [14] \_\_\_ .



Figure 339.1 Excellent water quality

## Diving deeper



- Become involved in monitoring your local creek or estuary.
- Make a newspaper scrapbook collection of articles involving water quality. Identify which of the issues are important and write a paragraph on each.
- Obtain some water testing equipment and study your aquarium over a week for the following parameters; pH, dissolved oxygen, temperature, turbidity, nitrogen as nitrates, phosphorous and salinity. Make notes and draw a graph of the changes.
- Type the word 'waterwatch' into your computer's search engine and locate information on water quality monitoring.
- Find out how dredging has affected water quality in Gladstone Qld.



# Chapter 30 Saving the sea



SurfLife Foundation

Wet Paper

## Web references

[www.reefed.edu.au](http://www.reefed.edu.au), [www.mesa.edu.au](http://www.mesa.edu.au),  
[www.ausmepa.org.au](http://www.ausmepa.org.au), [www.greenpeace.org.au](http://www.greenpeace.org.au)



Wet Paper

Figure 340.1 Recycling oil — acting locally



Wet Paper

Figure 340.2 Planting mangroves and cleaning up local creeks — acting locally

*Think of the link -the sea  
and the sink*



There are two ways of saving the sea — you can talk about it or you can do it. Governments spend millions of dollars on inquiries into the coastal zone and pay for huge volumes of paper that just sit on the shelves and collect dust. People acting together can do so much more.

The ultimate weapon against marine **pollution** is education. Marine studies programs like you are doing at school go a long way to saving our sea. If you know how to look after your marine environment in simple practical ways and you pass these skills onto your friends and your own children, you will save the sea. People carry practical skills into the workplace which transfer into environmental work practices that are written down and followed as **work procedures**. In the future, companies will do better business and make better profits from environmentally safe work practices because we will buy their products rather than environmentally unsafe ones.

An environmentally educated population will be able to follow a path of economic development that safeguards future generations from having to pay for previous generations' environmental disasters.

## Think globally, act locally

The photograph in the chapter title shows a group of marine educators protesting against nuclear testing. Radioactive pollution is an example of a global issue that we must all think about. But to save our seas, we must also act locally. Recycling oil (Figure 340.1) or planting mangroves in a local creek (Figure 340.2) are ways you can act locally to save the sea.

We need to educate people to change any behaviour that threatens the environment. Behaviour changes involve a combination of community group involvement, education, changed work practices and manufacturing procedures, fines and media campaigns. The *bin ya butts* campaign by Reef HQ in Townsville is an example of one such campaign.



Bin ya  
butts

# Acting locally

## Marine education pebbles

How do you tell someone they are polluting the sea? How do you tell your friends to stop throwing cigarette butts out of the window, or your local garage owner to clean the oil on the garage floor when that owner gives you a weekend job and is scraping to get by financially?

The first step is to create awareness in a nice way by dropping **marine education pebbles**. These are simple statements, put in simple humorous language, that are unlikely to offend people but can lead to permanent changes in environmental behaviour (see Figure 341.1).

You can, of course, fine people for littering, make laws to manage and control smokers and confront people with the damage their behaviour does.

But if people are educated and not confronted, they are more likely to change, the change will last a long time and not cost the government as much. Two examples are given below.

### *Hold onto your butt*

Most people are aware of the dangers of smoking and have the right to choose to smoke outdoors. However, throwing cigarette butts out into the street so that they wash down into our creeks is not a good way to save our sea.

By saying to smokers, 'Hey! Hold onto your butt, our creeks and beaches are not ashtrays,' you have dropped an environmental pebble which may be picked up by the smoker and change their behaviour.

Another way is to produce car bumper stickers as shown in Figure 341.1. This way people can get the message in a non-threatening way.

### *Scoop the poop*

A public health threat on beaches near densely populated areas is high concentrations of *E. coli* or *Escherichia coli* bacteria. This bacteria occurs naturally in the gut and faeces of birds and mammals. Heavy rainfall washes pet faeces into the sea, raising bacteria levels in the water.

Some local councils place bins in dog exercise areas so dog owners can dump their scooped poop (Figure 341.2).

The only way to deal with this problem is to follow your dog and pick up its poop. Use a plastic bag (Figure 341.3) or a special pooper scooper and put the poop out with the rubbish.



Figure 341.1 Environmental pebbles



Figure 341.2 Dog latrine bin



Figure 341.3 Scoop the poop

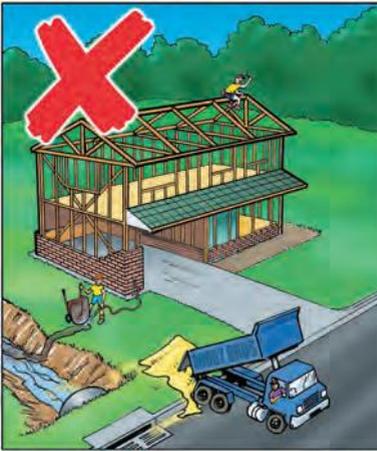


Figure 342.1 The wrong way to control sediment on a building site

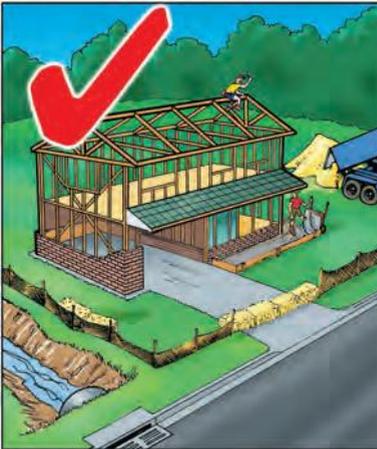


Figure 342.2 The right way to control sediment on a building site



Figure 342.3 Wash paint brushes in clean up trays

## Education programs

Providing solutions that care for our sea begins with community knowledge. Once the community has this knowledge, people can take responsibility for their behaviour.

Our streets and backyards are part of the catchment of our rivers, creeks, estuaries and ultimately the ocean. Dilution is not the solution to pollution. Fixing up our catchment management is.

## Builders

Marine education programs need to focus on the daily activities of industry. The building industry is a good place to start. Practical hints on how to construct buildings to minimise storm water pollution need to be part of school and marine vocational education programs.

Figure 342.1 shows how building waste will run off into creeks and rivers. Figure 342.2 shows how simply changing where materials are stored on a building site and putting in some inexpensive erosion control fences will help save the sea.

## Car users

Dust and dirt in storm water drains and gutters have high levels of zinc, a heavy metal pollutant. This zinc wears off the brake pads of cars and trucks. How can we act locally to reduce the amount of zinc from this source that gets into the waterways and so into the sea? One way is to drive more carefully and steadily so that you don't use your vehicle's brakes so much. Another way to reduce zinc pollution is to walk, cycle or use public transport whenever possible.

You could also start a campaign to pressure manufacturers to phase out zinc in brake pads.

## An estuary of many paint colours

Washing paint off brushes and paint trays into storm water drains also pollutes our seas. Estimate the exact amount of paint needed for a job. Let the paint dry in the tin before putting it out in the recycling bin.

## Pesticides and wildlife

Many insecticides and fertilisers contain endosulphin which is very poisonous to fish. Don't rinse insecticide containers into the storm water system. Use up all the contents and then put the can out with the rubbish.

Try to use natural alternatives to pesticides.

If you cannot find one to suit your needs, use pesticides only during dry weather so that rain doesn't wash the chemicals into the storm water drains.

## Reduce, reuse and recycle

These three Rs go a long way to saving our sea because they change our relationship with our planet. The figures on this page illustrate ways to reduce, reuse and recycle – see how many you can find.

### Reducing

The first and most important step is to **reduce** what you buy. If you don't buy it, then it can't become rubbish. Items that are over-packaged or are only used once show how we have become an over-consuming society. If you can learn to buy in bulk (but not a bigger amount than you need), to choose products with recyclable or minimal packaging and to buy quality goods that will last, then you are reducing the strain on our natural resources and the pressure on our landfills. You can also reduce the need to buy fruit and vegetables by growing your own. You can use the mulch and compost from your recycling projects as fertiliser.

### Reusing

The second step is to **reuse** what you have bought. Before you throw a product away, think of possible ways of reusing it at home or at work. By reusing a product, you prevent it from becoming rubbish.

### Recycling

The third step is to **recycle** as much as you can. Bottles, cans, glass and plastic containers can be recycled through local authority recycling programs.

Some paper and cardboard products are also recyclable in the split bin system (check the sticker on your bin). A worm farm or a compost bin are also methods of recycling materials we would otherwise throw away.

Recycling enables us to reduce pollution, save natural resources, reduce the strain on landfills and use less energy to produce new products.



Figure 343.1 Acting locally by reducing, reusing and recycling



Figure 343.2 Recycling cardboard



Figure 343.3 Recycling plastic bags

# Thinking globally

## Campaigning

Politicians react to campaigns and lobbying. So an educated population that cares for its coast and understands how it works can save it from destruction. People who are educated about the environment will vote for politicians who represent their environmental wishes. The problems discussed in Chapters 28 and 29 will not go away. If we do not do something about pollution, our seas will deteriorate further. You can do something. You can make a difference. This section discusses some of the actions taken by people who think globally.



Figure 344.1 Community protest rally against sewage pollution



Figure 344.2 Surfrider Foundation protest rally against oil pollution



Figure 344.3 Surfrider media interview



Figure 344.4 Council library display



Figure 344.5 Homemakers trade show

## Sewage outfalls

In the mid-1990s, a group of surfers formed the **Surfrider Foundation**. This organisation worked hard to change government attitudes to dumping of sewage from ocean outfalls. At the time, not one political party would support ending this practice. The Foundation organised huge public protests like those shown in Figures 344.1 and 344.2 and conducted thousands of media interviews (Figure 344.3). Within three years, every political party had agreed to support the phasing out of ocean outfall of sewage.

## Marine Protected Areas

Marine protected areas (MPAs) are a very important strategy for conserving marine biodiversity. Large marine protected areas are considered a safe, 'catch all' way of protecting marine biodiversity because they provide the range of different habitats a species requires during its life history. MPAs are a particularly important strategy for fisheries management for they can protect juvenile and adult fish habitats, and protect a proportion of the breeding population of adult fish. Larvae from protected areas can 'seed' fished areas outside.

Multiple-use MPAs are especially important for they provide a way of conserving biodiversity whilst enabling planned and ecologically sustainable human uses. Their use have been largely pioneered by Australia, and we now have the most, and the largest areas of MPAs in the world.

## Definition of ' Marine Protected Area' (MPA)

*A marine protected area is an area of estuary, intertidal shore or sea, especially for the protection and maintenance of biodiversity and of natural and associated cultural resources, and managed through legal or other effective means.*

It may be fully protected like national parks or nature reserves on land, or protected from a specific threatening activity such as prawn trawling or netting.

There are many different types and functions for MPAs: marine parks, marine reserves, aquatic reserves, fisheries reserves, fish sanctuaries, wetlands reserves and so on. *Multiple use* marine protected areas protect habitats and species of biodiversity importance, but allow for sustainable uses such as fisheries, tourism, shipping and other marine industries.

## Whaling

Marine conservationists from the Greenpeace organisation have campaigned for many years to ban whaling (Figures 345.1 and 345.2). In the mid - 20th century whaling was banned as humpback whale populations around Australia and New Zealand dropped to just hundreds.

In the 1990s, the population numbers of more common whale species rose to be in the thousands. However in 2009, they are still threatened by unsustainable commercial whaling operations based in Japan under the name of scientific research!

## Nuclear testing in the Pacific Ocean

The French government was still carrying out nuclear testing in the Pacific Ocean in the 1990s. Protests from around the world, especially South Pacific nations like Australia and New Zealand, demanded the tests stop.

Campaigns finally led to the total banning of nuclear testing with treaties signed between the world's superpowers. However, our seas are still threatened by radioactive pollution from the waste of nuclear reactors.

## Rainforest timbers

Rainforests, like those in Tasmania and the South Island of New Zealand, recycle trillions of tonnes of water from the atmosphere into the sea.

Today they are threatened by the timber industry that supplies us with furniture and housing materials. Environmental organisations like the Wilderness Society are campaigning to stop the use of rainforest timbers in building, furniture and paper products. This book was printed on paper made from **plantation** trees grown specifically for printing books. In the future, textbooks may be replaced by the internet thus saving millions of trees.

## Harvesting marine animals

Although marine farms breed crocodiles and pearls specifically to produce clothing and jewellery, some countries still allow the commercial hunting of seals and other native wildlife. The Worldwide Fund for Nature constantly calls for the banning of these industries to safeguard populations of marine life.



Figure 345.1 Anti-whaling protest



Figure 345.2 Greenpeace protest southern ocean 2008



Figure 345.3 Information stall

Check out

[www.greenpeace.org.au](http://www.greenpeace.org.au) and

[www.greenpeace.org](http://www.greenpeace.org)



Figure 346.1 The calico bag project

GBRMPA



Figure 346.2 Worm farm project

West Paper



Figure 346.2 National water week

West Paper



Figure 346.4 Drain spraying education

West Paper

# Case study



## The reef guardians schools project

The Reef Guardian Schools Program is an education initiative of the Great Barrier Reef Marine Park Authority that aims to develop partnerships between schools, government, industry, environmental groups and local business in order to work together towards a more sustainable future for our natural resources and in particular the Great Barrier Reef. It is an excellent conduit through which schools can promote sustainable environmental practices within their local community, whilst projecting a positive image of the school itself. Reef Guardian Schools commit to participate in projects and activities that relate to four key criteria:

### 1. Curriculum

Implementation of teaching and learning opportunities focused on the Reef, sustainability and/or other parts of our natural environment.

### 2. Resource management

Refuse, reduce, reuse and recycle resources such as waste, water and energy. This also includes working towards improving the biodiversity of the school grounds.

### 3. On-ground projects

Students participate in experiential (hands-on) learning projects. The size and scale of on-ground projects is dependent on the school's location, student numbers, ages of students and the partnerships established within in the local community.

### 4. Education of the community

Encourage others to adopt best environmental practices through announcements on school assemblies, in school newsletters, media opportunities and Reef Guardian displays at school and community events.

The Reef Guardian Schools Program is a dynamic program that unites teachers and their students in a common goal of protecting the Great Barrier Reef. Schools participating in the program consistently report that it provides cohesiveness amongst the school and its community and generates a can-do attitude amongst learners of all ages.

For more information about the Reef Guardian Schools Program please visit the Reef Guardian section of the Reef ED website -

[www.reefED.edu.au](http://www.reefED.edu.au)

Email: [education@gbrmpa.gov.au](mailto:education@gbrmpa.gov.au)



For more information about Reef Guardians

visit [www.reefed.edu.au](http://www.reefed.edu.au)

# Repairing the sea

Obviously, it is better to save the sea by putting a stop to all activities that harm the marine environment. However, this is not always possible. Sometimes we have to save the sea by repairing damage already done to the environment. We can act locally to repair the damage ourselves and think globally by campaigning to force companies that damage the environment to clean up their mess. This section discusses ways that the marine environment can be repaired.

## Industry and the sea

Some industrial companies are now developing ways to treat their waste before discharging it into the sea.

One company that did this was ICI Olefines at Botany, NSW, which produces petroleum chemicals that are used to make plastics. In the 1990's, the company was discharging significant amounts of petroleum waste straight into the sewerage system.

These petroleum by-products are difficult to break down at the waste water treatment plant and can be **toxic** when mixed with water. In response to stricter controls on waste water quality, the company designed and constructed new machinery that recycled waste water for cooling purposes in the plant and reclaimed the petroleum by-products.

This program was highly successful and resulted in a 95% reduction of petroleum in the discharged waste water which was clean enough to irrigate company gardens and lawns. In addition, the company significantly reduced its water consumption and obtained useful by-products from the reclaimed hydrocarbons. Estimates showed the company had saved \$6.4 million in three years.

## Oil spills

The biggest problem with oil spills from coastal refineries and seagoing tankers is that both crude oil and refined oil have devastating effects on marine life at sea (see Chapter 28). Refined or fuel oils, such as petrol and diesel, tend to mix with the water, especially with strong wave action. This can make them highly toxic to all marine life. Large spills well out to sea may be sprayed from the air with chemical dispersants which break up the oil into smaller particles so that they form a bond with the water called an **emulsion**. In this form, they may be acted upon, broken down and made less harmful by micro-organisms. Unfortunately, dispersants are usually highly toxic and are not recommended for use in waters shallower than 20 metres or within 5 kilometres of the coast.

## Diving deeper



1. Debate the effectiveness of national cleanup days.
2. Explain the meaning of the statement, 'We may yet have to cure the cause rather than the effect of the problem'.
3. On the internet? Get involved with saving the beaches worldwide on <http://ednhp.hartford.edu/www/nina/beaches2.html>.
4. Find out about nutrient removal drains and apply for a Landcare/Coastcare grant to build one.
5. Apply for a dune revegetation grant. Work as a team to remove introduced plant species and start a planting program to revegetate the dune system into a natural state.
6. Conduct a beach litter survey to see where the most litter on your local beach is coming from.
7. Design a series of posters and campaign to reduce litter.
8. Design a drain stencil and, after getting permission from your local council, start a drain spray and leaflet drop program.
9. Become a Reef Guardian school.





Figure 348.1 Boom containment



Figure 348.2 Replanting the riparian zone in a coastal creek



Figure 348.3 Nutrient-absorbent drains

If a spill occurs close to the coast and is likely to come ashore, a rapid response is vital. Firstly, the oil must be contained in one area so it cannot spread further. Response teams can use containment **booms** (Figure 348.1) which look like long chains of floating macaroni and contain oil-absorbing material. Once contained, in calm conditions, the oil can be removed by pumping it onto tankers. Containment booms are not effective in strong waves or currents because the oil can escape over or under them.

Until the oil reaches the coast, cleaning up the spill is the responsibility of trained personnel such as Department of Transport and Sea Rescue officers. If oil does come ashore, we need to act quickly to save affected marine birds and mammals and clean up the beach. At this point everybody in the community can be involved by forming into organised action groups.

These are some of the jobs that you can do in the action groups. Wash oil-coated seabirds and mammals carefully with warm, soapy water then rinse with salt water. After a suitable recovery period, they can be released back into the sea. Clean up oil on sandy beaches with hand spades, rakes and bulldozers. The oil-contaminated sand can then be removed and replaced with clean sand. Fortunately, beaches can recover very quickly in cases like this. Oil on rocky shores and mangroves is best left alone. Strong wave action on rocky shores will eventually break the oil up. In mangrove swamps, oil is best left because more damage can be done to the environment by people trampling through it. Unfortunately, when oil pollutes mangrove communities, you cannot do much, except wait.

## The riparian zone

Repairing the sea starts in the catchment, for example by replanting trees in the **riparian** zone (Figure 348.2) or building **nutrient**-absorbing drains (Figure 348.3). Once the trees grow, they will encourage an undergrowth of plants which will increase the absorbent power of the soil.

Nutrient-absorbing rubble drains and dam walls made of rocks bound together with wire promote the growth of beneficial algae which remove phosphorus and nitrogen from the water as it percolates through. Rubble drains are a better drainage system than storm water pipes that speed up water flow and only pollute the sea faster.

## Sandmining and seabed mining

Sandmining and seabed mining and the damage caused by these industries are a continuing environmental issue. On the one hand, our industries need minerals produced by these extraction

enterprises and the mining industry provides employment - always a significant factor in political decision-making. On the other hand, sandmining and seabed mining upset marine habitats.

For example, seagrass beds around extraction sites can be permanently ruined and seagrass beds are the basis of many marine food chains and dune systems which stabilise the coastal zone. Mining damage may also affect long-term food resources and reduce the local area's tourist potential.

## Managing the sea

**Note: Zoning changes. Consult your State Government Environment web site for the latest information.**

The three levels of government in our part of the world are national, state and local. Each have sets of laws designed to manage the sea. All we have to do is follow these rules put in place to protect the biodiversity of marine life and allow us all to enjoy the sea.

### Local government

Simple rules like keeping to common walking tracks on the way to the beach will help stop beach erosion and help local government manage coastal zones (Figure 349.1). Other practical rules put out at local authority level are as follows: take your rubbish home, keep your storm water drains clean and plan your garden so that topsoil does not get washed away in the rain.

Local authorities also try to stop people hosing concrete surfaces because this washes dirt, chemicals and other accumulated substances (like lead from petrol) into storm water drains.

Local authorities also often have environmental rules about running businesses. For example, you may want to set up a dog-washing business with a car and a trailer fitted out with dog-wash equipment. This type of business will require a permit and have controls regarding the discharge of waste water.

### State government

State governments also have environmental rules, for example, fishing bag limits, closed seasons, net and tackle use, boating rules and regulations, marine park entry, taking of protected species, mining rights, whale-watching permits, coastal zone building applications and development control plans. Each state government has its own set of rules and each will change over time depending on the environmental concerns of the party in power. Figure 349.2 shows a zoning map for a marine park in Western Australia. State governments continually upgrade marine park maps to best manage sustainable use of the sea.



1. What does the phrase '*think globally — act locally*' mean?
2. Give an example of what you could do to think globally.
3. Name two things you could do to act locally.
4. What does the phrase '*scoop the poop*' refer to?
5. Give an example of how materials on a building site could be arranged to reduce sediment and rubbish pollution.
6. How does a sediment control fence help save our sea?
7. What is one source of the high levels of zinc that pollute our seas?
8. What happens to paint that is washed down into storm water drains?
9. Name two activities involving reducing waste, four involving reusing materials and four involving recycling.
10. Why should we walk only on beach walkways?



Figure 349.1 Use beach walkways



Figure 349.2 WA Marine park zoning

## Diving deeper



- Use your search engine to find out about membership of such groups as Greenpeace, Surfrider Foundation or Worldwide Fund for Nature. Find out if there are any local branches and how to get involved in activities such as World Environment Day, Ocean Care Day or Seaweed.
- Ask your school to join education groups such as Reef Guardians, AUSMEPA, Surfrider Foundation, the Australian Marine Teachers Associations, MESA or the New Zealand Association for Environmental Education.

### Web references

[www.mesa.edu.au](http://www.mesa.edu.au)

[www.ausmepa.org.au](http://www.ausmepa.org.au)

[www.surfrider.org.au](http://www.surfrider.org.au)

[www.reefed.edu.au](http://www.reefed.edu.au)

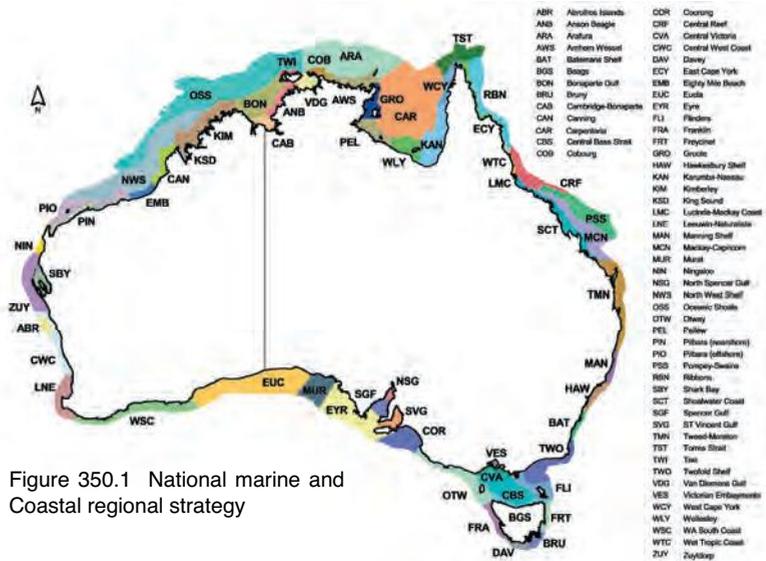


Figure 350.1 National marine and Coastal regional strategy

## National government strategies

In recent years, the federal government has set up a marine and coastal strategy for coastal management aimed at conservation and sustainable resource use. Figure 350.1 shows a map that has identified large scale marine bioregions that can be used as a planning tool for Australian coastal and marine environments.

## Marine reserves, parks and no-take areas

These areas are controlled by cooperation between state and national governments because the sea knows no boundaries. Reserves, no take areas or parks are usually marked by signs like the one shown in Figure 351.1. National governments also can declare **marine protected** and **no-take** areas and set guidelines for local and state governments to ensure the sea is protected.

## Multi-use areas

Because the sea is a common resource property, the idea of **multi-use areas** were introduced to allow the activities of different user groups in marine parks. User activities were allotted different zones in which they could operate, based on marine research and **ecological sustainability**.

In recent years, the federal government has set up a Marine and Coastal regional strategy for coastal management aimed at conservation and sustainable resource use in Australian coastal and marine environments. Figure 350.1 shows a map that has identified large scale marine bioregions that can be used to zone coastal use.

## Exclusive economic zones

Other aspects of national management schemes involve the concept of the **Exclusive Economic Zone (EEZ)** which takes into account national and international interests (Figure 350.2).

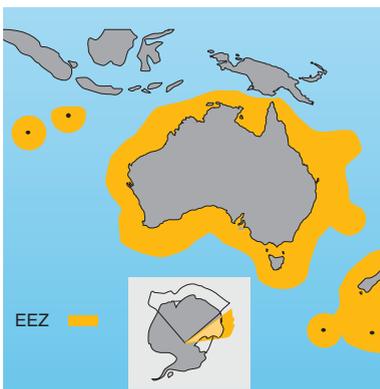


Figure 350.2 Australian and New Zealand EEZs



Figure 351.1 Marine park management boat ramp sign

The declaration of an EEZ under the international law of the sea allows national governments to sign treaties with other countries to allow or prohibit activities such as mining of offshore reefs, longline fishing, whaling or marine safety.

For example, oil mining was not allowed on the Great Barrier Reef, Queensland, but was allowed on the North-West Shelf, WA. Commercial fishing is allowed in some zones and not in others. Multi-use zoning saves our sea because it allows controlled use of the ocean (Figure 351.1). In your next book, *Marine Science for Australian Students*, you will learn a lot more about this important topic.

## MARPOL

**MARPOL** is an international marine pollution agreement that is part of the international law of the sea convention. This international convention for the prevention of pollution from ships prevents people from throwing rubbish overboard from boats and shipping. These regulations apply to all vessels include dinghies, yachts and fishing vessels.

The basic principles of MARPOL are that no plastics are to be thrown into the sea and no garbage discharged within 12 nautical miles of the nearest land.

Under international law, ports must have facilities for the disposal of waste. Special ports called **ecoports** are now catering for large ships.



11. Give an example of how a group of surfers got together to change government policy on sewage ocean outfalls.
12. What is MARPOL and what are its regulations and basic principles?
13. Name any two international campaigns to save the sea.
14. Why must the riparian zone be repaired if we are to improve the water quality of our beaches?
15. What do nutrient-absorbent rubble drains do and how do they help save our seas?
16. Describe how one chemical company became more environmentally friendly in its production process.
17. Describe how to treat a large oil slick at sea.
18. How do containment booms work and what are their limitations?
19. Describe the steps you would take to clean up a beach if oil came ashore.
20. What is the problem with sandmining our coastline?
21. Draw a diagram of the EEZ around your country.



## Diving deeper



12. Type in Surf rider and Waterwatch to your www. search engine and surf to the student pages.
13. Find out about acid sulphate soils and how they are caused in the coastal zone.
14. Find out about the Dawsville Cut and what effect it had in Western Australia.
15. Who was Eddie Marbo and what did he achieve?



Bob Worlatt



ONPWLS

Figure 352.1 Look after ground-nesting birds



Bob Winters

Figure 352.2 Keep oil leaks to a minimum in cars

## Sea rights

National governments have also had to respond to the traditional rights of Aboriginal and Pacific Island people. The Treaty of Waitangi in New Zealand and the Mabo judgement of the High Court in Australia are both sea rights issues.

## Key words

Booms, drain spraying, *E. coli*, ecological sustainability, ecoports, emulsion, exclusive economic zone, marine education pebbles, MARPOL, multi-use areas, nutrient, plantation, pollution, radioactive, recycle, reduce, reuse, riparian, storm water taskforce, Surf rider Foundation, toxic, work procedures.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. An [1] \_\_\_ population will be able to follow a path of economic development that safeguards future generations from having to pay for previous [2] \_\_\_ environmental disasters.
- b. A public health threat on beaches near [3] \_\_\_ populated areas is high concentrations of *E. coli* or *Escherichia coli* [4] \_\_\_.
- c. Dust and dirt in storm water drains and gutters have high levels of [5] \_\_\_, a heavy metal pollutant.
- d. Estimate the exact amount of [6] \_\_\_ needed for a job. Let the paint dry in the tin before putting it out in the [7] \_\_\_ bin to save our sea from paint [8] \_\_\_.
- e. The first and most important step is to [9] \_\_\_ what we buy.
- f. You can also reduce the need to buy fruit and vegetables by [10] \_\_\_ your own.
- g. A [11] \_\_\_ farm or a [12] \_\_\_ bin are also methods of [13] \_\_\_ materials we otherwise throw away.
- h. Other aspects of national management schemes involve the concept of the [14] \_\_\_ \_\_\_ .
- i. The basic principles of [15] \_\_\_ are that no plastics are to be thrown into the sea and no [16] \_\_\_ discharged within 12 nautical miles of the nearest land.
- j. User activities were allotted different zones in which they could operate, based on marine research and [17] \_\_\_
- k. The Treaty of [18] \_\_\_ in New Zealand and the [19] \_\_\_ judgement in the High Court in Australia are examples of sea rights issues.

# Chapter 31 Antarctica



## Web references

[www.classroom.antarctica.gov.au](http://www.classroom.antarctica.gov.au), [www.aad.gov.au](http://www.aad.gov.au), [www.csiro.au](http://www.csiro.au)

Antarctica, a continent nearly twice as large as Australia (36 million square kilometers) and surrounds the South Pole (Figure 353.2). It is one of the harshest environments on Earth. In 1983, Soviet Union researchers recorded a temperature of  $-89.6^{\circ}\text{C}$  — which is cold enough to shatter steel — and wind gusts of up to 300 kilometres per hour. No one ever lived in Antarctica before it was first explored in the last century.

Antarctica currently has no economic activity apart from offshore fishing and tourism, and these are run by other nations (i.e. not the continent of Antarctica). The population varies from fewer than 1,000 in winter to over 50,000 in summer: 5,000 scientists from 27 of the countries party to the Antarctic Treaty, plus tourists.

## About Antarctica

Antarctica contains 70% of the world's fresh water in its ice. If all that ice were to melt, marine scientists have estimated that world sea levels would rise by about 60 metres.

About 500 million years ago, Australia and New Zealand were connected to Antarctica in the super continent **Gondwanaland**. About 85 million years ago, forces in the Earth caused Gondwanaland to break up. As Australia and New Zealand drifted north, Antarctica drifted south, gathering its ice sheets from water in the air.

## Antarctic convergence

The **Antarctic convergence** is a distinct region where the warmer northern waters sink below the cold Antarctic currents (Figure 353.3).

The waters inside the Antarctic convergence are rich in oxygen. This is because the high winds in the region dissolve large amounts of oxygen from the atmosphere and the strong currents mix this oxygen to great depths. Since gases are dissolved more easily at colder temperatures, there is almost twice as much oxygen in Antarctic waters as there is in tropical sea water.



Figure 353.1 Antarctic peninsula off South America in summer



Figure 353.2 Mount Erebus on the Antarctic continent

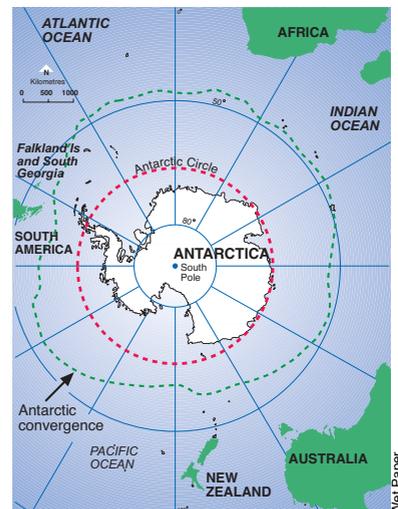


Figure 353.3 Antarctica and convergence

## Diving deeper



1. New Zealand students can check out their home page on: [www.antarcticanz.govt.nz/](http://www.antarcticanz.govt.nz/)
2. Australian students can check out their home page on: [www.antdiv.gov.au/](http://www.antdiv.gov.au/)
3. Use your web sites to find out about:
  - a. how to survive at 50° below zero;
  - b. getting around Antarctica;
  - c. Antarctic stations and their buildings; and
  - d. Antarctica's ice fields.



Figure 354.2 Icebergs about to form from glacier



Figure 354.3 Pack Ice on Ross Ice Shelf



Figure 354.4 Krill



Figure 354.3 Continental glacier

## Ice fields

Two types of ice are found in Antarctica. The ice shown in Figures 354.1 and 354.2 are made of **continental ice** which is composed of fresh water. These ice sheets contain the original mountains of the continent and many glaciers. Because this ice formed over a long period of time, it contains an accurate record of the Earth's climate over millions of years. From time to time the ice breaks off to form icebergs.

The second type of ice is made from sea water and forms the **pack ice** shown in Figure 354.2.

## Marine life



## Phytoplankton

There are over 400 species of phytoplankton in the southern waters. In winter, when the pack ice covers the seas and the sunlight is at a low angle, the numbers of phytoplankton are low. However, as the pack ice breaks up in the summer months, light penetrates these oxygen-rich waters and many of the phytoplankton discussed in Chapter 25 bloom.

## Krill

**Krill** is a general term used to describe about 85% of open-ocean crustaceans. Antarctic krill have large black eyes and almost transparent bodies (Figure 354.4) and are confined to the Antarctic convergence. Like most planktonic animals, krill migrate to the ocean surface at night to feed on phytoplankton. During the day, they sink into deeper waters. Antarctic krill can grow to about 6 centimetres in length and weigh about 1 gram. Researchers have estimated that there are about 500 million tonnes of krill in the Southern Ocean. This is believed to be the largest **biomass** of any one species on our planet.

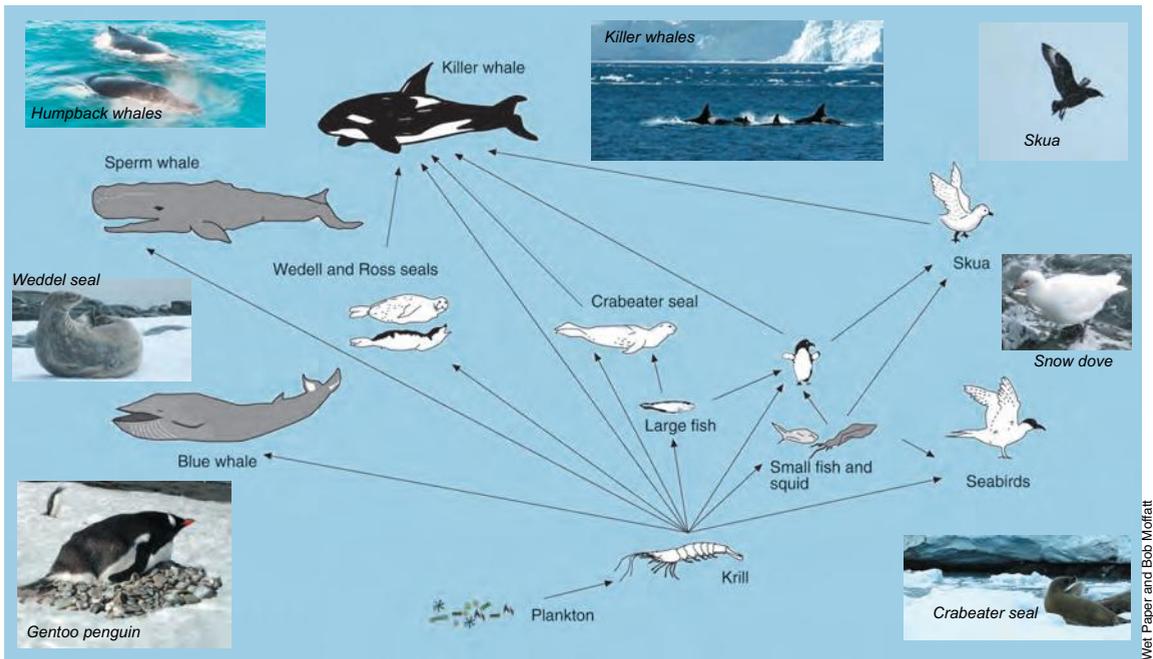


Figure 355.1 Antarctic marine food chain (After Pacific Circle Project 1984)

Compare this to the total amount of fish, shellfish and crustaceans harvested worldwide which is over 100 million tonnes.

### Surviving the winter months

ANARE scientists discovered that whereas many polar animals survive the starvation of the winter months by building up their body bulk and living off their fat reserves, krill can survive without food for up to 200 days by doing the opposite.

The scientists from ANARE have discovered that krill can change back to its juvenile stage by moulting and ‘downsizing’.

Krill survive the Antarctic winters conditions because they reduce their body size and use the discarded protein in their own bodies as food.

As summer approaches, the krill **spawn** many times, producing up to 8 000 eggs per female per spawn over a season lasting 5 months.

### Importance

The Antarctic marine food chain shown in Figure 355.1 is unusual because so many animals depend on this one food resource. Krill are consumed by penguins, seabirds, whales, small and large fish, seals and even killer whales. Without krill, the Antarctic food chain would collapse.

So if krill are to be harvested commercially, a great deal of research must be conducted into the management of the species.



Figure 355.2 Chinstrap penguins



## Questions

Use your textbook to find the answers

1. When did Gondwanaland begin to break up and where did the continents go?
2. What is continental and pack ice composed of?
3. How do icebergs form?
4. What happens when krill downsize?
5. How much more oxygen is dissolved in Antarctic waters compared to tropical waters?



Figure 356.1 An Adélie penguin feeding its chick



Figure 356.2 King penguins



Figure 356.3 Weddell seals hauling out



Figure 356.4 Seal

## Penguins

Penguins are a group of flightless birds that have adapted to living in cold climates. On the land they walk with difficulty but are great underwater swimmers when they tuck their wings and legs in close to their bodies to become streamlined. Penguins can spend up to two years at sea before returning to land. They feed on krill and small fish. Their greatest enemies are killer whales and leopard seals.

### Adélie penguins

The Adélie is a medium-sized penguin that stands about 0.7 metre tall and feeds mainly on krill. Males and females are about the same size and spend their whole life in Antarctica. They breed in spring and summer in rocky areas free from melting snow and make their nests out of small stones. Like other birds, the Adélie penguins feed their young by **regurgitating** food from their stomachs (Figure 356.1). The stomachs of Adélie penguins contain **antibiotics** which sterilise the food while it is stored there which allows the parents to feed the chicks small portions of krill each day. These antibiotics preserve the food for several weeks.

### Emperor penguins

Emperor penguins are migratory birds that build their nests from rocks in a **rookery** with thousands of other birds. After each pair's single egg is laid, the male takes over the incubation while the female leaves the nest to fish at sea. The males then keep the eggs between their legs and on top of their feet for about 70 days until they hatch. The females return to feed the young while the males, having lost considerable weight during the nursing period, struggle to the sea to feed.

An amazing feat of nature is how these penguins find each other after so long and among so many other penguins. Scientists believe that they do this through voice communication in which they call to each other when they complete their journey over the ice and snow.

## Seals

Seals are mammals and are well-adapted to life in Antarctica. They have a sleek coating of hair on a tough layer of skin with numerous oil glands. Under their skin, seals have a thick layer of fat called **blubber** which **insulates** them from the cold.

### Weddell seals

The Weddell seals shown in Figure 356.3 live under the stable inshore ice that surrounds the continent. They are quite large (about 3 metres long) and breathe air through cracks in the ice. This is difficult in winter.

During this time they use their teeth to keep open small holes in the ice and must use their remarkable powers of navigation to find these underwater holes in the darkness of the Antarctic winter.

During the summer months, the seals climb out of their holes in a process called hauling out. While on the ice females also give birth to young seals called pups. Pups grow rapidly and learn to swim, feed and haul-out in their first week. During the breeding season, males **defend** their underwater territory and breathing holes from other males. Scientists that study this seal describe it as a very placid animal that can be approached without it becoming stressed (Figure 357.1).

### Crabeater seals

The Crabeater seal does not eat crabs but krill and has specially adapted teeth with extra projections to strain out the krill after gulping a mouthful of sea water. Marine scientists estimate Crabeater seal populations consume over 100 million tonnes of krill a year, possibly making them the world's largest consumer of this food source (See Figure 357.1 food chain).

### Elephant seals

Elephant seals are named for the trunk-like projection over their mouths (Figure 357.3). They have a thick layer of blubber and for many years they were hunted and their carcasses boiled down to make oil. Elephant seals can dive to depths of more than 1500 metres and can stay submerged for up to 2 hours while they hunt for squid and fish.

Elephant seals breed in groups called **harems** in which a single dominant male can control up to 50 females. In groups larger than this, other males are allowed into the group. ANARE scientists have estimated that harems can grow to include 1000 females and more than 30 males.



Figure 357.3 Elephant seal and penguin colony



Figure 357.1 Weddell seal and pup



Figure 357.2 Gentoo courtship



6. What is the name of the zone around Antarctica where the warm tropical waters sink?
7. What are *krill*?
8. Name nine animals that feed directly off *krill*.
9. How do penguins swim underwater?
10. How big is an Adélie penguin?
11. What is so special about the stomach of an Adélie penguin?
12. Which parent incubates the emperor penguin's eggs?
13. Which seals are the world's greatest consumer of krill?
14. How do Weddell seals keep their breathing holes open in winter?
15. What is the term given to the behaviour when a seal crawls out of its hole?
16. Why were Elephant seals killed in the first half of the 20th century?

## Diving deeper



4. Use your web browser to find a picture and write a paragraph about any two of the following

Crustaceans - krill

Penguins - adélie, chinstrap, emperor, gentoo, king, rockhopper, royal

Flying seabirds - grey-headed albatross, short-tailed shearwater, antarctic tern, blue-eyed cormorant, southern fulmar

Seals - crabeater, elephant, fur, leopard, weddell

Whales - blue, humpback, minke, orca, sei

5. Locate the following web site, print the data out and then draw a graph of the distances from Hobart and Christchurch to the bases in Antarctica:

[www.antdiv.gov.au/misc/antmap\\_km.html](http://www.antdiv.gov.au/misc/antmap_km.html)

6. Discuss how to get to Antarctica from South America. Include
- How to get to Ushuaia (Tierra del Fuego) from Australia.
  - What it would be like crossing the Drake Passage
  - The types of activities and costs
  - Conservation measures set up by travel companies.
  - How many tourists go each year.



Mr and Mrs Wen Popper

## Whales

The whales of the Southern Ocean are migratory and spend the warmer months off the coasts of Australia and New Zealand where they breed and raise their young.

Whales spend about 4 months in Antarctic waters where they feast on tonnes of krill, consuming 4 to 5 times their body weight before beginning migration. During migration they hardly feed but spend a large amount of their time bonding with their close social organisation. Scientists from around the world study whale songs to see if it will help people understand this social structure.

## The benthos

Under the Southern Ocean lies the Antarctic benthos which is fed by a rich supply of nutrients enriched with large amounts of oxygen. During summer, when the days are longer and the light intensity is greater, the nutrients increase, promoting rich growths of algae and seaweed.

Living in these underwater jungles are many of the animals we discussed in Chapter 26: sea anemones, worms, crustaceans, molluscs and even corals.

## The significance of Antarctica

Management of the Antarctic is organised through the legal framework of the Antarctic Treaty of 1959. Forty-three nations are now party to this agreement, and seven of those - UK, Norway, Chile, France, Australia, Argentina and New Zealand - have historic claims on parts of the continent as national territory.

## Ozone hole

Ozone is a gas which forms a layer in the upper atmosphere which stops ultraviolet radiation from reaching the Earth's surface. Without it, we would all have to walk around in space suits. Studies in the 1970s in Antarctica showed that each spring this protective layer was thinning. It was called the **ozone hole**. The destruction is caused by a gas in aerosol propellants and refrigerator coolants called chlorofluorocarbons (CFCs).

It is therefore very important for people living in our southern cities and towns to wear 15+ sunscreen in spring and summer to minimise the effects of harmful radiation.

World governments are moving to ban the use of aerosols that contain CFCs so industry is having to change its manufacturing policies. We would not have known about this if it were not for the work of Antarctica's scientists.

# Tourism

Tourism in the Antarctic is mainly by ship and depart mainly from the Southern tip of South America. The ships are ice strengthened and sail primarily to the Antarctic Peninsula region sometimes also including South Georgia and the Falkland Islands. A few ships depart from Australia and New Zealand but take a lot longer to get to the southern continent..

Antarctic visits are mainly concentrated at ice-free coastal zones over the Antarctic summer, the five-month period from November to March, in high summer there will be 20+ hours of daylight.

The formation and movement of sea-ice outside of these times means that from March to November, Antarctica is left to the over-wintering scientific bases and their crews.

As a rule in November and December there is more ice to see and fewer animals but as summer comes on, chicks start to hatch, seal pups are born and small plants flower. By late March the receding ice pack allows ships to explore further south.

Antarctic cruises aren't like other more well known cruises to warmer climates with discos, and showbiz entertainment. What you find are a number of very well informed and experienced cruise guides working on the ship who will give lectures on a regular basis about various aspects of Antarctic history and natural history.

There are rules laid down by the International Association of Antarctic Tour Operators (IAATO) covering such things as the size of cruise ship allowed to enter Antarctic waters and covering conduct at landing sites in Antarctica.

One of the main rules that will impact on your visit is that only 100 passengers at any one time may be landed in any one place in Antarctica.

There is also the one metre rule where you do not approach any animal closer than few metres. Another important rule is not to walk into penguin walkways (Figure 359.3). As the majority of penguins are no more than half a metre, a human footprint hole can be a death trap for any penguin falling in.

Tourists who travel from South America get to sail past Cape Horn and experience the Drake Passage in its varied moods. Those who are lucky experience the "Drake Lake", others pay the "Drake Tax" and experience the "Drake Shake". You might like to look at some U tube videos of Drake Passage storms and decide if you want to go.



Figure 359.1 Converted ice breaker



Figure 359.2 Sea kayaking is one tourist activity



Figure 359.3 Penguin walkways



Figure 359.4 The Drake shake



Figure 359.5 Tourists at Cape Horn



Bob Moffatt

Figure 360.1 Iceberg and tourists in rubber ducks

## Diving deeper



7. Figure 360.2 shows a group of penguins huddled together in a katabatic wind. Find out how these winds are formed and how dangerous they are.
8. What are *nunatacks* and *ablations*?
9. Who was Douglas Mawson and why is he famous?
10. Read the book, *The Fire in the Snow*.
11. Arrange a visit to your local Antarctic centre in New Zealand or the Australian Antarctic Division in Tasmania.
12. What role has Greenpeace played in Antarctica?



Nick Mooney

Figure 360.1 Adélie penguins in a katabatic wind

## Key words

ANARE, Antarctic convergence, antibiotics, biomass, blubber, continental ice, defend, extinction, Gondwanaland, harems, icebergs, insulates, krill, ozone hole, pack ice, regurgitating, rookery, spawn.

## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. About 85 million years ago, forces in the Earth caused [1] \_\_\_ to break up. As Australia and New Zealand drifted north, Antarctica drifted south, gaining its [2] \_\_\_ from water in the air.
- b. Because this ice formed over a long period of time, it contains an accurate record of the Earth's [3] \_\_\_ over millions of years.
- c. [4] \_\_\_ can form from glaciers which break off from the mainland.
- d. Researchers from ANARE [5] (\_\_\_ \_\_\_ \_\_\_ \_\_\_) have estimated that there are about 500 million tonnes of krill in the Southern Ocean.
- e. Krill survive the in [6] \_\_\_ conditions because when they reduce their body size, they use the [7] \_\_\_ in their own bodies as food.
- f. Like other birds, the Adélie penguins feed their young by [8] \_\_\_ food from their stomachs.
- g. Under their skins, seals have a thick layer of fat called [9] \_\_\_ which [10] \_\_\_ them from the cold.
- h. Marine scientists estimate [11] \_\_\_ populations consume over 100 million t of krill a year, possibly making them the world's largest [12] \_\_\_.
- i. Elephant seals breed in groups called [13] \_\_\_ where a single dominant male can control up to 50 females.

# Chapter 32 Shipwrecks

Warning. This chapter contains the images of Aboriginal and Islander people now deceased.



Wet Paper



internet.org



WA Museum

## Web references

[www.abc.net.au](http://www.abc.net.au), [www.environment.gov.au/heritage/shipwrecks](http://www.environment.gov.au/heritage/shipwrecks), [www.nla.gov.au](http://www.nla.gov.au), [www.cultureandrecreation.gov.au](http://www.cultureandrecreation.gov.au), [www.maryrose.org](http://www.maryrose.org), [www.heritage.nsw.gov.au](http://www.heritage.nsw.gov.au), [www.findingsydney.com](http://www.findingsydney.com), [www.museum.wa.gov.au](http://www.museum.wa.gov.au)

For thousands of years, the oceans of the world have been the pathway to new lands. The courage of early navigators and explorers has been recognised by all nations (Figure 361.1). Early expeditions set out into unknown waters in primitive craft that were not very seaworthy and a great many voyagers ended their lives on the seabed.

A **shipwreck** is a ship that has sunk to the bottom of the sea or run aground so that it cannot move off where it has become stuck (Figures 361.2). Over one million shipwrecks lie beneath the sea around the world. Some of these ships carried priceless treasures and many can be salvaged.

A shipwreck can be like a time capsule, often preserving a snapshot of everyday life at the time the ship went down. This chapter looks at many of the shipwrecks around Australia's coast, and the part that maritime archaeology is playing in recovering these wrecks and what they can teach us about how people lived in the past.

In 1446, two ancient roman galleys were discovered in Lake Nemi 27 kilometres from Rome. Local divers originally found the wrecks, but the discovery was not confirmed until the 1920s by conventional diving methods. In 1942, Mussolini ordered water to be pumped from the lake to reveal these two objects from antiquity. The galleons had belonged to the Emperor Caligula 1700 years before. Unfortunately, the wrecks were deliberately destroyed at the end of the Second World War.



Vasco da Gama  
Magellan  
Columbus

Bob Morlat

Figure 361.1 Monument to famous explorers of Portugal and Genoa



Wet Paper

Figure 361.2 The wreck of the *Cheyne* 4, Albany, WA



Geoff Jensen

Figure 361.3 Galley reconstruction

## The importance of shipwrecks

In the 18th and 19th centuries, up to 30% of passengers and crew died on the long voyage from Europe to our country. The study of shipwrecks around our coast gives European settlers a chance to learn about their past and provides real links with our heritage.



Figure 362.1 Reconstruction of an ancient barge



Figure 362.2 Aboriginal canoe,  
Source - from Sydney Museum

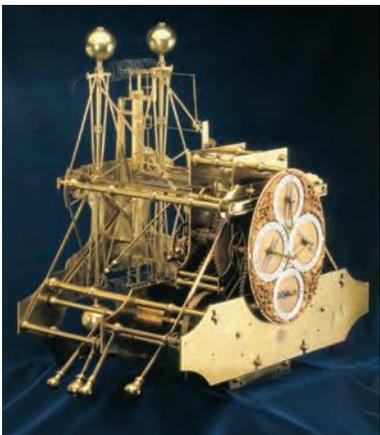


Figure 362.3 The invention of Harrison's maritime clock enabled navigators to determine how far west they had sailed on the way to Australia.

## Early maritime visitors

Records of pre-European settlement are hard to find because very little information was written down. The history of Aboriginal and Torres Strait Islanders was recorded in song and story, passed down from tribal elders and much of this history is now lost. By comparison, in New Zealand the history of Maori settlement is well recorded and many Maoris today can trace their history back to early times. Some scientists believe that Aboriginal people migrated to Australia many thousands of years ago when Australia was part of a giant land mass connecting with what is now Papua New Guinea. Parts of that land bridge from Asia may have been underwater (Figure 363.2), yet people in small canoes could have migrated from Indonesia (Figure 363.1). We cannot precisely date when these people arrived on our shores although reconstructions of their canoes give some idea of the types of craft they could have used. Maritime archaeologists may one day discover, frozen in time, some of these craft used in that epic migration.

## Visits by Europeans and others

Apart from Aboriginal people, Europeans also visited Australia prior to British settlement, including English, Dutch, French and Portuguese mariners. Even the Spanish visited this part of the world when de Quiros and de Torres (1605–1606) sailed between the island of New Guinea and northern Australia.

There is some speculation that people from Asia visited our shores long before the Europeans. In November 1995, a Western Australian map dealer found that an antique world map he had in his possession showed an accurate outline of the West Australian coast. The map, dated 1581, was drawn by German cartographer Heinrich Buntin some 35 years before the first known European map of the area.

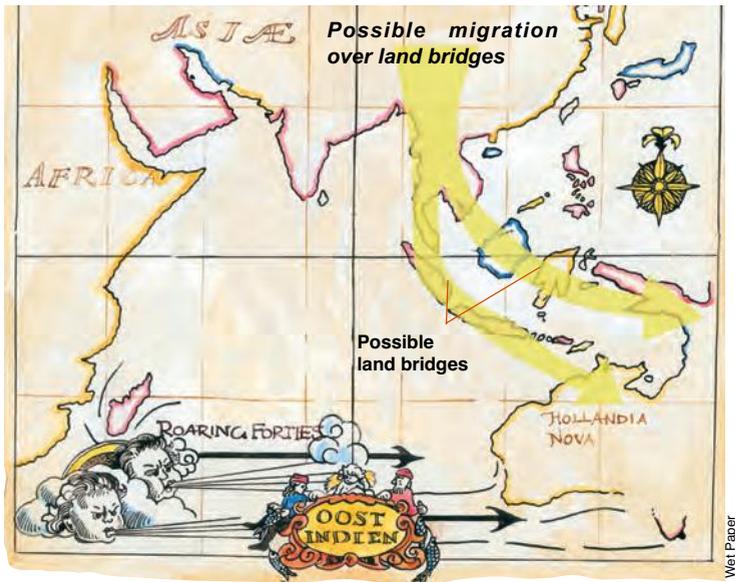


Figure 363.2 Possible land bridges and migration routes

This map may have been drawn using information from Arab sources dating from before the Crusades. Chinese explorers are known to have visited the Persian Gulf in the 1300s because Marco Polo described them. A great Chinese mariner, Admiral Cheng Ho, made many journeys to south-east Asia, India, and the east coast of Africa between 1404 and 1433. Chinese traders may even have visited New Guinea and Australia to trade iron implements for pearl shell, shark fin and slaves. Finding evidence of non-European wrecks is difficult, however maritime archaeologists are continually seeking new ways to search.

### Australia's treacherous coastline

Australia has over 30 000 kilometres of coastline dotted with outlying reefs and islands. Because of these hazards, our shores are littered with hundreds of shipwrecks dating from the early 1600s up to the present day. For over 200 years, the winds known as the roaring forties, as shown in Figure 363.2, filled the sails of European ships that sailed east round the bottom of Africa towards the East Indies and the Spice Islands, now Indonesia. These ships often carried rich cargoes of trading goods or coins. They were specially built to sail this route and were known as 'Indian' built.

Because their skippers were unable to estimate **longitude**, they were often blown far to the south of their intended route to be wrecked on the coast of Western Australia. The wrecks of many of these unfortunate ships have now been found, some by accident, some after much research, but many are still awaiting discovery. These finds represent part of our national heritage.



Figure 363.1 Aboriginal raft  
(Courtesy WA Maritime Museum)

### Diving deeper



1. Research your library and gather information about:
  - a. vessels used by primitive cultures
  - b. Portuguese maritime exploration
  - c. Dutch exploration
  - d. the English navigators
  - e. Spanish navigators
2. Collect information about a shipwreck.
  - Describe how it is like a time capsule. Give specific examples of how it represents people at that time.
  - Use diagrams and pictures to illustrate your answer.
3. Collect information about the laws protecting Australian, New Zealand and overseas shipwrecks.
  - Conduct a debate on possible advantages and disadvantages of this.
4. Over 20 per cent of the gold that has ever been mined now lies beneath the sea as sunken treasure. Use your library to find out about shipwrecks that contain gold treasures.
5. Find out when Harrison's Clock was invented.



Pat Baker (W.A. Museum)

Figure 364.1 Bell from the *Robertina* which sank in 1859



Australian War Memorial

Figure 364.2 HMAS *Sydney* before it sank in November 1941

## How shipwrecks are lost

Occasionally divers come across shipwrecks by accident. More often, they may swim over shipwrecks without even knowing that such a time capsule from the past exists.

Many divers expect to see the hull of the ship intact with sails and rigging, but in reality the hulls of ships break up very quickly, leaving little evidence that a shipwreck existed.

**Perishable** materials such as food degenerate completely and, with seabed movement, materials can be covered rapidly on the site and within a few years there may be little evidence of a wreck site at all. **Mechanical forces** such as wind, waves and currents take loose objects away from the wreck site. Heavy objects such as cannons, waterlogged timber or metal structures sink to the bottom whereas light, free structures such as doors, sails or bottles may float free. Apart from the mechanical forces of nature, chemical and biological factors will degrade a shipwreck.

Eventually the site may be completely covered by sand, coral and other marine growth making the remains of the shipwreck invisible to the untrained eye. How shipwrecks are found is discussed at the end of this chapter in the section on maritime archaeology. Figure 367.1 shows the stages of a shipwreck.

## Australian shipwreck discoveries

Web reference  
[www.findingsydney.com](http://www.findingsydney.com)

### Western Australian shipwrecks

The HMAS *Sydney* and the German raider *Kormoran* which sank in November 1941 World War II, were found about 100 nautical miles off Shark Bay, which is about 800km north of Perth at a depth of some 2470 metres. The *Sydney*'s entire crew of 645 went down with the ship in the Indian Ocean and its location had been a mystery for 66 years.

The *Robertina*, which sank in 1859, was found by accident in November 1986 and its bronze bell (Figure 364.1) in January 1988. The names of some shipwrecks may not be easy to uncover but finding the ship's bell quickly identified this wreck.

In 1978 while spear fishing off Point Cloates in north-west Western Australia, a group of divers discovered the shipwreck of the *Rapid 1811* (Figure 369.3). No records existed on this ship in Australia. Apart from a name on the keelson, a whisky jug with 'Boston' written on it and some American coins, little was known about the wreck even though over 20 000 Spanish dollars were retrieved from it in around 6 metres of water. However, when the Curator of Marine Archaeology in Perth went to Boston, USA, he found the full story about the shipwreck in local archives.

## Diving deeper



6. The *Batavia* and *Pandora* are two examples of how a maritime museum has preserved maritime history.
  - Research the story of the *Batavia* or the *Pandora* in your local museum.
  - Write an essay about the events surrounding these wrecks.
7. Contact your local museum for information about a well-documented wreck and produce an information poster on it.

For other investigators in the field, many hours of research have been spent in libraries and state archives, looking for information about where ships came to grief off our coast.

Research was responsible for finding one of the most famous of Western Australia's shipwrecks — the *Batavia*. Author Henrietta Drake-Brockman (1901–68) spent a lot of time researching the *Batavia* wrecked in 1629 off Geraldton, Western Australia. When the shipwreck was discovered by locals it lay exactly where Drake-Brockman predicted. Figure 365.1 shows a Dutch reconstruction of the ship.

The *Batavia* was on her way from the Netherlands to Batavia in the Dutch East Indies with a cargo that included 12 chests of silver coins and jewels. The ship was wrecked in a fierce storm, but most of the crew and passengers reached the nearby Houtman Abrolhos islands. The ship's captain took the only boat left and sailed for Batavia (now Jakarta), to get help.

While he was away, rebellious crew members murdered 125 other crew members and passengers and planned to capture the relief ship. A further 40 people drowned attempting to reach the shore and 20 died from illness and disease.

A rescue ship arrived 65 days after the vessel was sunk. Most of the murderers were hung and of the 316 people who set out on the voyage only 74 reached their destination.

### An important find in Queensland

In 1791, while transporting the *Bounty* mutineers back to British justice, the *Pandora* was wrecked on the Great Barrier Reef.

Two private vessels and the RAAF, using magnetometers (see the information on search techniques later in this chapter), located the wreck of the *Pandora* in November 1977 (Figures 365.3 and 365.4).



Figures 365.1 A reconstruction of the *Batavia*



Figures 365.2 Diving on *Batavia*



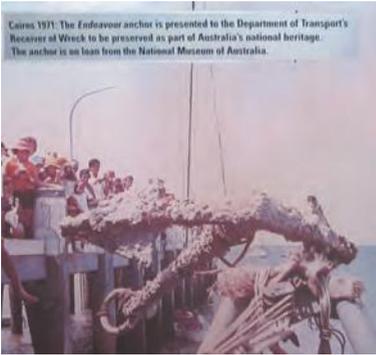
Figures 365.3 The *Pandora* just before she was wrecked



Figure 365.4 *Pandora*'s anchor and divers working on the bottom



Figure 365.5 Ship surgeons watch from the *Pandora*



From a photo taken at the Cooktown Museum

Figure 366.1 Raising Cooks anchor from the *Endeavour*

The Federal Government quickly passed legislation to protect shipwrecks found off the Queensland coast.

**Maritime archaeologists** working on the wreck found some **artifacts** such as a crude syringe and medical bowl. These were thought to belong to the ship's surgeon, George Hamilton. Close to where these objects were found, they recovered Hamilton's silver watch, complete with its intricate parts (Figure 365.5). The watchmaker's name on the case could even be traced back to an English jeweller that is still in business. The watch, now in Townsville, is a priceless relic. Another priceless relic is Cooks Anchor from the *Endeavour* which is housed in James Cook Museum in Cooktown.

### Tasmania's oldest shipwreck

In 1977, the makers of a film about Tasmania's shipwrecks discovered the wreck of the *Sydney Cove* lost in 1798 off the north of the island. A total of 450 artifacts have been raised from this site which give an interesting insight on 18th century life. This is Tasmania's oldest shipwreck and the earliest known 'Indian' built ship to be found off Australia.

### A shallow water discovery in South Australia

In 1981, South Australian members of the Society for Underwater Historical Research located archives to trace the *Tigress* which sank in 1848. The wreck was found lying in only 2 metres of water where it could easily have been looted and its heritage value destroyed. The South Australian Government passed a law to protect it.

### Sunken heritage off New South Wales

The *Sirius* was wrecked in 1790 off Norfolk Island, a notoriously harsh penal colony. This ship was part of the First Fleet which sailed to Australia under Captain Arthur Phillip, governor of the colony of New South Wales (1788–92). While unloading in stormy winds, the ship was thrown onto a reef by heavy surf. Anchors could not hold the ship and she became a total wreck. The *Sirius* is now a designated archaeological site.

An historic shipwreck near Sydney that has been an exciting destination for many divers is the wrecked *Dunbar*. The *Dunbar*, a clipper of 1321 tons, was wrecked in 1857 at the base of cliffs at South Head. Over the years, some beautiful artifacts have been recovered from the site.

### Victoria's mahogany ship

On the south coasts of Victoria an unidentified vessel known as the 'Mahogany Ship' was discovered near the beach of Warnambool. The date and name of the vessel still remain unknown, but the timbers were originally thought to be of mahogany.



1. Why did Australia have so many shipwrecks?
2. Define the term 'maritime archaeology'.
3. Discuss the statement 'shipwrecks are like time capsules'. Use a class group discussion to get ideas.
4. How is the development of diving techniques linked to an increase in the number of shipwrecks discovered?
5. Where could the Aboriginal people have migrated from?
6. Who was the great Chinese mariner who made many journeys to south-east Asia?
7. How were the roman galleons recovered from Lake Nemi?
8. Why are perishable materials not found on shipwrecks?
9. List two mechanical forces that would move objects from a wreck site.
10. How was the wreck of the *Batavia* discovered?
11. How was the *Pandora* discovered?
12. Give examples of two artifacts found on board the *Pandora* and explain their significance.



Figure 367.1 Gerlton museum display of *Sydney (11)* search techniques

The remains of the vessel were first found by two shipwrecked sailors in 1836. The timbers were reported to have had a mahogany appearance. Further speculation said that the wreck may have been a ship from Portugal which, if proven correct, would rewrite Australian history books.

## Maritime archaeology

Maritime archaeology is the study of shipwrecks and their cargo, providing an insight into life at sea in the past. Maritime archaeology is not salvage, treasure hunting or souvenir hunting. Shipwrecks contain important information about how people lived and worked in the past. They have been called 'museums beneath the sea'. Each shipwreck, in its own way, has frozen the history of the way people lived at that time.

### Search techniques

In 2008 the research ship *Geosounder* located two ships the German raider *HSK Kormoran* and *HMAS Sydney (II)* using sonar technology at a depth of about 2,500 metres in the Indian Ocean 200 km West of Steep Point (Figures 367.1 and 367.2). These are sonars which are towed in a sled behind the ship and obviously at a great tow length because of the depth of the water. The team lead by David Mearns, found the Sydney with high-resolution sonar. The ship was found near the wreck of *HSK Kormoran* and represented one of the most remarkable undersea search efforts of all time.

### Diving techniques

Where the water is shallow where most shipwrecks happen and visibility is good, snorkelling can be the best search method:

- snorkellers can cover areas quicker;
- they are not bound by decompression constraints; and
- they are not limited by available air supply.

For high-resolution sonar images of HMAS Sydney as well as underwater photographs on the discovery go to [www.findingsydney.com](http://www.findingsydney.com)

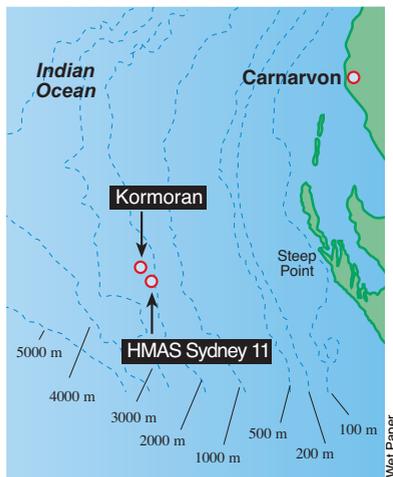


Figure 367.2 HMAS *Sydney (11)* location

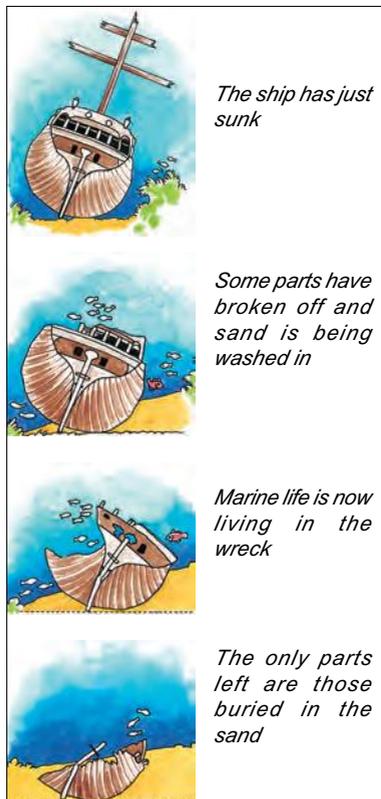


Figure 367.3 Stages of a shipwreck  
Rose Bedford

## Diving deeper



8. Collect information about an important historical find. Provide information about how the item or items were recovered, stored, transported and eventually treated. How did the object or objects reflect part of our heritage?
9. If wreck sites were allowed to be plundered, what effect would this have on our national heritage?
10. If your school or college has work experience opportunities, ask for a placement in a maritime museum.
11. Join a dive club or association that is involved with wreck sites.
12. Research life as a convict on a transportation ship.



### Web reference

[www.cultureandrecreation.gov.au](http://www.cultureandrecreation.gov.au)



Figure 368.1 Steel cannon being lifted by giant air balloon from a 17th century wreck off the West Australian coast

Where ships have foundered or sunk in deep water after hitting a shallow reef, scuba diving or other forms of diving using compressed air may be needed.

Figure 368.1 shows how heavy objects can be raised to the surface. Other recovery techniques involve the use of suction pumps as shown in Figure 369.3 where a pump on the surface is used to create a vacuum that can gently suck up artifacts from a shipwreck. Great care and exact dive planning is necessary in such cases to prevent diving accidents.

For deep diving, only bathyspheres, robots or their derivatives can be used. (For more information on diving technology, read Chapter 8 on Snorkelling).

Never before have humans had the potential to dive deeper and discover more. We also have the potential to destroy our maritime heritage through greed and stupidity.

## Sophisticated search methods

1. Water and depth-proof video cameras can be housed in stainless steel casings. They are towed behind the search craft, sending and/or recording pictures of the seabed.
2. Aerial photographs, generally using some kind of grid photos of the search area, are systematically taken from the air.
3. Bathyspheres are underwater vehicles which explore the ocean floor. They are built to withstand incredible pressure. No longer are shipwrecks in deep water beyond our reach.
4. Deep-sea diving suits can take divers to the seabed without causing decompression problems.
5. Robots which are controlled from the surface can do the things that a diver could not do without depth problems.

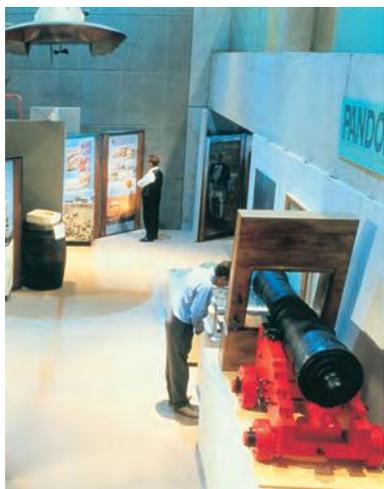


Figure 368.2 Maritime museum display

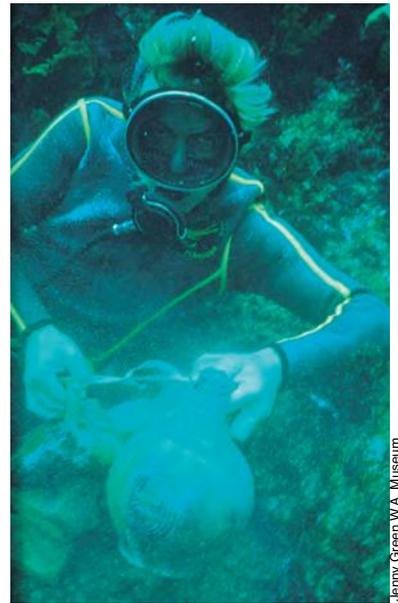
6. Towed waterproof metal detectors work exactly like the metal detectors used on land except that they are constructed specifically to work underwater.
7. Magnetometers can either be mounted on the stern of a search ship or towed behind. They measure the intensity of the Earth's magnetic field on which ferrous (metal) objects are recorded. The strength of the signal will vary with the size of the object and the distance of the magnetometer from the object. In November 1978, Burt Webber on board the *Sea Quest* located the Spanish galleon *Conception* off the Dominican coast of South America using a magnetometer. This shipwreck was estimated to have been carrying \$40 million in silver and gold.
8. Sonar equipment is very much like radar. It enables a plan of the seabed to be relayed to the surface vessel.
9. Submersibles are basically manned mini-submarines.

### Historic Shipwreck Act 1976

A wreck that is declared an historic shipwreck under the Act is granted legal protection. This means the wreck itself, any human remains, and its relics are protected from damage, disturbance or removal. For example the wreck of the HMAS *Sydney* and the 645 crew found in 2008 are fully protected for all time.

In addition, to further protect the site the Act allows the Minister to declare a protected zone of up to 200 hectares. It is an offence to engage in any underwater activity within the protected zone.

The penalty for breaching the Act is a fine of many tens of thousands of dollars or imprisonment for a period of up to five years.



Jenny Green (W.A. Museum)

Figure 369.1 Jug found miraculously intact in 17th century shipwreck



Graham Anderton

Figure 369.2 Untreated cannon showing deterioration in metal



Pat Baker (W.A. Museum)

Figure 369.3 Using a suction pump to investigate the shipwreck of the *Rapid 1811*



13. Where do some people think Victoria's Mahogany Ship came from?
14. List nine search methods that have only been developed in the 20th century.
15. Discuss how ferrous objects are preserved.
16. How are copper and its alloys conserved?
17. Where is conservation work done and what do conservers seek to do with artifacts from shipwrecks?
18. What happens to wood when under the sea for a long period of time and what must be done if the timbers are to be displayed in a museum?



Figure 370.1 Check out the national library of Australia digital web pages



Figure 370.2 Remarkable find of a perfectly intact bottle from the *Pandora*

## Preserving the past

Conservation is the science of preserving the past. It relies on experts working with a variety of materials including textiles, ceramics, metals and organic compounds, for example timber, leather, rope, ivory, glass, bone and clay (Figure 371.2).

Conservation work is often done in a laboratory to restore items gathered from wrecks or other sites to a state close to the condition they were in when they were lost. Conservators seek to reverse the processes of breakdown and degradation. This may involve many, many years of treatment.

The difficulty that conservators have is that items found underwater may have stayed in a stable condition for hundreds of years but removing them from the water triggers physical and chemical changes. Delicate organic items will deteriorate rapidly in normal atmospheric conditions.

### Ferrous objects

Once ferrous or iron objects like iron cannons have been removed from the sea they must be treated for many years to reduce electrolytes which cause corrosion. Leaving the smallest residue of oxides or chlorides from salt water could start corrosive processes spreading through the entire object.

The best way to preserve ferrous objects is in electrolysed tanks of sodium hydroxide. The voltage and direct current should be adjusted so that hydrogen evolves at the metallic surface of the artefact.

This allows for a gradual restoration of the metal. Tank treatments can take many months to many years.



Figure 370.3 Silver coins from the *Batavia*



Wet Paper Photograph taken at W.A. museum

Figure 371.1 Clay pipes from a shipwreck

Initially ferrous objects should be stored in the water they came from or in fresh water. Leaving them in the open air with a damp surface will speed up oxidation (rusting).

### Copper and copper alloys

If copper artifacts are recovered in good condition, they can generally be stored for short periods of time in a dry atmosphere. Smaller items can be stored in dry air-tight containers. Some items like cast brass and bronze objects need to be handled carefully because they may have soft and weakened surfaces.

### Lead and lead alloys

Objects made from lead and its derivatives are found on many historic maritime sites. Lead is relatively easy to identify because of its heavy weight in proportion to size.

Pure lead has a relatively resistant and inert structure. In most cases, lead, pewter (a combination of lead and tin) and other lead alloys recovered from wrecks simply need to be washed and stored dry until they reach the conservation laboratory.

### Silver and gold

Precious metals like silver and gold, often considered the delight of the treasure hunter, are easy to treat when recovered once corrosive substances such as salts are removed.

### Wood

Wood, of which most 18th and 19th century ships were built, becomes waterlogged when immersed in the sea. This means its natural resins are replaced by the water it has been immersed in.

When exposed to the atmosphere, the timbers may look the same yet can **disintegrate** into dust when dried.

## Diving deeper



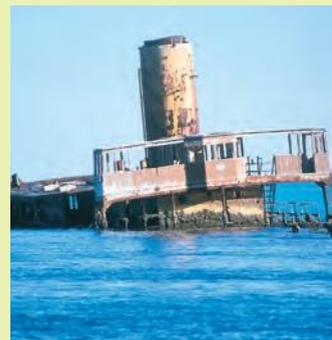
- Imagine you are shipwrecked on an uninhabited island.

There is an abundance of fish and bird life, but the vegetation is low lying scrub. Draw up a plan for how you would survive and how you could prepare for your rescue.

- Make up your own time capsule of how people are living today.

Collect newspaper stories or any other relevant material that could go into the capsule. Large bore PVC piping could be used to house the material.

- Make up your own sailing ship, the SS *Mishap*. Use what ever materials you can scrounge: icy pole sticks, etc. then wreck the boat and see what happens to its structure, etc.
- Research the role trade unions played in the development of ports.
- Research current legislation on shipwrecks and national heritage listing.



BOB Merfitt

Figure 371.2 Shipwreck close to land



Graham Anderson

Figure 372.1 Treated timbers of the *Batavia*



Graham Anderson

Figure 372.2 Reconstructed model

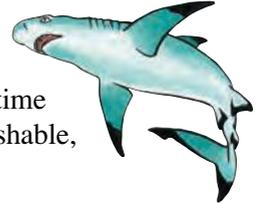
The timbers must therefore be treated carefully before being displayed in a museum.

### Other organic substances

These include skin, leather, bone, ivory, horn, textiles and related materials (rope and matting). Without exception, all these materials must be prevented from drying out and should be initially stored in the water from which the object was recovered.

## Key words

Artifacts, disintegrate, longitude, maritime archaeologists, mechanical forces, perishable, shipwreck.



## Summary questions

Fill in the gaps in these sentences. The missing words can be found in this chapter.

- a. A [1] \_\_\_ is a ship that has sunk to the bottom of the sea or run [2] \_\_\_ so that it cannot move off where it has become stuck.
- b. The study of shipwrecks around our coast gives [3] \_\_\_ settlers a chance to learn about their past and provides real links with our [4] \_\_\_ .
- c. Because their skippers were unable to estimate [5] \_\_\_ , they were often blown far to the south of their intended route to be wrecked on the coast of [6] \_\_\_ .
- d. [7] \_\_\_ materials such as food, degenerate completely and, with seabed movement, materials can be covered rapidly on the site and within a few years there may be little [8] \_\_\_ of a wreck site at all.
- e. [9] \_\_\_ forces such as wind, waves and currents take loose objects away from the wreck site. [10] \_\_\_ objects such as cannons, waterlogged timber or metal structures sink to the bottom whereas [11] \_\_\_ , free structures such as doors, sails or bottles may float free.
- f. Apart from the mechanical forces of nature, [12] \_\_\_ and [13] \_\_\_ factors will degrade a shipwreck.
- g. With the development of [14] \_\_\_ -air diving in the 1950s, many shipwrecks were discovered and exploited.
- h. [15] \_\_\_ is the science of preserving the past. It relies on [16] \_\_\_ working with a variety of materials including textiles, ceramics, metals and organic compounds.

## Diving deeper



18. Collect information about the development of diving technology. How is it related to maritime archaeology and salvage? Explain.
19. Why is it important to preserve shipwrecks around our coast and prevent looting?
20. What other shipwreck sites exist in your home state? Give details of why you think these areas could contain material from past days that could be important.
21. Research the restoration methods used to raise the *Mary Rose*  
[www.maryrose.org](http://www.maryrose.org)

# Appendices

## New South Wales syllabus match

### Marine and Aquaculture Technology CEC Years 7-10

For information about this syllabus and its use go to their web site

[www.boardofstudies.nsw.edu.au](http://www.boardofstudies.nsw.edu.au)

The chapter matches for these modules are outlined below.

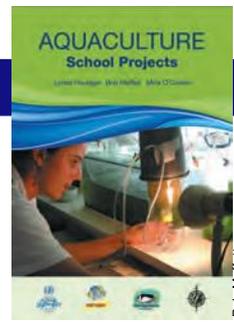
No	Module name	Chapter	Title
Core	Marine and aquaculture technology	00	Introduction
Core	Water safety	01	Water safety
Core	First aid	02	First aid
Core	Maintaining equipment used in water	04	Maintaining equipment
Core	The marine environment	05	Living in the sea
Core	Management and employment	00, 17, 30	Introduction, Marine employment, Saving the sea
1	Water birds of NSW	27	Marine vertebrates
2	Mangroves	21	Estuaries and marine life
3	Microscopic aquatic organisms	25	Small sea creatures
4	Aquatic plants	21	Estuaries and marine life
5	Marine mammals	27	Marine vertebrates
6	Dangerous marine creatures	03	Dangerous creatures
7	The oceans	18, 19	Weather, Oceans
8	Rock platforms	20, 23, 26	Coastlines and marine life, Waves, Animals without backbones
9	Introducing estuaries	21	Estuaries and marine life
10	Living together in the sea	5	Living in the sea
11	Marine pests and threats	28	Trashing the sea
12	Temperate marine ecosystems	6	Sea water
13	Antarctica's marine ecology	31	Antarctica
14	The abyss	5	Living in the sea
15	Watercraft design, construction and repair	7, 10	Boating, Making a surfboard
16	Basic snorkelling	8	Snorkelling
17	Open water snorkelling	8	Snorkelling
18	Fish harvesting	9	Fishing
19	Manufacturing fishing equipment	9	Fishing
20	Boat building	7	Boating
21	Sailing theory and practice	7	Boating
22	Aquarium design, construction and maint	11	Aquariums
23	Underwater farming	12	Underwater farming
24	Designing systems for aquaculture	14	Aquaculture farm designs
25	Economics of aquaculture	14	Aquaculture farm designs
26	Growing stock feed for aquaculture	12, 14	Underwater farming, Aquaculture farm design
27	Biology of native crayfish	13	Crayfish
28	Growing crustaceans	13	Crayfish
29	Fish biology	27	Marine vertebrates
30	Managing fish production	12, 14	Underwater farming, Aquaculture farm design
31	Managing water quality in aquaculture	6, 29	Sea water, Sea water quality
32	Pests and diseases in aquatic organisms	14	Aquaculture farm design
33	Small motorboats	07	Boating
34	Advanced motor-boating	07	Boating
35	Tourism	16	Marine industries
36	Food from the sea	15	Food from the sea
37	Local fishing industries	16	Marine industries
38	Industries and employment	16, 17	Marine industries, Marine employment
39	Coastal management	30	Saving the sea
40	Tides and currents	24	Tides and currents
41	Marine and civil engineering	22	Coastal engineering
42	Saving water environments	28, 29, 30	Trashing the sea, Sea water quality, Saving the sea
43	Recreational and community groups	00, 30	Introduction, Saving the sea
44	Shipwrecks and salvage	32	Shipwrecks
45	Basic navigation	07	Boating
46	Marine disasters	28, 32	Trashing the sea, Shipwrecks

## Aquaculture project ideas

In 2011 the Marine Teachers Associations of New South Wales and Queensland got together with Wet Paper and published the ideas of Ballina SHS in a school project book. Pages 374 - 376 show some of the 55 projects detailed in this 120 page excellent resource for Chs 11 - 15 of this book.

Copies of this *Aquaculture School Project Book* are available from:

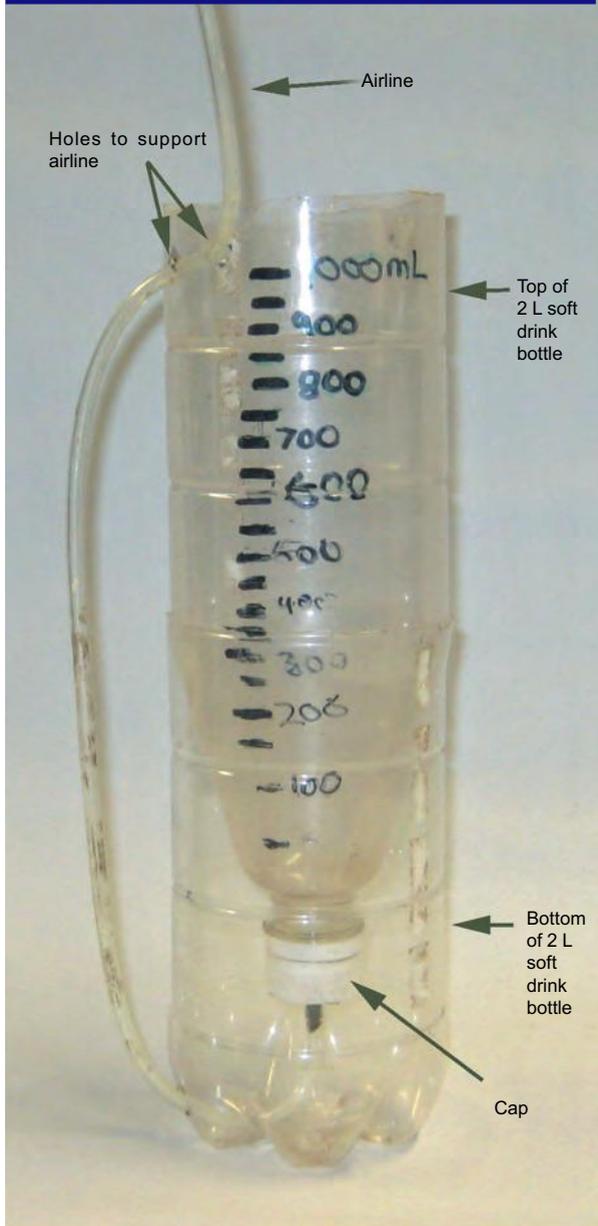
[www.wetpaper.com.au](http://www.wetpaper.com.au)



Bob Moffatt

### Example project:

Artemia hatchery (see page 34 of project book)



Mick O'Connor

#### What to do

1. Select two appropriate 2 litre plastic soft drink containers.
2. Soak the label off the bottles and wash thoroughly with clean water.
3. Rinse the bottle 2 or 3 times in clean detergent free water - all chemicals **MUST** be removed from the bottle.
4. Using scissors cut off the bottom of one of the bottles. This bottle will become the 'container'.
5. Cut the other bottle in half. It will be the 'stand'.
6. Drill a 5mm hole 10cm from the bottom, up the side, of this 'stand bottle'.
7. Using a poly jetpunch/spanner place a hole in one of the bottle caps.
8. Screw in to this hole the 4mm screwed adapter and attach the airline.
9. Screw the lid back on the container bottle, invert it into the stand bottle and feed the airline out through the hole in the stand.
10. Punch two 4mm holes apart in the 200 mm apart at the top (cut end) of the container bottle with a hole punch (see Figure opposite).
11. Thread the airline through these two holes before connecting to the aerator. This will ensure the airline remains above the surface of the liquid and will prevent siphoning out the aerator.

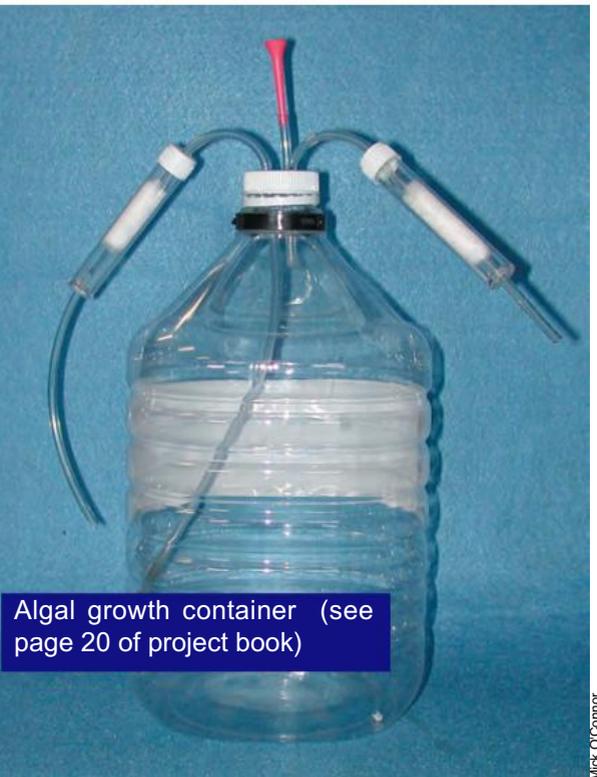
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## Aquaculture project ideas (cont'd)

Light cupboard (see page 22 of project book)



Crayfish restrainer and measurer (see page 82 of project book)



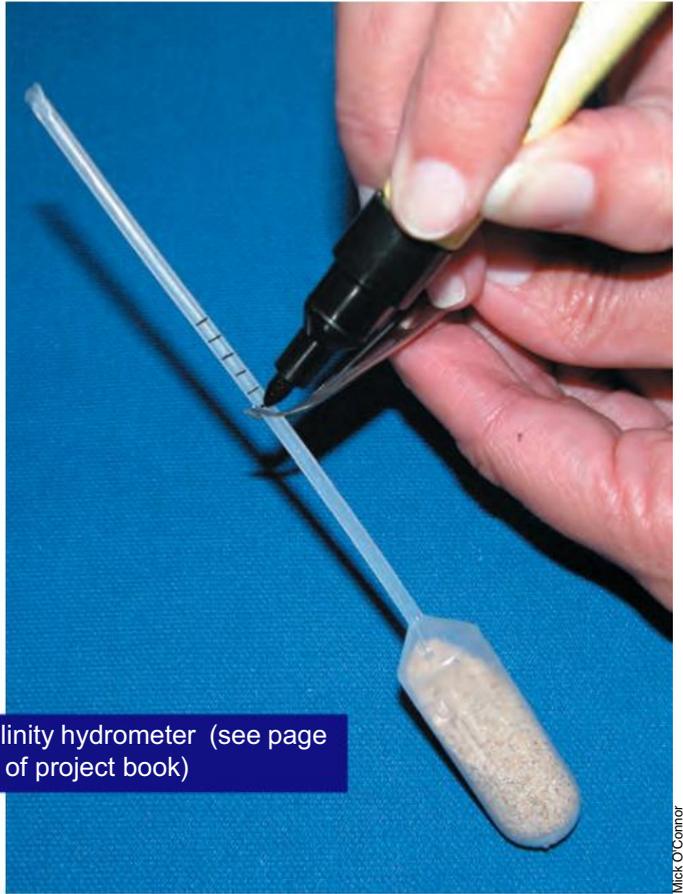
Algal growth container (see page 20 of project book)

## Aquaculture project ideas (cont'd)



Salinity hydrometer (see page 44 of project book)

Mick O'Connor



Mick O'Connor



Growing algae (see page 89 of project book)



Fish measure (see page 80 of project book)

Mick O'Connor

Mick O'Connor

## Knowledge

### Verbs

- Describe
- Find
- List
- Locate
- Name
- Relate
- State
- Tell
- Write

### Questions

- Can you name the ...
- Describe the appearance of ...
- Find the meaning of the following terms
- How many ...
- What happened after ...
- What is the name of ...
- Who was the person that ...
- Which is the right answer ...

### Instructions/activities

- Last all the stages of ...
- Make a time line of the events
- Prepare a chart showing ...
- Recite a poem
- Write the formula for photosynthesis
- Describe the events leading up to ...
- Locate a place that ...
- Name the animals in the ...
- State the formula for ...
- Tell the story about ...
- What is the scientific name for, the common name for

## Understanding

### Verbs

- Convert
- Draw
- Describe
- Distinguish
- Name
- Interpret
- Match
- Outline
- Restate
- Show
- Translate
- Write

### Questions

- Write the formula for photosynthesis in your own words
- Give a definition of species
- Provide an example of a ...
- Write a brief outline for ...
- What differences exist between ...
- What do you think could have happened next?
- What was the main idea of the article?
- Match the ... with the description

### Instructions/activities

- Draw pictures to show ...
- Convert this ... into a statement
- Describe/express in your own words/restate the ...
- Give an example of a ...
- Illustrate the main ideas of the article
- Prepare a flow chart of the steps involved in ...
- Outline the main reasons for ...
- Distinguish between ...

## Analysing

### Verbs

- Analyse
- Arrange
- Classify
- Classify
- Categorise
- Compare
- Contrast
- Distinguish
- Examine
- Explain
- Identify
- Show
- Investigate
- Separate
- Survey

### Questions

- Which events could not have happened and why?
- How is this similar to or different from ...
- What was the main theme?
- Distinguish between ...
- What was the turning point in the development?
- Explain what must have happened when ...
- Are there any other possible outcomes?
- What were some of the motives behind ...
- Write a number of questions that could be used in the interview.
- Write ... similarities and ... differences between ...

### Instructions/activities

- Design a questionnaire to gather data
- Make a flow chart to show the reproductive cycle of a ...
- Construct a graph to illustrate the relationship between ...
- Which events could not have happened and why
- Write a number of questions that could be used to ...
- Explain the difference between the following words
- Identify the following animals from the illustrations below
- Investigate the effects of ...
- Carry out a survey to ...
- Prepare a scientific report of ...

## Creating

### Verbs

- Compose
- Research
- Create
- Design
- Estimate
- Formulate
- Imagine
- Improve
- Invent
- Justify
- Plan
- Predict
- Propose
- Conduct

### Questions

- Create new uses for ...
- If you had access to all the necessary resources, how could you stop ships hitting the reef?
- Invent a solution to ...
- Can you develop a proposal which will ...?
- How many ways can you ...
- Propose how we could improve this experiment!
- Predict what will happen if ...

### Instructions/activities

- Create a new product (fish) and plan a marketing campaign
- Devise a number of ways to improve ...
- Write and perform a play to illustrate a farmale feeding
- Invent a machine to ...
- Design a cover for a brochure
- Compose a rhythm and/or add new words to a well known tune
- Devise an experiment that will extract more ... from tidal energy
- Construct a model of a (cropcod)
- Design a wave power house
- Suggest ways to improve the management of ...
- Choose music to reflect the movement of ...

## Evaluating

### Verbs

- Argue
- Assess
- Choose
- Choose
- Debate
- Determine
- Evaluate
- Discuss
- Judge
- Justify
- Prioritise
- Rate
- Recommend
- Verify

### Questions

- Plan and conduct an experiment to justify your answer!
- How would you defend your position in relation to ...?
- Assess and choose a better solution to ...
- How would you have handled ...?
- What changes would you recommend to ...? Why?
- Do you believe that ...
- How would you feel if ...
- How ineffective are ...

### Instructions/activities

- Prepare a list to be used by ... to judge a ...
- Organise and conduct a debate about a controversial issue
- Prepare a booklet that could be used by four operators to ...
- Write a letter to the editor of the local newspaper advising on changes needed to ...
- Prepare a report in which you evaluate the research on ...
- Recommend new strategies to be adopted by the ... based on your strategic plan and group's analysis

# Sample workprogram and activity ideas

The workprogram below is a guide only for teachers designing a course in the middle school for 3 years. The book is also suitable in senior courses for students who are not bound for university. There are many ideas and activities for you to download from old Wet Paper books on our web site: [www.wetpaper.com.au/teacher](http://www.wetpaper.com.au/teacher). The answers to the first edition are on [www.wetpaper.com.au/student](http://www.wetpaper.com.au/student)



<p><b>Year 1</b></p> <p>Introduction            Ch 1 Water safety            Ch 2 First aid            Ch 23 Waves            Ch 24 Tides and currents            Ch 19 Oceans</p>	<p><b>Activity ideas</b></p> <p>Decorate the room with marine related gear from table on page 5            Bronze star, pool safety, excursion to life saving club, voluntary marine rescue            First aid certificate, ambulance visit to school, dangerous creature wall chart            Wave tank experiments, surfing culture project, beach erosion project            Reading a tide book, graphing tides, current meter design and experiments            Make simple oceanographic equipment and test it in local creek or waterway</p> <p style="text-align: right;"><b>SEM 1</b></p>
<p>Ch 32 Shipwrecks            Ch 3 Dangerous creatures            Ch 31 Antarctica            Ch 18 Weather            Ch 7 Boating            Ch 6 Sea water</p>	<p>Internet research, make a model ship, immigration, marine museum visit            Design a dangerous creature, wall chart, power point presentation            Assignment, internet research, ABC videos, humpback whale project            Visit to weather station, emergency plan for severe storms and coastal bushfires            Canoeing certificate, trip on a boat, navigation assignment, windsurfing, sailing            Classroom experiments salinity, temperature, pressure, Cartesian diver</p> <p style="text-align: right;"><b>SEM 2</b></p>
<p><b>Year 2</b></p> <p>Introduction            Ch 8 Snorkelling            Ch 4 Maintaining equipment            Ch 10 Making a surfboard            Ch 11 Aquariums            Ch 12 Underwater farming            Ch 13 Crayfish</p>	<p><b>Activity ideas</b></p> <p>Decorate the room with marine related gear from chapters to be studied this year            Snorkelling certificate, pool skills, rescue, underwater hockey games            Repairs to surfboards, fishing rods, snorkelling gear            Visit to a surf shop., industrial arts department, make a model surfboard            Making and stocking an aquarium, class visit from aquarium shop, glass cutting            Visit to aquaculture farm, rich task on export of aquaculture products            Aquarium breeding, grow out pond construction, crayfish colour wall chart</p> <p style="text-align: right;"><b>SEM 1</b></p>
<p>Ch 25 Small sea creatures            Ch 28 Trashing the sea            Ch 29 Sea water quality            Ch 30 Saving the sea</p>	<p>Plankton collection and net making, digital microscope collection            Pollution experiments, community surveys, plastic bag studies, media study            Laboratory experiments, waterwatch involvement, action based research            Reef guardians, drain spraying, media project, seaweek display, worm farms</p> <p style="text-align: right;"><b>SEM 2</b></p>
<p><b>Year 3</b></p> <p>Introduction            Ch 5 Living in the sea            Ch 26 Animals without backbones            Ch 27 Marine vertebrates            Ch 14 Aquaculture farm designs            Ch 16 Marine industries</p>	<p><b>Activity ideas</b></p> <p>Decorate the room with marine related gear from chapters to be studied this year            Marine ecology excursion report, deep sea animal project, ecosystem wall mural            Make a marine invertebrate, digital photograph collection            Excursion to sea world, underwater world, marine aquarium            Convert the school oval into a aquaculture farm project            Visit to a marine industry, port, marina, boat building factory</p> <p style="text-align: right;"><b>SEM 1</b></p>
<p>Ch 17 Marine employment            Ch 9 Fishing            Ch 15 Food from the sea            Ch 22 Coastal engineering            Ch 20 Coastlines and marine life            Ch 21 Estuaries and marine life</p>	<p>Work experience for one week in a local marine industry            Build a fishing rod, bait bag, lobster pot, catching fish, make a tackle book            Seafood cooking, visit to a fish marketing board            Excursion to marina, port, groyne, canal estate, model making/ research project            Rocky shore excursion, digital photograph collection, wall mural of zonation            Mangroves or seagrass excursion, digital photograph collection, mangrove mud</p> <p style="text-align: right;"><b>SEM 2</b></p>

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Bob Moffatt



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