TOPIC 16
Marine change and management

16.1 Overview

Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

16.1.1 Introduction

Imagine you are on a beach. You are looking out to sea at the endless, constantly moving mass of water that stretches to the horizon. Why does it move, how does it move, what lies beneath?

Life on Earth would not be possible without our oceans. Humans are interconnected to the oceans, which provide or regulate our water, oxygen, weather, food, minerals and resources. Oceans also create a surface for transport and trade and provide a habitat for 80 per cent of all life on Earth. Our oceans are under threat as we use them to extract resources, dump waste and destroy them. It has been very much a case of 'out of sight, out of mind'. Let's now look at this problem in more detail.

Accumulated marine debris floating in the ocean

Starter questions

1. What are your first thoughts when you view this photograph?
2. Suggest items that might be floating in this rubbish.
3. Where do you think this waste has come from, and how did it get here?
4. What waste does your family generate, and what happens to it?

INQUIRY SEQUENCE

16.2 Why is there motion in the ocean?

16.2.1 What are ocean currents?

In January 1992, a ship sailing from Hong Kong to the United States lost a shipping crate containing 28 000 plastic bath toys at sea during a storm. The toys drifted off in the currents, the first ones eventually reaching the Alaskan coast in November of that year. More than 20 years later, many are still floating! The tracking of these toys has enabled scientists to improve their understanding of ocean currents.

Why doesn't water at the equator get hotter and hotter and water at the poles get colder and colder? The answer is ocean currents. Currents are movements of water from one region to another, often over long distances and time periods. Currents effectively interconnect the world's oceans and seas. They are critically important for 'stirring' the waters and transporting heat, oxygen, carbon dioxide, salts, nutrients, sediments and marine creatures.

A knowledge of currents is vital for navigation, shipping, search and rescue and the dispersal of pollutants. The direction that currents take is influenced by a number of factors, including the Earth's rotation, the shape of the sea floor, water temperature, salinity levels and the wind.

16.2.2 What are the different types of ocean currents?

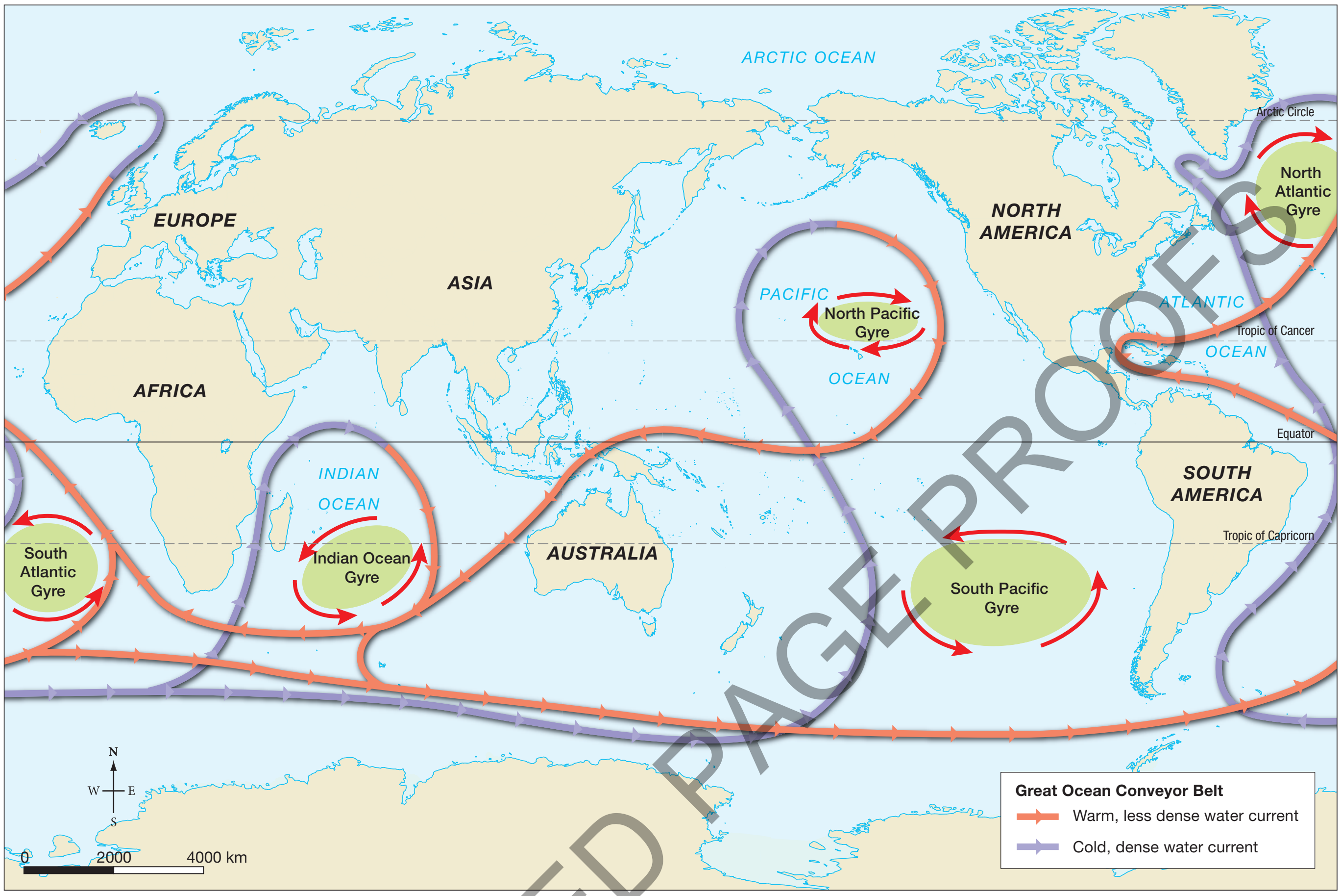
Surface currents

The action of winds blowing over the surface of the water sets up the movement of water in the top 400 metres of the ocean, creating surface currents. These currents flow in a regular pattern, but they can vary in depth, width and speed. Due to the rotation of the Earth, the **Coriolis force** deflects currents into large circular patterns called **gyres**, which flow clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere (see figure 1).

Deep water currents

Deep water currents are powered by **thermoline circulation** and make up about 90 per cent of water movements in the ocean. Surface currents make up the remaining 10 per cent.

FIGURE 1 The Global Ocean Conveyor Belt and the five main ocean gyres



Source: Map by Spatial Vision

Global Ocean Conveyor Belt

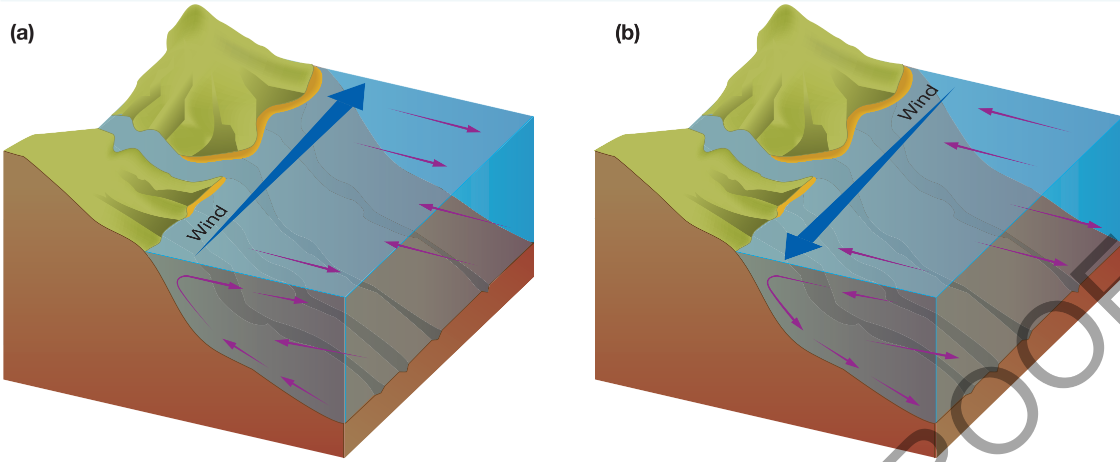
The Global Ocean Conveyor Belt is the largest of the thermoline-driven ocean currents (see figure 1). Warm water, which holds less salt and is less dense than cold water, travels from the equator near the surface into higher latitudes. There it loses some of its heat to the atmosphere. The current mixes with colder Arctic waters and this cold, salty water becomes more dense and sinks, flowing as a deep ocean current. This creates a continual looping current which moves at a rate of 10 cm/s and may take up to 1000 years to complete one loop. The quantity of water moved in the Global Ocean Conveyor Belt is more than 16 times the water volume of all the world's rivers.

Upwellings and downwellings

The movement of cold water currents from the deep sea to the surface is called an upwelling. This is shown in figure 2(a). Regions where these occur are very productive fishing grounds as the upwellings bring nutrients from the seabed, which provide food for the growth of plankton, often the start of marine food chains. Over 50 per cent of the world's fish are caught in these areas.

Downwellings, shown in figure 2(b), occur when currents sink, taking with them oxygen and carbon dioxide from the atmosphere. These currents essentially 'stir up' the water and help distribute heat, gases and nutrients.

FIGURE 2 (a) Upwelling and (b) downwelling



16.2 Activities

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note*: Question numbers may vary slightly.

Remember

1. (a) Why do ocean currents form? What is the driving force behind surface and thermoline currents?
   (b) Why are upwellings and downwellings important for marine ***environments***?
2. Refer to figure 1. Describe the location of the five main ocean gyres.
3. What factors influence the direction that ocean currents take?
4. Why do you think ocean currents are described as 'conveyor belts'?
5. Looking at figure 1, how does the Global Ocean Conveyor Belt current ***interconnect*** the world's oceans?
6. Refer to figure 1. Describe the route taken by the Global Ocean Conveyor Belt. At each of the locations marked A–E, name the ocean, the direction the current is taking, the continent it is passing, and its thermoline features (warm, cold, higher salt content, lower salt content).

Discover

7. Research the ***interconnection*** between the Humboldt current (cold upwelling) on the west coast of South America and El Niño events.

Predict

8. Suggest what ***changes*** might happen to the Global Ocean Conveyor Belt if there was a significant melting of the polar ice caps.

Think

9. Why doesn't water at the equator keep getting hotter and water at the poles keep getting colder? Use your knowledge of currents to write an explanation for a younger student.

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Try out this interactivity: Motion in the ocean (int-3298)

16.3 Where does trash travel?

16.3.1 What is marine pollution?

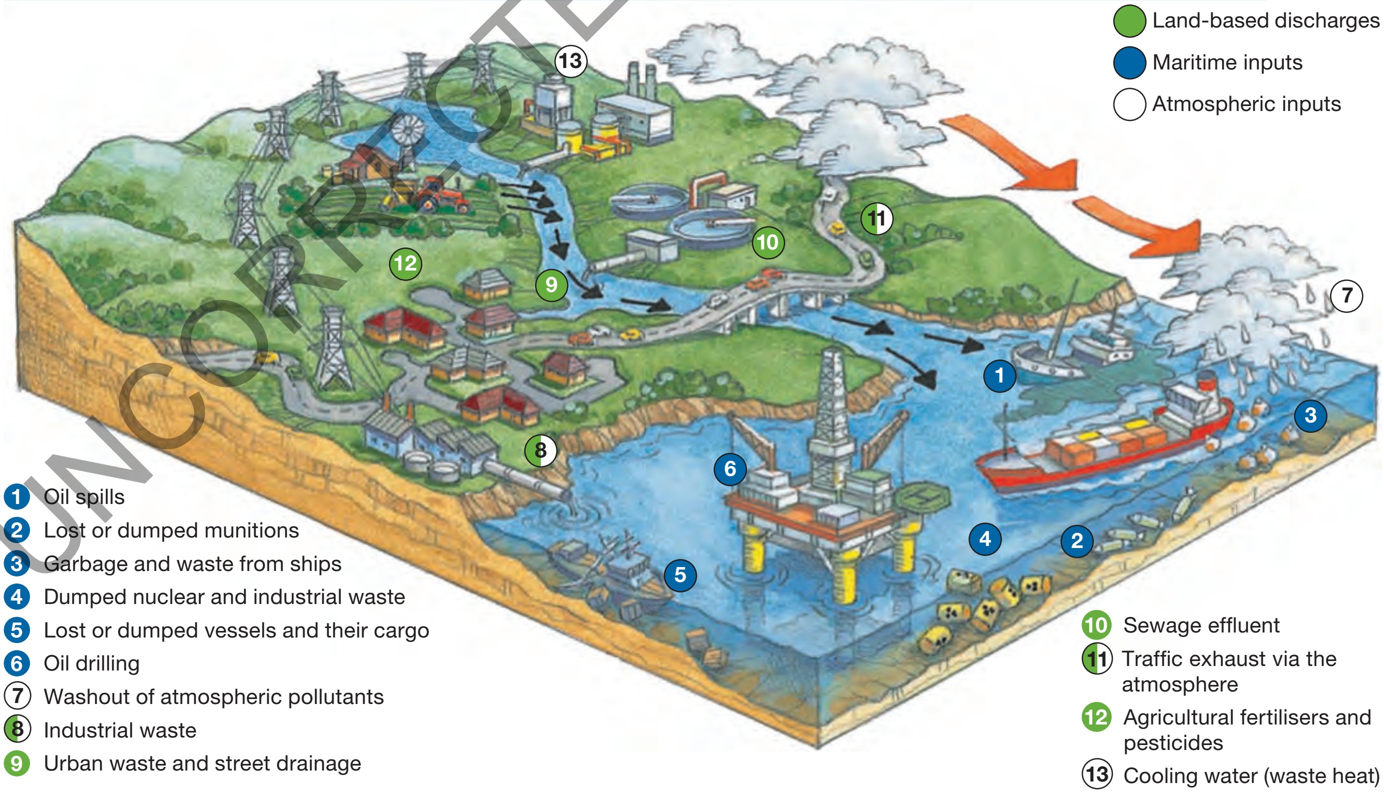
What happens to that empty drink can or plastic bag that misses the bin? There's a good chance it might wash down the gutter, into the drain and out to sea, never to be seen again. The world's largest rubbish dump is not on land, it is in the ocean. Accidentally or deliberately, the oceans receive millions of tonnes of man-made pollutants each year, which are collected in currents and swirled around the oceans.

Marine pollution is any harmful substance or product that enters the ocean. Most are human pollutants including fertilisers, chemicals, sewage, plastics and other solids, including over 1000 shipping containers per year.

FIGURE 1 Most marine debris starts off on land. Much of the litter in this creek in the Philippines will end up in the sea.

Close to 80 per cent of marine pollutants start off on land and are either washed or deposited into rivers, from where they make their way to the coast (see figure 1). Even industrial air pollution can be returned to Earth's surface via rainfall (see figure 2).

FIGURE 2 The sources of marine pollution



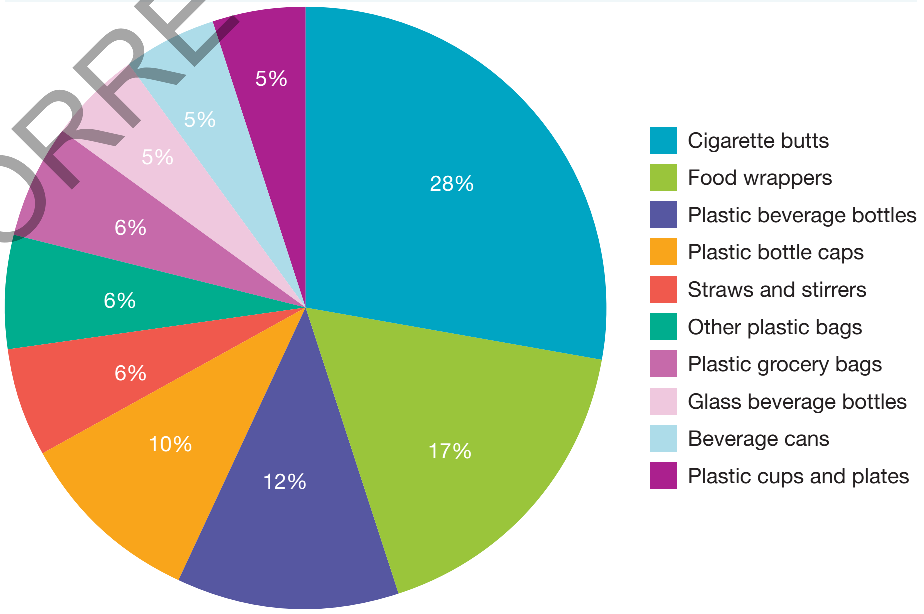
16.3.2 What is marine debris?

Marine debris is litter and other solid material that washes or is dumped into the oceans, much of which is plastic (see figure 3). The special features of plastic that make it such a useful product — it is light, cheap to produce and disposable — also make it a major problem for the ocean (see figure 4). Over 270 million tonnes of plastic are produced each year, approximately 55 per cent of which is recovered, recycled or sent to landfill. The rest is unaccounted for, lost in the environment and eventually washed out to sea, often ending up in the gut or wrapped around the neck of marine creatures, or even buried in Arctic ice. Data collected by scientists from the US, France, Chile, Australia and New Zealand calculated that there were more than 5 trillion pieces of plastic, weighing 269 000 tonnes, floating in the world's oceans. A survey of Australia's coastline found that plastics made up 74 per cent of marine litter. Surface currents and wind can also move debris back on to the coast, where it can become buried in sand or swept back out to sea again.

Unlike most other litter, plastics generally are not **biodegradable**. The technological features of plastic mean that when it is exposed to constant wind, waves, salt and sunlight, it breaks down into tiny fragments known as microplastics (20–50 microns in diameter, thinner than a human hair), which can float or sink to the seabed. Samples taken from selected sites in the Mediterranean Sea and the Atlantic and Indian Oceans have shown microplastics as deep as 3000 metres and in concentrations 1000 times higher than those found floating on the surface.

FIGURE 4 Discarded plastic bags resembling jellyfish, floating in the ocean

FIGURE 3 Top 10 marine debris items

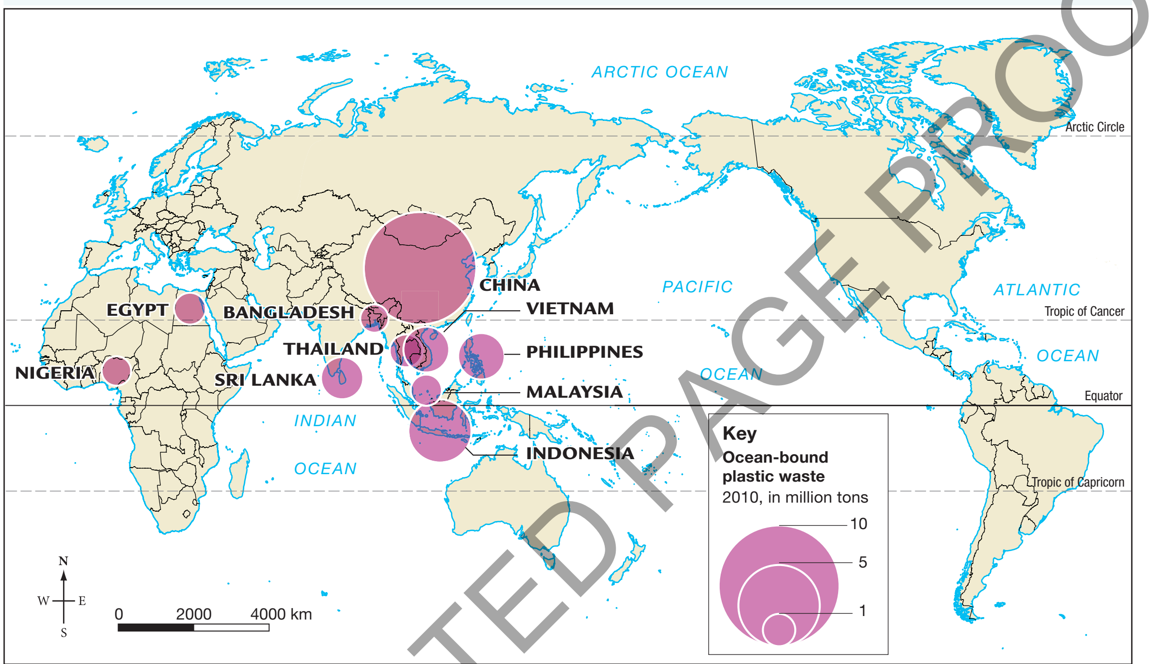


Note: Data is the result of 25 years of surveying debris collected by volunteers in annual debris clean-ups in over 100 countries.

16.3.3 Where do we find the most marine debris?

The worst-affected places for marine debris tend to be heavily populated coastal places and popular tourist destinations; for example, the Caribbean Sea. Research in 2014 identified the 10 countries that generate the most marine plastic debris, with more than 50 per cent coming from just five countries: China, Indonesia, the Philippines, Vietnam and Sri Lanka (see figure 5). Many of these countries have growing economies and demand for plastic products, but as yet do not have the infrastructure to collect, recycle and dispose of plastic waste before it enters the sea. By comparison, developed countries tend to have systems to trap and collect this waste.

FIGURE 5 Top 10 sources of marine plastic waste



Source: © The American Association for the Advancement of Science

What is the Great Pacific Ocean Garbage Patch?

A swirling sea of plastic bottles, garbage bags and other rubbish is growing in the middle of the North Pacific Ocean, thousands of kilometres from the nearest coastline. Why is it there and how did it get there? Discarded waste from the east coast of Japan and west coast of the United States gets swept up in the North Pacific gyre. Within the marine environment, the slow-moving currents and winds push material into the calmer centre of the gyre, where much of it stays and accumulates. It can take a year for material to reach the centre of the gyre from Japan and five years from the United States. The accumulation of debris has earned this region the name the 'Great Pacific Ocean Garbage Patch' (see figure 6). Very little garbage is visible on the surface; rather, it is a thick soupy mass of minute pieces of plastic with an average depth of 10 metres. The size of the patch is estimated to be anywhere from 700 000 to more than 15 million square kilometres. Scientists have detected up to 1 million plastic particles per square kilometre in the patch. Another large garbage patch is located in the Atlantic Ocean.

16.3.4 What are the environmental impacts of marine debris?

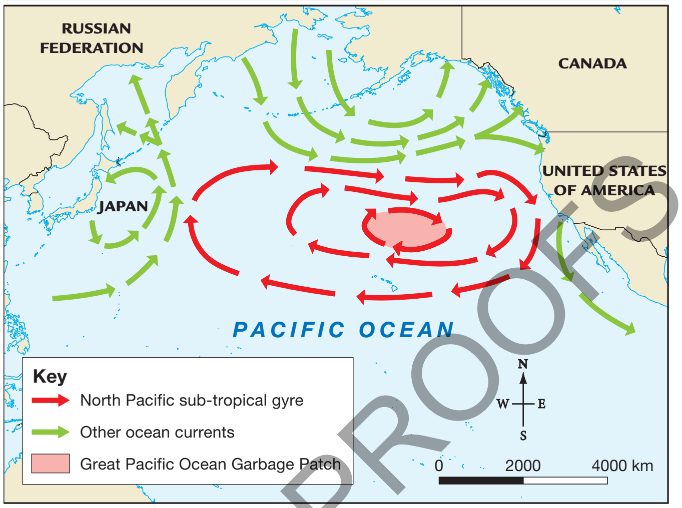
Figure 7 gives estimates for the length of time some marine debris takes to decompose. Most plastics undergo **photodegradation**, which is much slower in water than on land due to reduced exposure to the sun and cooler temperatures. As the particles break down into smaller particles, they 'thicken' the water and can release toxins. If less than 5 mm in diameter, they can be consumed by sea creatures, which in turn are eaten by bigger creatures and so on up the food chain. Marine animals such as mussels which filter seawater take up the micro-plastics, which can release toxins into their tissues. Small floating pieces of debris are often mistaken for food and are scooped up by seabirds and fed to their chicks (see figure 8).

More than 44 per cent of seabirds are known to eat plastic, while 267 marine species are known to swallow plastic bags, mistaking them for jellyfish (see figure 4). An estimated 100 000 marine mammals and up to 1 million seabirds die each year after ingesting plastic.

Ghost nets

Up to 10 per cent of marine debris is made up of abandoned and discarded fishing nets, known as ghost nets, which pose a very common threat to marine creatures (see table 1). Once tangled, they are prevented from swimming, fishing and breeding, and ultimately they drown. Over time, the nets fill with debris and form rafts which grow to hundreds of metres in diameter. These can drag across reefs or scrape along the seabed, causing considerable damage (see section 16.5).

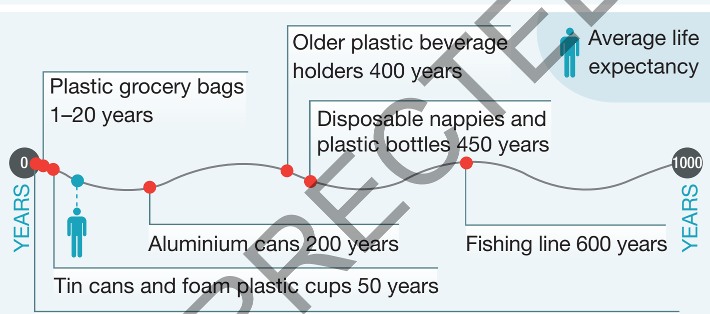
FIGURE 6 Location of the Great Pacific Ocean Garbage Patch



Source: Greenpeace International Made with Natural Earth. Map by Spatial Vision (GAT-22)

Note: The Great Pacific Ocean Garbage Patch floats between Japan and the United States, just north of the Hawaiian Islands. The rotational current caused by the North Pacific gyre draws in garbage from neighbouring coastlines, where it becomes trapped in large quantities in the calmer waters of the gyre's centre.

FIGURE 7 Time periods for the decomposition of marine litter



Paper towels	2–4 weeks	Waxed milk cartons	3 months
Newspapers	6 weeks	New photodegradable beverage holders	<6 months
Cotton ropes	1–5 months	Plywood	1–3 years
Apple cores	2 months	Wool socks	1–3 years
Cardboard boxes	2 months		

Note: Estimated individual item timelines depend on product composition and environmental conditions.

Source: South Carolina Sea Grant Consortium, South Carolina Department of Health and Envrionmental Control (DFHC) — Ocean and Coastal Resource Management, Centers for Ocean Sciences Education Excellence (COSEE) — Southeast and NOAA 2008

FIGURE 8 Foreign objects found in the stomach of a seabird. How many different items can you identify?

TABLE 1 Numbers of wildlife found entangled in marine debris, from 25 years of data

	Amphibians	Birds	Corals/ Sponges	Fish	Invertebrates	Mammals	Reptiles	Total
Beverage bottles	3	8	0	27	47	13	2	100
Beverage cans	1	2	0	15	17	1	0	36
Crab/ Lobster/ Fish traps	1	11	1	48	106	3	3	173
Fishing hooks	2	76	0	54	10	3	6	151
Fishing line	9	722	14	553	237	46	55	1636
Fishing nets	3	153	1	249	207	29	30	672
Bags (plastic)	13	102	0	142	91	33	23	404
Ribbon/ String	0	91	0	37	29	7	2	166
Rope	4	160	0	114	53	71	24	426
6-Pack holders	2	63	0	52	21	3	5	146
Plastic straps	2	30		34	12	5	5	88
Wire	1	31	1	16	13	7	6	75
Total	**41**	**1449**	**17**	**1341**	**843**	**221**	**161**	**4073**

Hitchhikers

Small marine creatures, such as barnacles, that normally spend their lives attached to rock, coral or coconut shells, can 'hitch a ride' on marine debris. The arrival of pest species in new locations can seriously affect ecosystems as they compete with native species for food or habitat.

Fishing industry

While the fishing industry contributes to marine debris, the industry itself is also affected by the litter. A survey in northern Scotland found that 92 per cent of fishermen had continual problems with marine debris in their nets, snagging nets on rubbish, and that some fishing grounds were avoided due to high litter concentrations.

People

Due to the action of currents, garbage discarded in one country can end up on the beaches of another country thousands of kilometres away. Thus the impacts of marine litter on people are mostly found in coastal regions. Impacts include the rising cost of clearing debris from beaches, loss of tourism revenue, and debris interfering with boating and **aquaculture**. At the extreme end, humans eat fish that might have ingested toxic substances.

16.3 Activities

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Remember

1. What are the two biggest contributors to marine pollution across the world's ocean ***space***?

2. (a) Refer to figure 2. Give an example of a pollutant from each of the following sources of marine pollution: (i) atmospheric-based, (ii) land-based, (iii) marine-based.
   (b) Which of the three sources makes up the largest component of marine pollution?

Explain

3. Explain how a plastic bag discarded after a picnic in Los Angeles can end up in the middle of the Pacific Ocean.
4. Refer to figure 3. How would these items compare to a survey of marine litter conducted 50 years ago? What do you think has ***changed*** the most?
5. Refer to figure 5.
   (a) Using the scale provided, estimate the amount of plastic waste that comes from the top three polluters.
   (b) Suggest two reasons why Australia is not on the map.
6. Refer to figure 7. Compare the decomposition ***changes*** for natural materials and man-made materials as seen in this timeline. What does this indicate to the packaging industry and consumers?
7. Refer to table 1. What three items create the most problems for marine wildlife? Suggest reasons why.
8. Is our use of plastic a ***sustainable*** practice? Justify your answer.
9. What are the ***environmental***, economic and technological factors that have created the Great Pacific Ocean Garbage Patch?
10. What are the ***environmental changes*** that rubbish brings to oceans?

Discover

11. Use the **Plastiki Expedition** weblink in the Resources tab to learn about this project. Plastiki is a catamaran that was built by a team led by David De Rothschild. It is made totally out of recycled plastic bottles, and was used to sail the Pacific Ocean to demonstrate the impacts of plastic on the ***environment***. Write a newspaper report of the journey and the team's observations, and map the route they took.

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Try out this interactivity: Garbage patch (int-3299)

Explore more with this weblink: Plastiki Expedition

16.4 How can we best clean up ocean debris?

16.4.1 What can be done?

The way we consume and discard our resources has created one of the biggest environmental challenges in the world. Our throwaway society has literally thrown all our waste into the oceans! 'The water in our oceans is like blood for our planet. If we continue to fill it with toxic materials such as plastic, it will be to the detriment of life on Earth' (D. Woodring, Project Kaisei director).

Marine debris might start as a local problem, but it also creates a global problem as it often travels a great distance from its original source, crossing both geographic and political boundaries. Marine debris will be reduced only if land-based sources can be controlled. Communities and governments need to develop effective waste reduction schemes if we want to manage our oceans sustainably (see figure 1). If no action is taken, by 2025 we could end up with one tonne of plastic for every three tonnes of fish in our oceans.

Can't we just scoop it up?

Scooping up marine debris is not as easy as it sounds. Firstly, debris like the Great Pacific Ocean Garbage Patch is constantly moving in response to shifts in winds and currents. Secondly, much of the garbage is in the form of minute particles suspended beneath the ocean's surface. To scoop it up would mean collecting marine life that inhabits these waters as well.

What can you do?

The Surfrider Foundation in Australia and the United States is responsible for the 'Rise Above Plastics' campaign. The aim of the campaign is to get people to think about how they can make a difference and prevent marine debris. They suggest 10 ways to reduce your personal plastic footprint. There are also many innovative ways to recycle plastic products that can be found on YouTube, such as converting plastic bags to rope or handbags (use the **Plastic to rope** and **Plastic to handbags** weblinks in the Resources tab to view these videos).

FIGURE 1 What message is this advertisement sending?

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Explore more with these weblinks: Plastic to rope, Plastic to handbags

TEN WAYS TO REDUCE YOUR PERSONAL PLASTIC FOOTPRINT

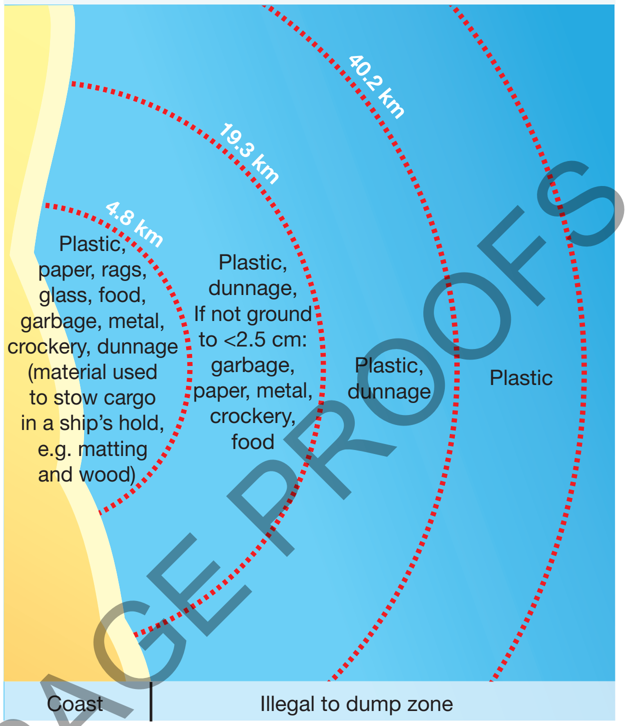
1. Choose to reuse when it comes to shopping bags and bottled water. Use cloth bags and metal or glass reusable bottles if possible.
2. Refuse single-serving packaging, excess packaging, straws and other 'disposable' plastics. Carry reusable utensils in your bag, backpack or car.
3. Reduce everyday plastics such as sandwich bags and juice cartons by replacing them with a reusable lunch bag or box that includes a thermos.
4. Bring your to-go mug with you to the coffee shop, smoothie shop or restaurants that let you use them. This is a great way to reduce lids, plastic cups and/or plastic-lined cups.
5. Go digital! No need for plastic CDs, DVDs and jewel cases when you can buy your music and videos online.
6. Seek alternatives to the plastic items you use.
7. Recycle. If you must use plastic, try to choose #1 (PETE) or #2 (HDPE), which are the most commonly recycled plastics. Avoid plastic bags and polystyrene foam as both typically have very low recycling rates.
8. Volunteer at a beach clean-up. Surfrider Foundation Chapters often hold clean-ups monthly or more frequently.
9. Support plastic bag bans, polystyrene foam bans and bottle recycling bills.
10. Spread the word. Talk to your family and friends about why it is important to 'Rise Above Plastics'!

What can communities do?

Over 100 billion plastic bags are used each year in the United States, with less than 12 per cent recycled. Many governments and communities around the world now actively discourage the use of plastic bags.

When Ireland introduced a bag levy in 2002, plastic bag usage dropped by 90 per cent. On one day of each year, volunteers from over 152 countries clean up the shores of beaches, lakes and streams, by classifying, counting and collecting garbage, as part of the International Coastal Cleanup Campaign. Over the past 25 years, this campaign has led to the removal of more than 66 million kilograms of litter, the equivalent of 330 kilometres of cars nose to tail, or 66 000 average-sized cars! The data collected via the campaign have contributed to new littering laws (see figure 2).

FIGURE 2 Marine pollution restrictions in the United States



What can fishermen do?

A 'Fishing for Litter' scheme has been set up in Scotland where fishermen and port authorities have collaborated to collect all litter caught in nets. Instead of throwing this litter overboard, the debris is collected and brought back to port for managing. From 2005 to 2015, Scottish fishermen collected more than 900 tonnes of marine litter. Recreational fishermen in the United States can recycle fishing lines back to the manufacturer via collection points. Since the US scheme started in 1990, it has prevented over 15 million kilometres of fishing line potentially entangling wildlife.

What can manufacturers do?

In recent years, manufacturers have become much more environmentally aware. New biodegradable packaging materials and improved recycling methods have been developed. The United States has passed laws to phase out the use of microbeads in cosmetic and personal products from 2017 onwards. Microbeads are tiny plastic fabrics found in such things as toothpastes, body washes and other cosmetic products. On packaging they are labelled as polyethylene (PE). The beads pass through water filtration plants and are swept out to sea where they are ingested by sea creatures. These microbeads can contain toxic substances which can be passed up the food chain to people.

In Australia, major supermarket chains and beauty product manufacturers are also starting to phase out microbeads, although imported goods might still contain them.

What can the international community do?

The United Nations Environment Programme (UNEP) has launched an intensive publicity campaign to help raise awareness of marine debris. They are working at a regional level to promote schemes such as recycling, waste separations and other land-based actions. International agreements such as the International Convention for the Prevention of Pollution from Ships (known as MARPOL) prohibit the disposal of all plastic into the sea, and ships cannot dispose of food waste within 12 **nautical miles** of land. Such regulations are extremely difficult to police and have no impact on the amount of waste entering the ocean from land-based sources.

16.4 Activities

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Think

1. Is the saying, 'Think global, act local' applicable to marine pollution? Justify your answer.
2. How successful would an international agreement where all countries decide to reduce land-based marine pollution be? What would be the advantages and disadvantages?
3. (a) Construct a table, similar to the one below, to evaluate each of the proposals to help reduce ocean debris.

Response	Economic criteria (Cost)	Social criteria (Time and effort required)	Environmental criteria (Effectiveness)
Individual actions			
Manufacturers			
International community			

   (b) What conclusions can you draw from your table?
4. How can you reduce your school's plastic footprint? You may like to use the **School** weblink in the Resources tab for ideas. Brainstorm ideas as a class and then develop one idea in detail. How can you promote your idea? You may like to create a slogan and poster, address a school group or assembly or write a proposal to the school administration.
5. Undertake a plastic bottle survey at home. Check your kitchen, laundry and bathroom and count the number of plastic bottles, jars and other containers you find (only count containers). Collate your results, in graph form, with other students in your class and then write a summary of your findings.

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Explore more with this weblink: School

16.5 Where else is marine debris a problem?

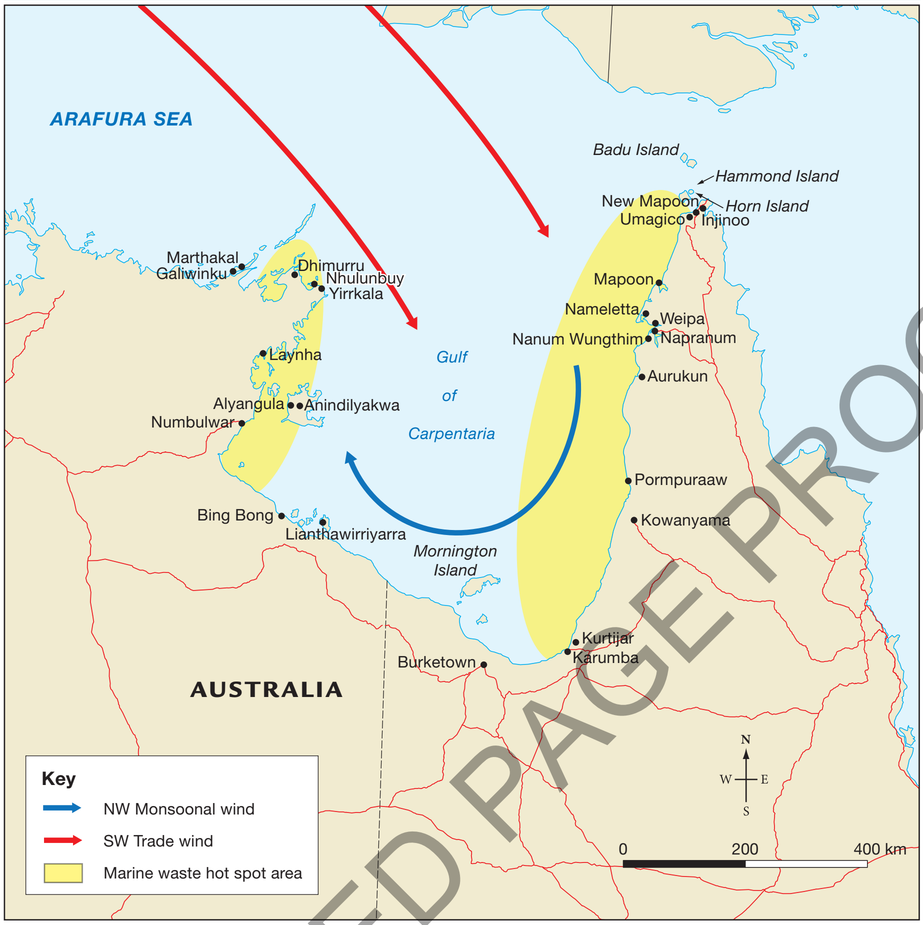
16.5.1 What are ghost nets?

The humble fishing net, once a simple handmade rope construction, has largely been replaced by thousands of metres of nylon webbing. If accidentally lost or purposely discarded, these massive rafts of netting drift around the oceans as **ghost nets**, waiting to trap any unwary sea creature or bird.

16.5.2 Where are ghost nets a problem in Australia?

Marine debris occurs around the coast of Australia, especially in places close to major population centres. It is also a major problem in northern Australia, particularly in the Gulf of Carpentaria. Here densities of nets can reach up to three tonnes per kilometre, among the highest in the world. The coastlines in this region are pristine environments and support six of the world's seven marine turtles. Turtles make up 80 per cent of marine creatures captured in the nets. Over 90 per cent of the debris that collects is derived from the fishing industry, most of it originating from South-East Asia, with the remaining 8.6 per cent being Australian in origin. Most of the nets come from the Arafura Sea, an important fishing ground, especially for the Indonesian fishing industry. More than 62 per cent of the nets are trawling nets – the Arafura Sea being the only region of Indonesian waters where trawling is not banned. Under the influence of the south-east trade winds and north-west monsoon winds, a circular gyre pattern develops, which allows the build-up of ghost nets to develop, similar to the Great Pacific Ocean Garbage Patch (see figure 1).

FIGURE 1 Distribution of ghost net hot spots around northern Australia



Source: © Commonwealth of Australia Geoscience Australia 2013. Ghost Nets Australia, www.ghostnets.com.au/index.html

16.5.3 What is being done?

GhostNets Australia is an alliance of over 22 Indigenous communities in remote coastal places of Western Australia, Queensland and the Northern Territory, funded by the Federal Government. Since its establishment in 2004, over 13 000 ghost nets have been captured by locally trained rangers (see figure 2).

FIGURE 2 Captured trawler nets being collected by rangers

Often, helicopters are used to spot the ghost nets washed ashore, which are then checked for trapped wildlife. Live turtles are tagged and data recorded before they are returned to the sea. Nets are dragged up above the **high tide line** to be identified, collected and disposed of later. The project works on a '6R' principle:

1. **R**emove ghost nets from waters and coastline of the Gulf of Carpentaria.
2. **R**ecord the number, size, type and location of nets.
3. **R**escue animals trapped in nets.

4. **R**eport the activities that the community has done to increase awareness.
5. **R**educe the number of nets in the Gulf by working together.
6. **R**esearch factors that influence the distribution, movement and impact of ghost nets.

This program is part of a Caring for our Country initiative in the region, which promotes stewardship of Indigenous customary lands and seas.

What can be done with the debris?

Traditionally, fishing nets were made of more eco-friendly materials, such as flax or hemp, but they are now increasingly made of nylon, which makes them stronger, cheaper and more buoyant. However, they are also harder to dispose of as they take a very long time to break down. Nets can also range in size from 30 cm to 6 km in length. There are three options for disposal of the waste: burning, placing in landfill or recycling. Each, however, has disadvantages, and all methods require the waste to be collected over long distances and difficult terrain.

Disadvantages of burning fishing nets include:
- burning plastic is illegal in most countries
- after burning, the residue is a huge, heavy, immovable mass of melted plastic, which is a visual eyesore
- health risks associated with burning plastic.

Disadvantages of disposing of fishing nets in landfill include:
- expense of transporting the waste over large distances to a landfill site
- often waste is burned in tips, and these tips are close to settlements.

Disadvantages of recycling or reusing fishing nets include:
- remoteness of and distances to recycling plants (South Australia and Taiwan have plants big enough to cope with fishing nets)
- expense of transporting the waste over large distances
- the need for large machinery to chop plastic into manageable pieces
- the need to find a local use for the recycled waste material.

What is GhostNets Australia's solution?

While only a partial solution to the large quantity of nets accumulating, GhostNets Australia promotes the reuse of nets by providing local artists with netting material. The artists use traditional weaving techniques to create artworks (see figure 3). This type of **cottage industry** brings economic and social benefits as well as raising awareness of the problem of marine debris.

FIGURE 3 Woven basket made of recycled fishing net

16.5 Activities

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note*: Question numbers may vary slightly.

Remember

1. Why are ghost nets a problem in northern Australia?
2. Why are fishing nets an ***environmental*** problem?

Explain

3. Refer to figure 1. On which side of the Gulf would you expect ghost nets to build up:
   (a) during the north-west monsoon season
   (b) during the south-east trade wind season?
4. Why is an understanding of local wind patterns useful to rangers?
5. Why is transporting nets to South Australia for recycling not a viable option?
6. Evaluate the ***environmental***, economic and social aspects of the GhostNets program.

Discover

7. If you have access to a beach, walk along the high tide line and see if you can collect and identify different forms of marine litter. Collate and record your findings. What were the most common forms of litter than you identified? Where have they come from?
8. Research information on the different types of fishing nets used: gill, purse, seine and trawl nets.
   (a) Construct a table to list the advantages and disadvantages of each from a fishing and an ***environmental*** perspective.
   (b) Which net design might prove to be the most damaging to the ***environment*** if lost or discarded?

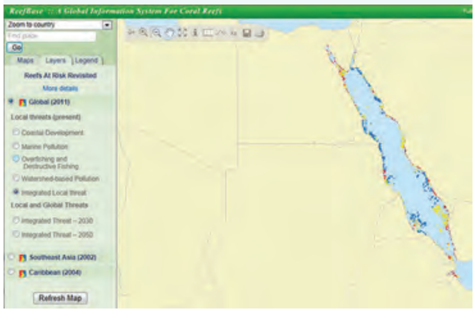
16.6 SkillBuilder: Using geographic information systems (GIS)

online only

WHAT IS GIS?

GIS is a computer-based system of layers of geographic data. Just as an overlay map allows you to interchange layers of information, GIS allows you to turn layers on and off to make comparisons between pieces of data.

FIGURE 1 Studying marine reefs using GIS on the Red Sea



Source: © Reefbase/Worldfish

Go online to access:

- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

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Watch this eLesson: Using geographic information systems (GIS) (eles-1752)

Try out this interactivity: Using geographic information systems (GIS) (int-3370)

c16MarineChangeAndManagement.indd Page 311 20/08/17 6:02 PM

16.7 Where does oil in the sea come from?

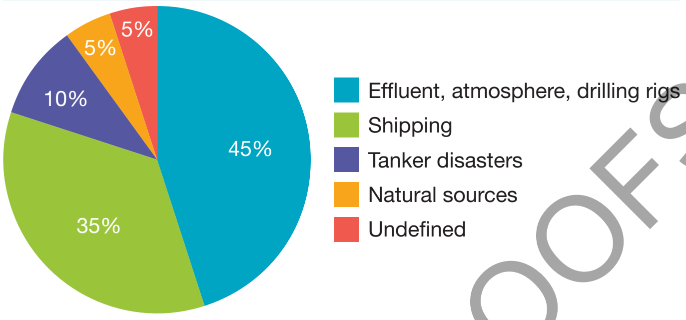
16.7.1 How does oil get into the ocean?

You have probably seen images of birds covered in sticky oil, usually as a result of the most dramatic type of marine pollution: oil spills and shipping accidents. The impact of oil on ocean and coastal ecosystems is often localised over a relatively small area, but may last for many years.

Almost all of the Earth's supply of oil and natural gas is found in deep underground reservoirs. Reservoirs can be under a landmass, under the seabed and under **continental shelves**. Extracting oil from the seabed accounts for nearly 30 per cent of the world's production. Offshore drilling takes place on huge floating platforms, in waters up to 2 kilometres deep and as far as 300 kilometres from the coast. More than 50 per cent of countries around the world drill for offshore oil and gas.

The most obvious and visible kinds of marine oil spills usually involve tanker accidents, or leaks from offshore oil rigs. However, oils enter the ocean from a variety of sources, with both natural and land-based sources accounting for a much larger proportion than disasters (see figure 1). There has been a decrease in the number of tanker accidents in recent years, mostly due to improved ship design and greater safety methods. However, with more ships and supertankers being built, the potential risk of an accident is still high.

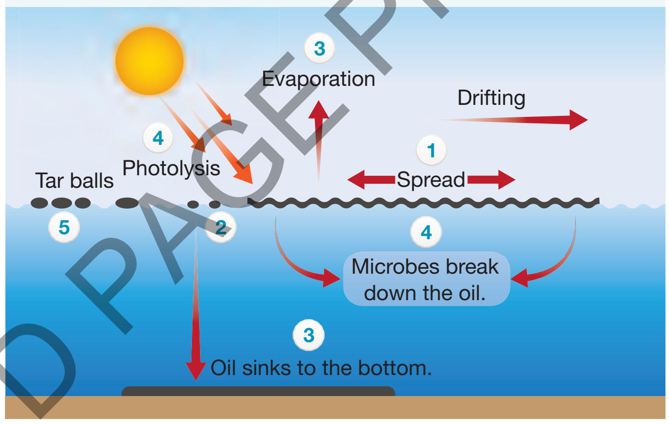
FIGURE 1 Main sources of marine oil pollution



16.7.2 What happens to oil in the ocean?

Each oil spill is different and there are various physical, chemical and biological factors that will influence the behaviour of spilt oil. The type of oil, temperature of the water, wave and current action, and the nutrient content of the water are all critical influences. The stages in the breakdown of oil can be seen in figure 2.

FIGURE 2 What happens to oil in the ocean?



1. When oil is released into the ocean it immediately forms large slicks which float on the surface. It can take only 10 minutes for one ton of oil to disperse over a radius of 50 m and be 10 mm thick.
2. After a few hours, weathering by wind and waves breaks down the slick into narrow bands, or windrows, that float parallel to the wind. The oil may be less than 1 mm thick but can now cover 12 km^2. After the slick thins down it breaks up into fragments and fine droplets that can be transported over larger distances.
3. Some of the oil evaporates or sinks.
4. Some of the oil can be chemically broken down by sunlight or bacteria.
5. Finally the oil solidifies into tar balls (clumps), which are more resistant to bacterial decomposition.

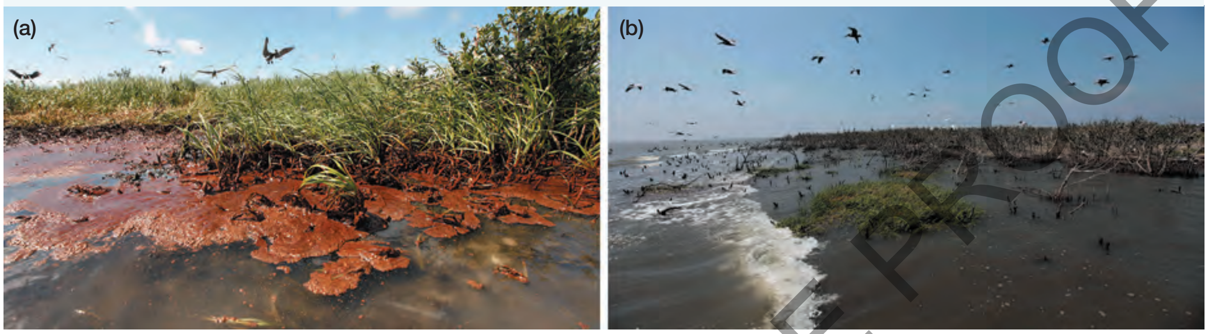
16.7.3 What does oil do to the environment?

Oil spills can result in both short- and long-term environmental change, with some damage lasting for decades. A spill in open waters is usually less destructive than a spill near coastal waters, where most fish and bird breeding takes place. Oil pollution is less visible in the open ocean, especially once it disappears from the surface, but it is still capable of being moved via ocean currents.

Coastlines

The geography of the coastline can influence the degree of impacts from an oil spill. Impacts are less on exposed coasts due to strong wave action. A long, sheltered, sandy coastline is vulnerable as the oil can soak into the sand, which is extremely difficult to clean. Mangroves, salt marshes and extensive sandbanks are also sensitive as the oil soaks into the fine sediments and can be taken up by plants. This affects wildlife that live in this habitat, and the loss of vegetation increases the risk of coastal erosion, as shown in figure 3 (a) and (b). Coral reefs are possibly the most vulnerable to oil spills, and they are extremely slow to recover.

FIGURE 3 (a) Oil damage to wetland habitat (b) The same area of wetlands one year after the oil spill



Wildlife

Any oil on the surface of the sea will kill birds that swim and dive for their food there. Feathers covered in oil rob birds of waterproofing and insulation. Ingesting the oil can poison them. Oil spills also damage coastal nesting and breeding grounds. Oil can block the blow holes of marine mammals such as whales, dolphins and seals, making breathing difficult. If oil coats their fur, they become vulnerable to hypothermia. Animals' food supply is also poisoned by floating oil. Fish, especially shellfish, suffer immediate effects of an oil accident. Reduced reproduction, birth defects and other abnormalities develop in the next generation of wildlife exposed to oil spills, creating a longer term impact.

16.7 Activities

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note*: Question numbers may vary slightly.

Remember

1. What percentage of the world's oil comes from the seabed?
2. Examine figure 2. Why is it important that oil spills are treated as quickly as possible?
3. Examine figures 3 (a) and (b) and describe the ***changes*** that you can see in the two ***environments***.
4. Use the **Oil spill** weblink in the Resources tab to examine a sequence of maps that track the distribution of the oil spill from the Deepwater Horizon oil rig explosion on 20 April 2010 until 3 August 2010. Select the 'Loop current' button and the 'Oil on shoreline' button to view the additional features these show. You may also like to view the satellite images.
(a) What were the main directions that the spill travelled in? What factors would have influenced the directions?
(b) What other ***places*** may have been affected had the oil spill moved in the Loop Current?

Explain

5. (a) Examine figure 2. Select the conditions from those listed below that would be most likely to encourage the rapid breakdown of an oil spill.
   - Cold ocean water/warm ocean water
   - Calm seas/choppy seas
   - Ready supply of bacteria/limited supply of bacteria
   - High level of oxygen in the water/low level of oxygen in the water
   - High number of bacteria-eating organisms/low number of bacteria-eating organisms

(b) Justify each of your choices in part (a).

6. Suggest one ***environmental***, economic and technological factor that can contribute to marine oil pollution.
7. List the ways in which oil creates ***environmental change*** in the ocean.
8. Compare some of the advantages and disadvantages of drilling for oil in the ocean compared to drilling for oil on land.

Discover

9. Research the potential impact of oil spills on the Great Barrier Reef. How does the Great Barrier Reef Marine Park Authority manage the park ***sustainably*** to prevent oil spills?

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Try out this interactivity: Oil slick (int-3300)

Explore more with this weblink: Oil spill

16.8 SkillBuilder: Describing change over time

online only

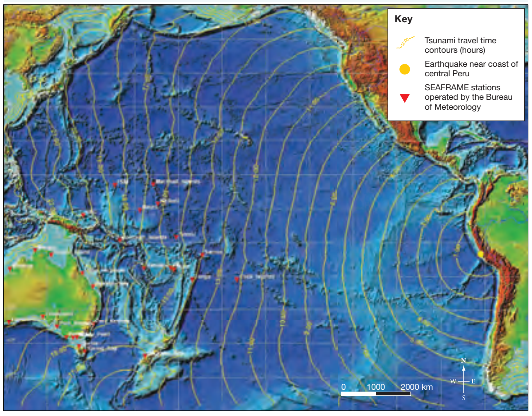
WHAT IS A DESCRIPTION OF CHANGE OVER TIME?

A description of change over time is a verbal or written description of how far a feature moves, or how much it is altered, over an extended time period, and can alert us to the possible impacts of a change or changes over a wider region.

Go online to access:

- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 Tsunami mapping from Peru, 2007. A magnitude 8.0 earthquake occurred on 15 August 2007 near the coast of Peru. A tsunami was detected by Seaframe (sea-level fine resolution acoustic measuring equipment) stations located on Pacific islands.



Source: © Bureau of Meteorology

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Watch this eLesson: Describing change over time (eles-1753)

Try out this interactivity: Describing change over time (int-3371)

16.9 What is the solution to marine pollution?

16.9.1 How can we clean up oil spills?

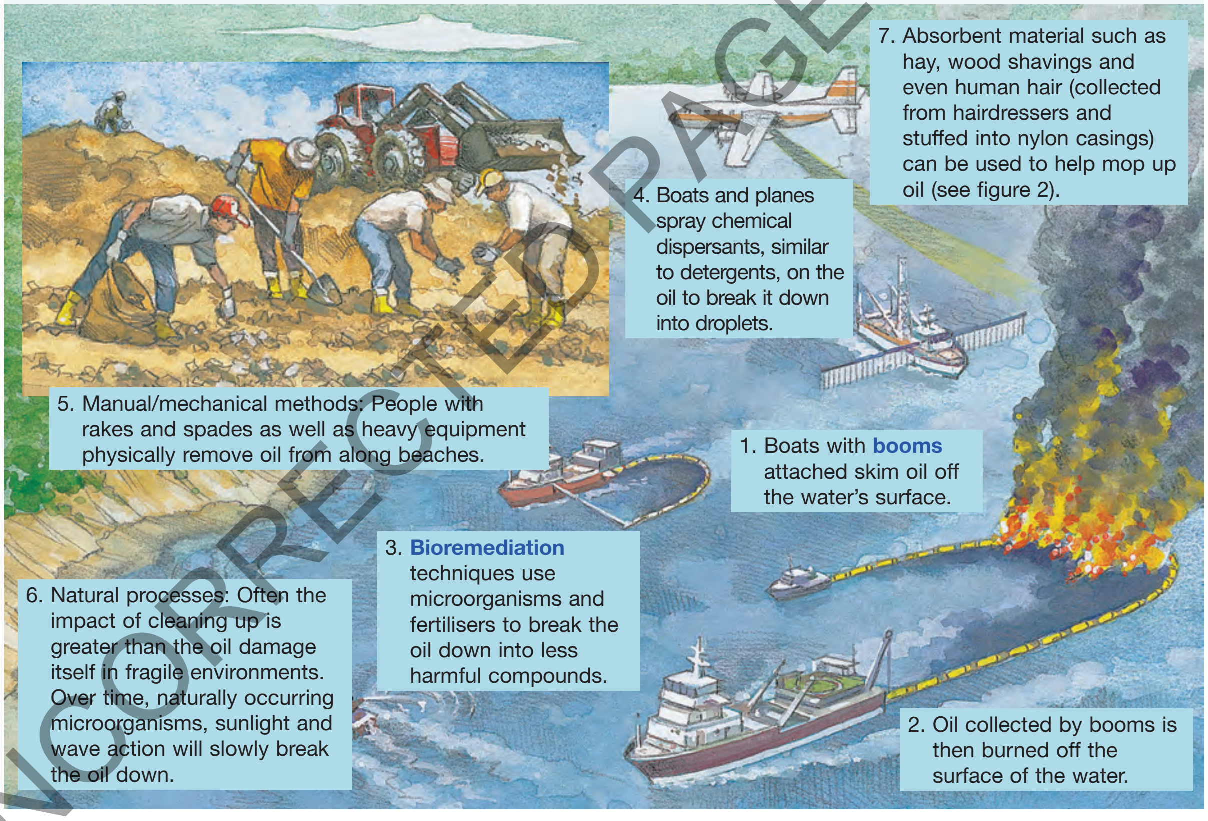
The solution to pollution is not dilution. For many years it was thought that any pollutants that ended up in the ocean would just disappear — the oceans were so vast and so deep. We now know better. Despite wonderful advances in technology, we still have marine accidents, specifically related to the oil industry.

There are two ways to deal with oil spills: **remediation** and prevention. A combination is used, depending on location, weather and the type of spill.

Remediation

It is extremely difficult to contain and clean up any size oil spill, and many of the earlier methods used often caused more environmental damage than the oil itself. For instance, consider the impact of a high pressure hose on a fragile ecosystem, or the spraying of toxic chemicals to absorb the oil. There is a range of remediation methods for cleaning up an oil spill (see figure 1).

FIGURE 1 Different methods of cleaning up oil spills



Prevention

The most important way to deal with oil spills is to prevent them from happening. International cooperation has seen the United Nations treaty MARPOL (MARine POLlution) established in 1983 to deal with the growing problem of marine pollution. Individual countries have also established new rules and regulations. For example, by 2015, all tankers operating in United States waters must be double hulled, so that if the outer hull is damaged the inner hull can still hold the fuel. The oil industry must now have detailed response plans for cleaning up any spills.

FIGURE 2 Recycled human hair turned into oil-absorbent logs for soaking up oil spills

16.9.2 How was the Gulf disaster cleaned up?

In April 2010, an explosion aboard the Deepwater Horizon oil rig in the Gulf of Mexico created a large-scale environmental disaster (see subtopic 16.10). Figure 3 shows the results of the clean-up following the oil spill, 103 days after the accident. Favourable weather conditions at the time enabled authorities to put some defensive measures in place, including more than 4000 kilometres of booms, to protect coastal land.

In all, an estimated 6.4 million litres of dispersants were used on the spill. Scientists believe that nearly 50 per cent of the oil spilt and nearly 100 per cent of the methane gas released has stayed deep in the ocean. As much as 3200 square kilometres of ocean floor is thought to be polluted. Patches of oil are still emerging in different locations, years after the accident. Some is being swept up the sea bed by currents and moved by storm waves. On the sea bed, coral reefs are still showing signs of damage, and on land, some marshes are still giving off toxic fumes.

Due to the high number and distribution of oil wells in the Gulf of Mexico (see figure 4), the threat of future accidents remains. In Florida, it has been estimated that the annual value of tourism and fishing along the state's eastern Gulf coast is three times higher, and considerably more sustainable, than the value of any oil or gas that might be found there. The US Federal Government has a ban on offshore oil and gas drilling in any new areas.

FIGURE 3 How the Gulf of Mexico oil spill was cleaned up

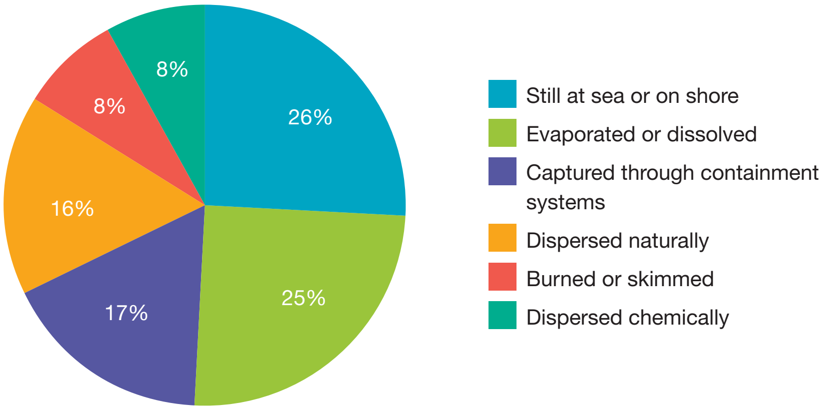
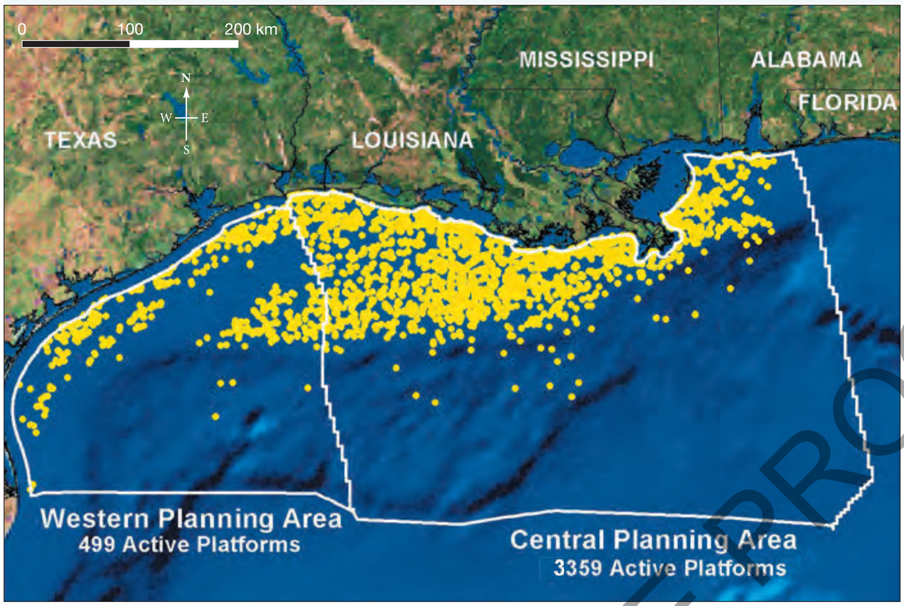


FIGURE 4 Distribution of oil wells in the northern Gulf of Mexico



Source: National Oceanic and Atmospheric Administration, Office of Ocean Exploration and Research, U.S. Department of Commerce. Adapted by Spatial Vision

16.9 Activities

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note*: Question numbers may vary slightly.

Remember

1. Why is it important to treat an oil spill quickly?
2. (a) Study figure 3. What percentage of the oil spill had been treated at this time? What percentage of the oil had dispersed naturally or evaporated?
   (b) Why do you think only a small percentage was chemically dispersed?
3. Imagine that you spill a whole bottle of cooking oil on your kitchen floor. Describe three different remediation methods that you could use to clean up the spill. Select from booms, skimmers, bioremediation, manual/mechanical, dispersants and absorbers. Would one method be more effective than another? Give reasons.

Explain

4. Construct a table to suggest the possible advantages and disadvantages of the seven methods of remediation shown in figure 1. Consider the influence of the following factors: weather conditions, timing, location of treatment area (at sea or on coast), size of area to be treated, ***environmental*** impacts, practicality, economic viability and social justice.
5. Why is there is no one solution to cleaning up oil spills?

Discover

6. Investigate the cause and impacts of the Montara oil rig explosion off the north-west coast of Western Australia in 2009. Why was this not as severe as the Gulf accident?

Think

7. Has the US Government made the right decision in banning drilling for oil in any new ***places***? What did it factor into its decision? Discuss.

16.10 The world's worst oil spill?

Access this subtopic at **www.jacplus.com.au**

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16.11 Review

online only

16.11.1 Review

The Review section contains a range of different questions and activities to help you revise and recall what you have learned, especially prior to a topic test.

16.11.2 Reflect

The Reflect section provides you with an opportunity to apply and extend your learning.

Access this subtopic at **www.jacplus.com.au**