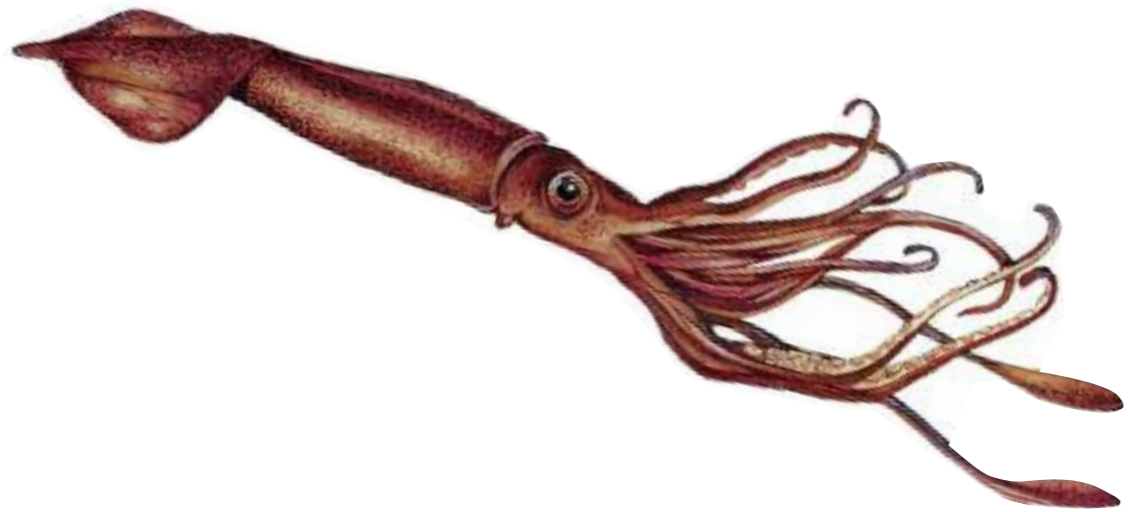


children's illustrated encyclopedia

# Ocean Life



 Orpheus

First published in 2009 by Orpheus Books Ltd.,  
6 Church Green, Witney, Oxfordshire OX28 4AW England  
www.orpheusbooks.com

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ISBN 978 1 905473 60 1

A CIP record for this book is available from the British Library.

Printed and bound in Singapore



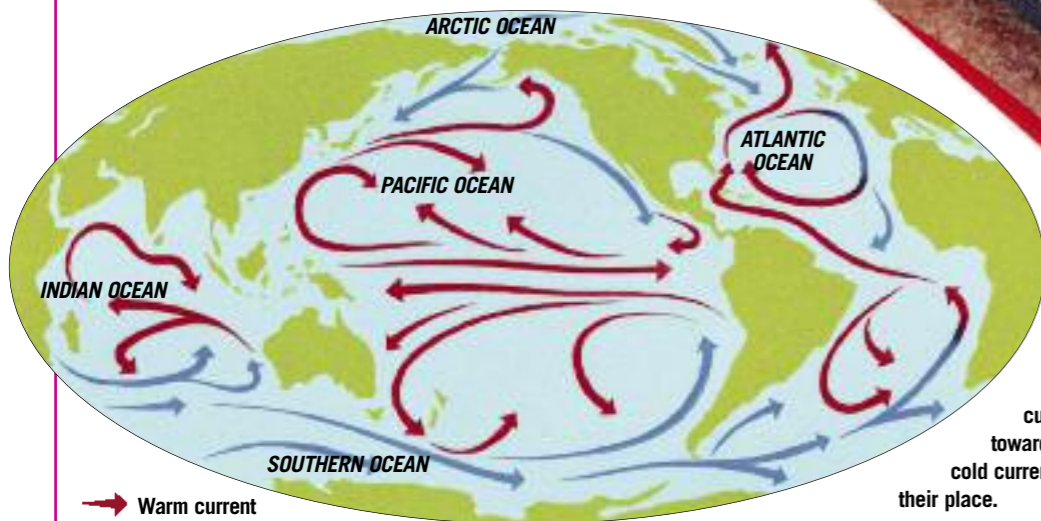
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# OCEANS

THE OCEANS cover more than 360 million square kilometres of the Earth's surface, approximately 71% of its total area. More than 1350 million cubic kilometres of water is contained within it, representing nearly 97% of the Earth's entire supply. The oceans hold enough salt in them to cover Europe to a depth of five kilometres. There are four great oceans: in order of size, the Pacific, Atlantic, Indian and Arctic Oceans (some would add a fifth, the Southern Ocean, surrounding Antarctica).



Warmed by the Sun, surface waters flow in currents towards the poles, while cold currents move in to take their place.

The ocean waters are not still, but move in tides and currents. Tides shift the water daily under the gravitational pull of the Moon (see page 19). Currents, great flowing bands of water, swirl around the globe. There are two kinds: surface currents, which are swept along by the wind, and deepwater currents, which are generated by differences in density (the colder and saltier the water is, the greater its density).

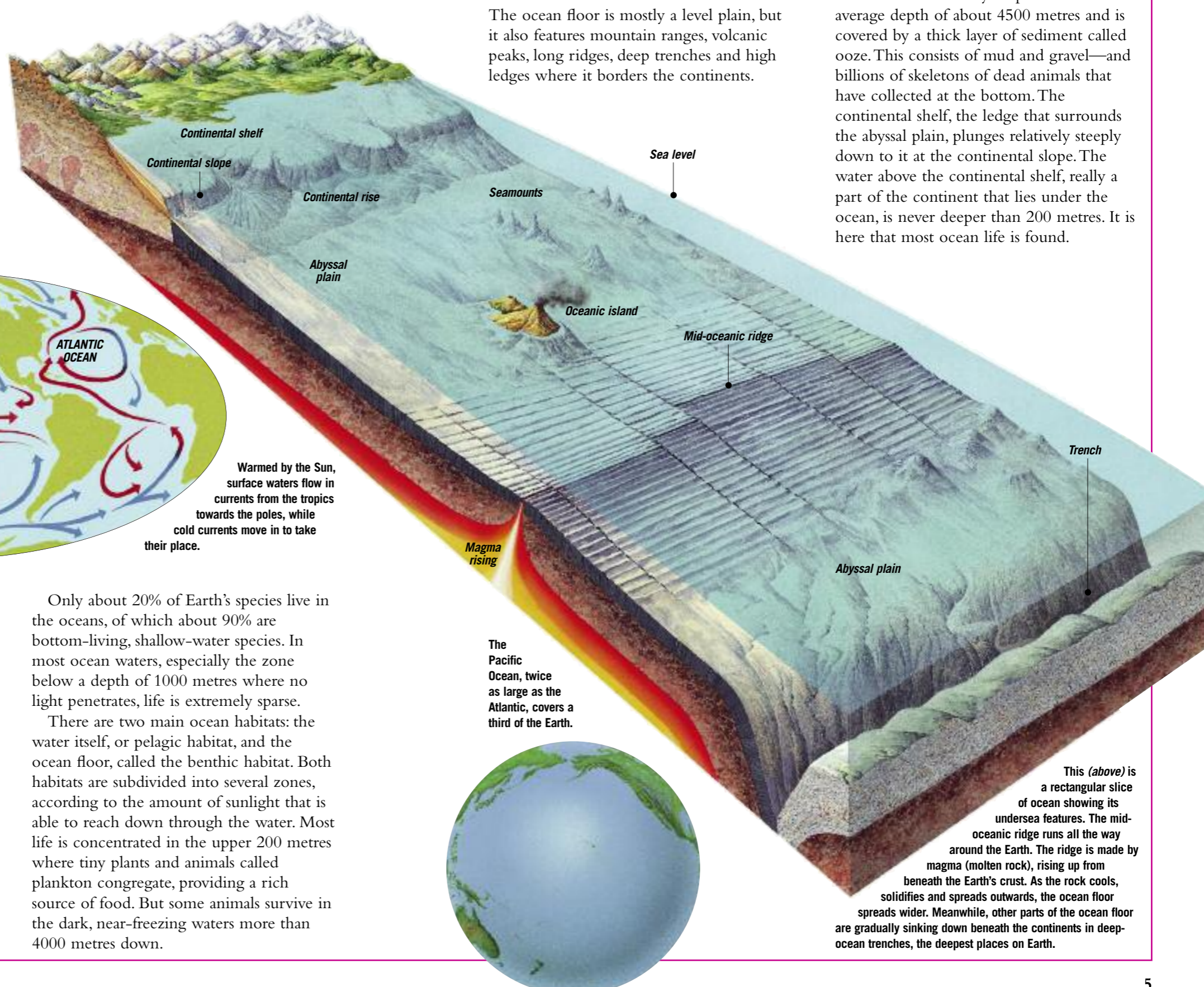
In the open oceans, currents flow clockwise in the northern hemisphere, anticlockwise in the southern. This is the Coriolis effect, caused by the direction of rotation of the planet. Ocean currents have a great influence on climate. The warm Gulf Stream, for example, brings relatively mild winters to northwestern Europe.

Only about 20% of Earth's species live in the oceans, of which about 90% are bottom-living, shallow-water species. In most ocean waters, especially the zone below a depth of 1000 metres where no light penetrates, life is extremely sparse.

There are two main ocean habitats: the water itself, or pelagic habitat, and the ocean floor, called the benthic habitat. Both habitats are subdivided into several zones, according to the amount of sunlight that is able to reach down through the water. Most life is concentrated in the upper 200 metres where tiny plants and animals called plankton congregate, providing a rich source of food. But some animals survive in the dark, near-freezing waters more than 4000 metres down.

# THE OCEAN FLOOR

The ocean floor is mostly a level plain, but it also features mountain ranges, volcanic peaks, long ridges, deep trenches and high ledges where it borders the continents.



The flat plain that forms most of the ocean is called the abyssal plain. It lies at an average depth of about 4500 metres and is covered by a thick layer of sediment called ooze. This consists of mud and gravel—and billions of skeletons of dead animals that have collected at the bottom. The continental shelf, the ledge that surrounds the abyssal plain, plunges relatively steeply down to it at the continental slope. The water above the continental shelf, really a part of the continent that lies under the ocean, is never deeper than 200 metres. It is here that most ocean life is found.

The Pacific Ocean, twice as large as the Atlantic, covers a third of the Earth.



This (above) is a rectangular slice of ocean showing its undersea features. The mid-oceanic ridge runs all the way around the Earth. The ridge is made by magma (molten rock), rising up from beneath the Earth's crust. As the rock cools, solidifies and spreads outwards, the ocean floor spreads wider. Meanwhile, other parts of the ocean floor are gradually sinking down beneath the continents in deep-ocean trenches, the deepest places on Earth.

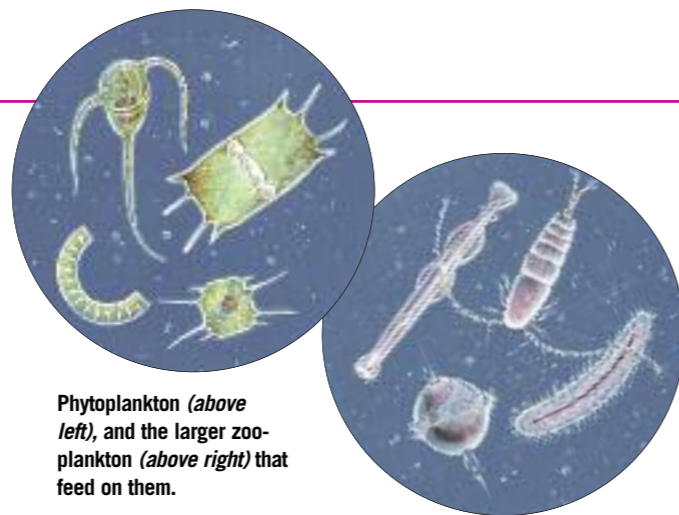
## SURFACE WATERS

THE RICHEST VARIETY of life in the oceans is found in the surface waters. Here, light from the sun penetrates the water, allowing plants to grow. Unlike land plants, oceanic plants cannot put down roots into the ground. Instead, they drift through the water in the form of tiny, usually single-celled organisms, known as phytoplankton. They use sunlight and nutrients dissolved in the water to make food by the process of photosynthesis.

Phytoplankton comprise most of the plant material found in the oceans (a small amount also comes from seaweeds and shallow-water marine grasses). Able to grow very quickly, they are the first and vital stage in the food web of the oceans.

Phytoplankton are fed upon by tiny animals called zooplankton. These include the larvae (young) of fish, as well as tiny relatives of crabs and shrimps, known as copepods. They rise and fall through the water, using the surface currents to carry them along to new grazing areas. Plankton is richest in those parts of the ocean where nutrients are stirred up from the ocean floor

by currents or winds, such as

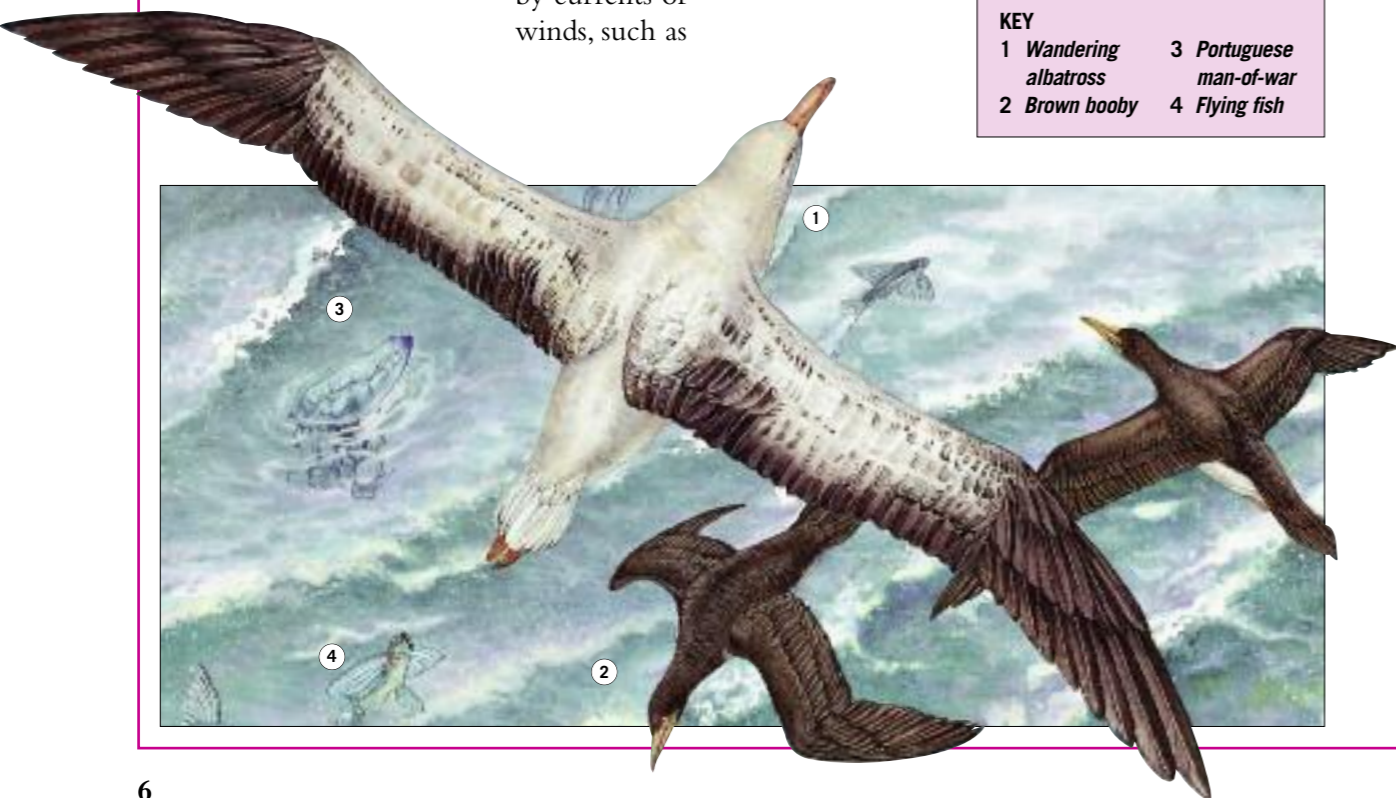


Phytoplankton (above left), and the larger zooplankton (above right) that feed on them.

on the continental shelf (see page 4). In some oceans, the amount of plankton in the water peaks in the spring and autumn. Many plankton-eating animals breed or migrate to coincide with these peaks.

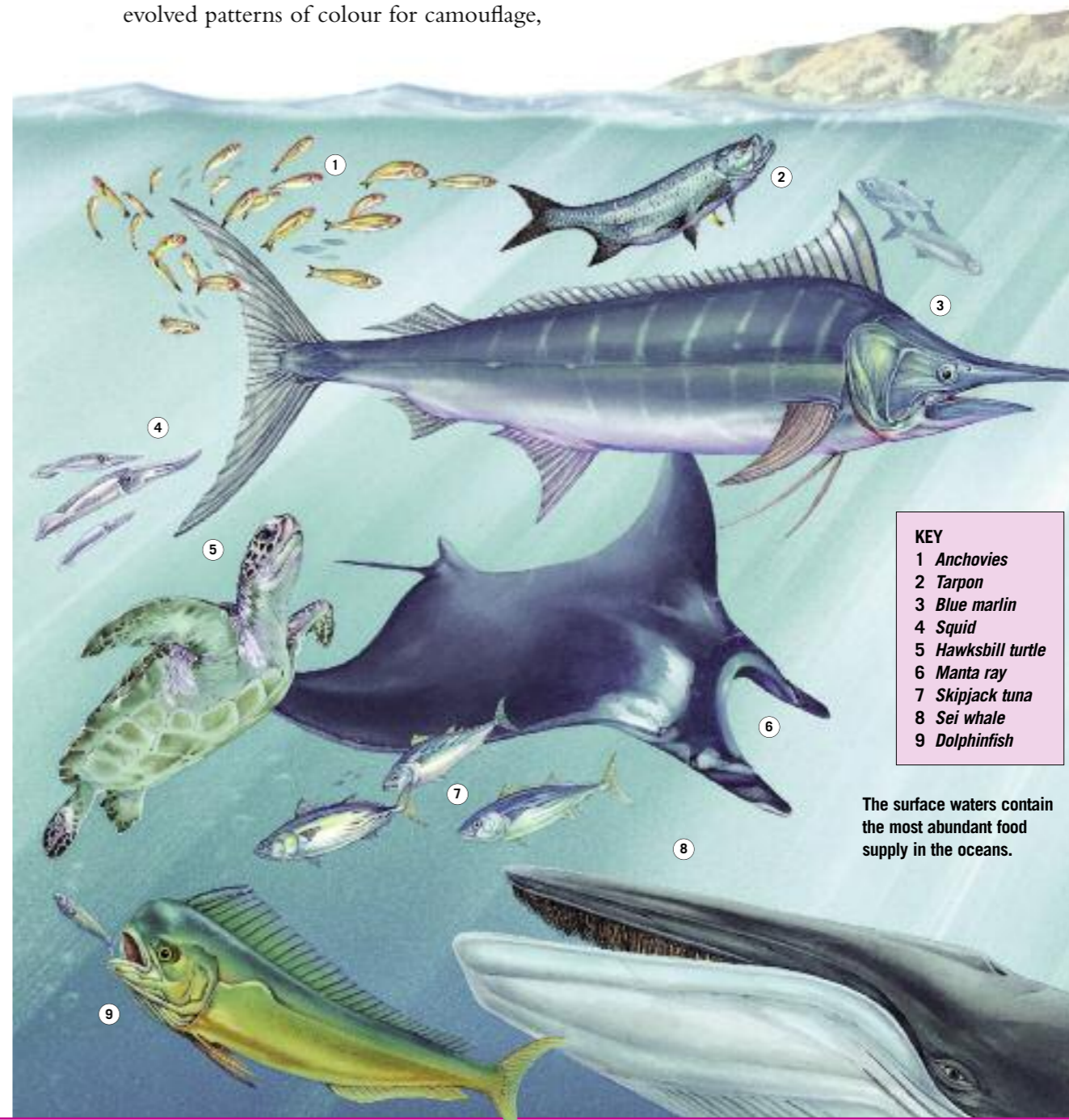
Zooplankton provide food for a wide range of ocean animals. In an attempt to escape attention, many zooplankton have confusing colour patterns, and some are even transparent. Fish and squid are major predators of zooplankton, and shoals of small fish throng the surface waters. They in turn attract larger predators. The Portuguese man-of-war floats on the surface, trailing its stinging tentacles down to catch small fish.

KEY	
1 Wandering albatross	3 Portuguese man-of-war
2 Brown booby	4 Flying fish



Sea birds (see illustration, opposite) glide over the ocean waves, looking out for fish. Some birds scoop up fish from the surface with their beaks or feet, while others, such as the booby, dive right into the water to grab their prey. Below the surface, small fish are preyed upon by larger, fast-moving predatory fish, such as tuna or sharks. They also fall prey to sea turtles, and mammals such as seals, dolphins and whales. With so many different predators, many fish have evolved patterns of colour for camouflage,

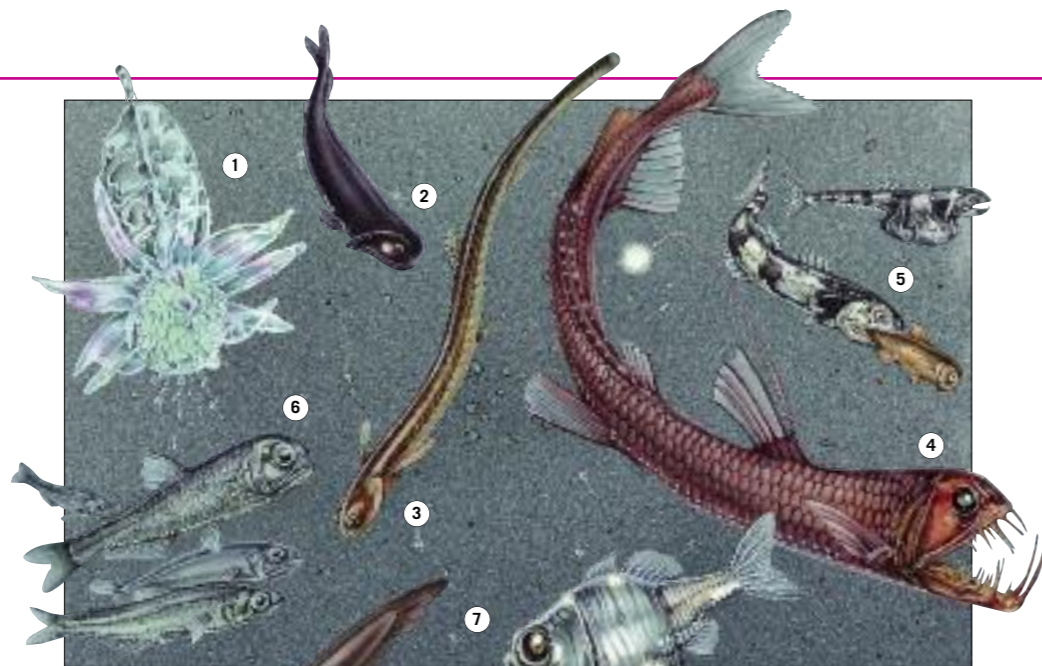
or spiny or armoured skin, for protection. The surface waters are home to some of the largest animals in the world. Many of these, however, feed on the smallest creatures of all, zooplankton. Baleen whales, such as the blue whale or the sei whale, as well as some sharks like the basking shark, take in great mouthfuls of water and filter out vast quantities of a shrimp-like zooplankton called krill.



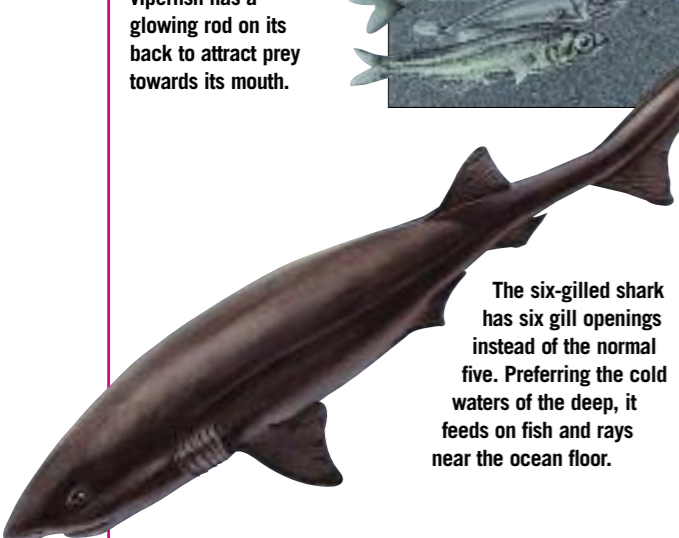
KEY	
1 Anchovies	2 Tarpon
3 Blue marlin	4 Squid
5 Hawksbill turtle	6 Manta ray
7 Skipjack tuna	8 Sei whale
9 Dolphin	

The surface waters contain the most abundant food supply in the oceans.

Between 200 metres and 1000 metres deep, there is an area of water known as the twilight zone. Hatchetfish, lanternfish, and the deadly siphonophore, a kind of jellyfish, migrate up towards the surface to feed. Barracudinas prey on any fish they can find, their stomachs expanding to take large prey. The viperfish has a glowing rod on its back to attract prey towards its mouth.



**KEY**  
 1 Siphonophore 4 Viperfish 6 Lanternfish  
 2 Loosejaw 5 Barracudinas 7 Hatchetfish  
 3 Argentine



The six-gilled shark has six gill openings instead of the normal five. Preferring the cold waters of the deep, it feeds on fish and rays near the ocean floor.

## DEEPWATER LIFE

LIGHT CANNOT penetrate very far through water, so after a depth of about 200 metres there is little light, and below 1000 metres the water is completely black and very cold. Phytoplankton cannot survive here, and the amount of animal life is greatly reduced. As there is no source of plant material to feed on, any creatures living in the deep waters need to find alternative sources of food.

Some scavenging deepwater animals feed on the dead plant and animal matter that rains down through the water from the surface waters above. Others, such as the hatchetfish, travel up towards the surface to feed, then return to the depths. On the way, they must avoid falling victim to the many predatory deepwater animals that patrol the dark waters.

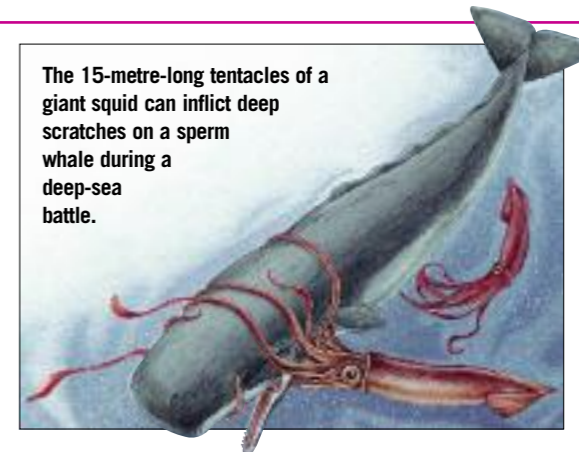
Animals that live in the deep waters all the time need to be specially adapted to survive. They are mostly small, and their bodies are frail and lacking in muscle mass. These factors reduce the amount of energy, and therefore food, needed to maintain their bodies. They have large, extremely sensitive eyes to see in the near-black waters. Many are coloured brown or black for camouflage, to conceal themselves from predators. Some prawns are bright red, but this colour is invisible at such depths.

Predators must adapt to an even greater extent in an environment where prey is scarce, and where there may be long periods of time between each successful attack. Fish such as the viperfish have long jaws and extremely long, needle-sharp teeth, which are backward-pointing for stabbing and holding on to their prey. To take advantage of any prey animal they encounter, many predators, such as the gulper eel, have huge jaws and stomachs that can stretch to hold fish even larger than themselves.

Despite the blackness of the water, there is still some light in the depths of the ocean. Some deepwater animals are able to produce light from their own bodies, either from their tissues or from special light-producing organs. This feature is known as bioluminescence. These lights may act as a lure to prey animals, or as a signal to others of the same species in the search for mates.

They may also be “flashed” on and off to confuse an attacker.

The 15-metre-long tentacles of a giant squid can inflict deep scratches on a sperm whale during a deep-sea battle.



As well as the small predators that live in the deep, larger animals also visit deep waters to hunt for prey. Deep-living sharks and deep-diving whales feed on fish and squid. Although whales need to come to the surface to breathe, some are able to stay underwater for long periods of time. The sperm whale may dive to 3000 metres below the surface, and stay there for up to two hours in search of its favourite prey, giant squid.



**KEY**  
 1 Vampire squid  
 2 Anglerfish  
 3 Gulper eels  
 4 Anglerfish  
 5 Prawns

Many of the animals that live in the deepwater zone look quite terrifying—apart from their small size. The glowing “lamp” hanging from the head of the anglerfish family attracts smaller fish which mistake it for prey, only to be snapped up themselves. Some anglerfish have teeth that lie flat and then spring back around their prey when it is inside their mouths. The gulper eel conserves energy by lying in wait and ambushing its prey.

## OCEAN FLOOR

AT THE LEVEL of the ocean floor, about 4500 metres deep, the water is completely black, and very cold. Animals living there cannot use sight to find their food—in fact, many are blind. Instead, they have highly-developed senses of touch, or are able to detect chemical changes in the water that lead them to a food source.

The floor of the oceans is covered with a thick layer of ooze, made up of sand, mud and tiny particles of rock, as well as debris from plant and animal life in the waters above. Some animals feed on this debris by burrowing into the ooze or creeping across it. Their digestive systems are specially adapted to process a diet of animal remains, including skeletons and droppings.

With their bases rooted in the ooze and their tentacles waving in the water, sea pens, relatives of corals and sea anemones, look almost like plants. Sponges such as the Venus flower basket also bed themselves into the ooze, filtering out debris from the water. Spiky-skinned sea urchins and their relatives, the sea cucumbers, have branched tentacles, known as tube-feet, beneath their bodies. Some of these help them to move across or burrow into the ooze, while others gather food from the water or the ocean floor, and pass it to the mouth.

As well as the scavengers, predatory animals are also found on the ocean floor. Sea spiders pick their way across the floor, their very long legs keeping them out of the soft ooze. They feed on sponges and burrowing worms.

Only a few kinds of fish are found close to the ocean floor. Among these is the rat-tail, which has a large head and a long body which tapers into an even longer tail. It makes a loud drumming noise by vibrating muscles attached to its swim bladder (the organ that keeps it afloat). This may be a way of signalling to others of its kind.

The tripod fish, as its name suggests, holds itself off the ocean floor on a “tripod” made of its long, stilt-like fins and tail. It sinks the tips of its fins into the soft surface of the ooze, to support its body. Another pair of fins is held up in the air to detect the movements of passing prey, whereupon the tripod fish pushes itself forward to feed.



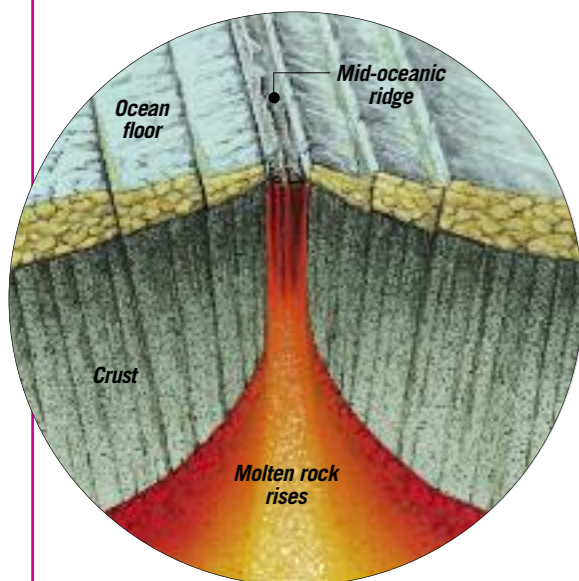
The ocean floor is littered with human waste, including old fishing nets, cans and bottles and wrecks of sunken ships. Found on all parts of the ocean floor, especially beneath major shipping lanes, is clinker, burnt coal dumped from steamships during the period between the 1850s and 1950s.



- KEY**
- 1 Rat-tail
  - 2 Sea pen
  - 3 Prawn
  - 4 Sea cucumber
  - 5 Tripodfish
  - 6 Sea cucumber
  - 7 Venus flower baskets
  - 8 Sea spider
  - 9 Sea cucumber
  - 10 Sea pens
  - 11 Sea urchin

# BLACK SMOKERS

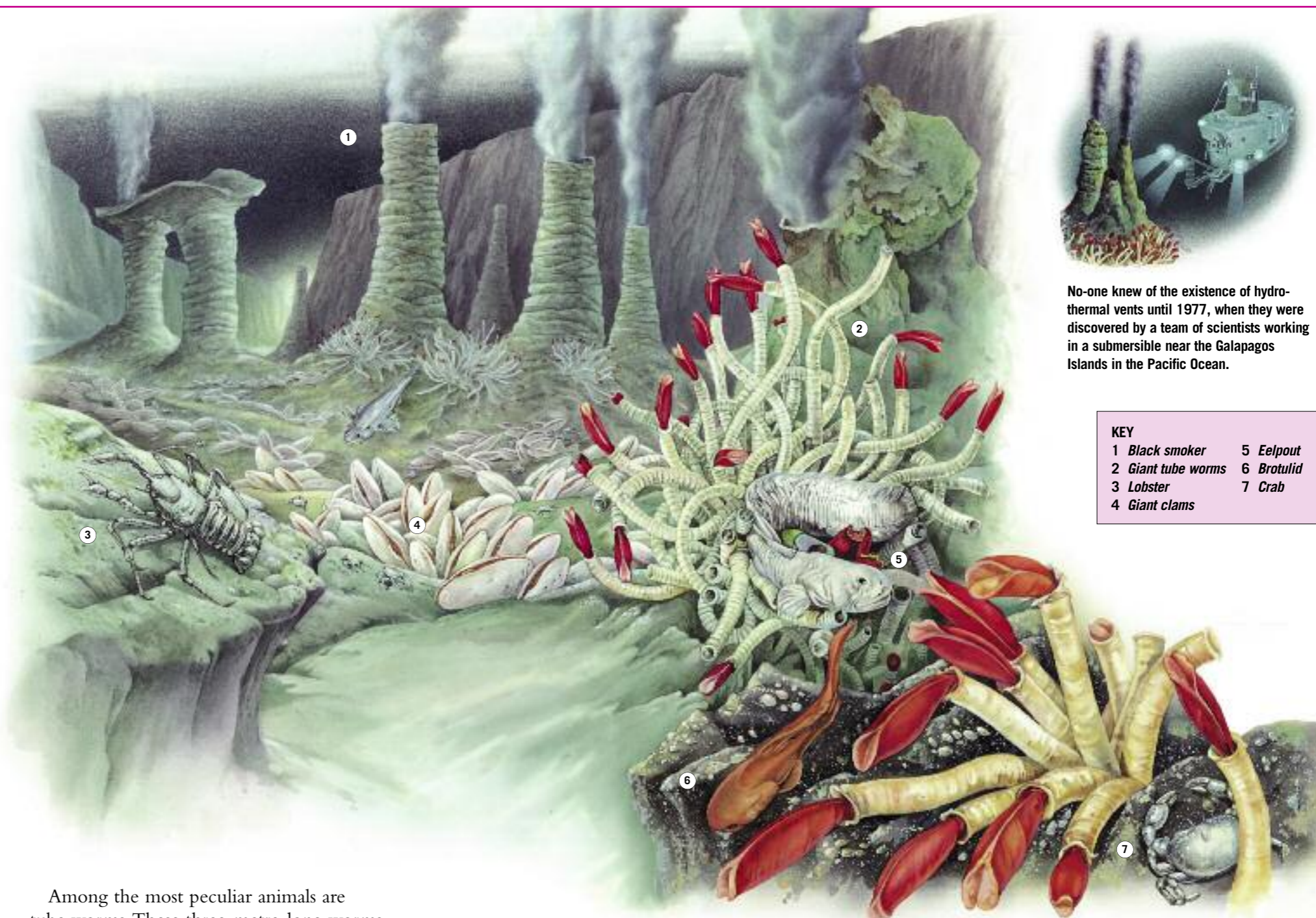
**S**NAKING ACROSS the ocean floor are undersea mountain chains known as mid-oceanic ridges. Here, the Earth's crust is gradually spreading apart and magma, hot molten rock from beneath the crust, rises to the surface of the sea bed. In some places along a mid-oceanic ridge, water seeping down into the rocks is heated by the magma. It shoots up through cracks in the ocean floor, known as hydrothermal vents.



As magma rises, it spreads apart the old rocks of the ocean floor. It then solidifies, forming a new part of the ocean floor.

These jets of water are rich in minerals from the Earth's crust, especially sulphur. As the minerals emerge, they are gradually deposited around the vents, creating tall chimneys. The sulphur turns the waters around the vents black, and gives these chimneys their name: "black smokers".

Most of the deep-sea ocean floor is very cold, with little animal life to be found. The temperature of the water shooting out of the black smokers, however, can be higher than 300°C. In the warm, mineral-rich water close by, an amazing amount of life flourishes. Some creatures are found nowhere else in the world, and several kinds reach enormous sizes.



No-one knew of the existence of hydrothermal vents until 1977, when they were discovered by a team of scientists working in a submersible near the Galapagos Islands in the Pacific Ocean.

**KEY**

- 1 Black smoker
- 2 Giant tube worms
- 3 Lobster
- 4 Giant clams
- 5 Eelpout
- 6 Brotulid
- 7 Crab

Among the most peculiar animals are tube worms. These three-metre-long worms cluster together in intertwined masses, most of their red bodies hidden inside white tube shells. Giant clams also thrive around the black smokers, while white, eyeless crabs and lobsters scavenge for scraps of food stirred up by the warm, swirling waters. Even a few kinds of fish live here, including the eelpout and members of a group of long-bodied fishes called brotulids, which prefer to live in dark places.

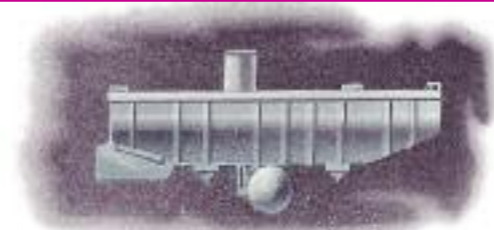
Without sunlight to grow plants, life around the black smokers relies on bacteria, which convert the sulphur dissolved in the water into food. This process is known as chemosynthesis. The bacteria provide food for some animals, which are then prey for predators. Tube worms and giant clams actually have bacteria inside their bodies to make food for them, as they do not have mouthparts or guts to feed themselves.



A small creature looking a little like a dandelion is also found near the black smokers. A kind of siphonophore (see page 8), related to the jellyfish, this animal holds itself above the sea bed with fine tentacles. Other tentacles, armed with stinging cells, capture its prey.

## OCEAN TRENCHES

THE DEEPEST places on Earth, ocean trenches are formed when the huge plates that make up the Earth's surface push together, forcing one to slide beneath the other. This creates great chasms in the ocean floor that can plunge down to 10,000 metres deep. At such depths, the water pressure is crushing, and the movement of the ocean floor creates frequent underwater earthquakes. Incredibly, there are some animals that can survive even here.

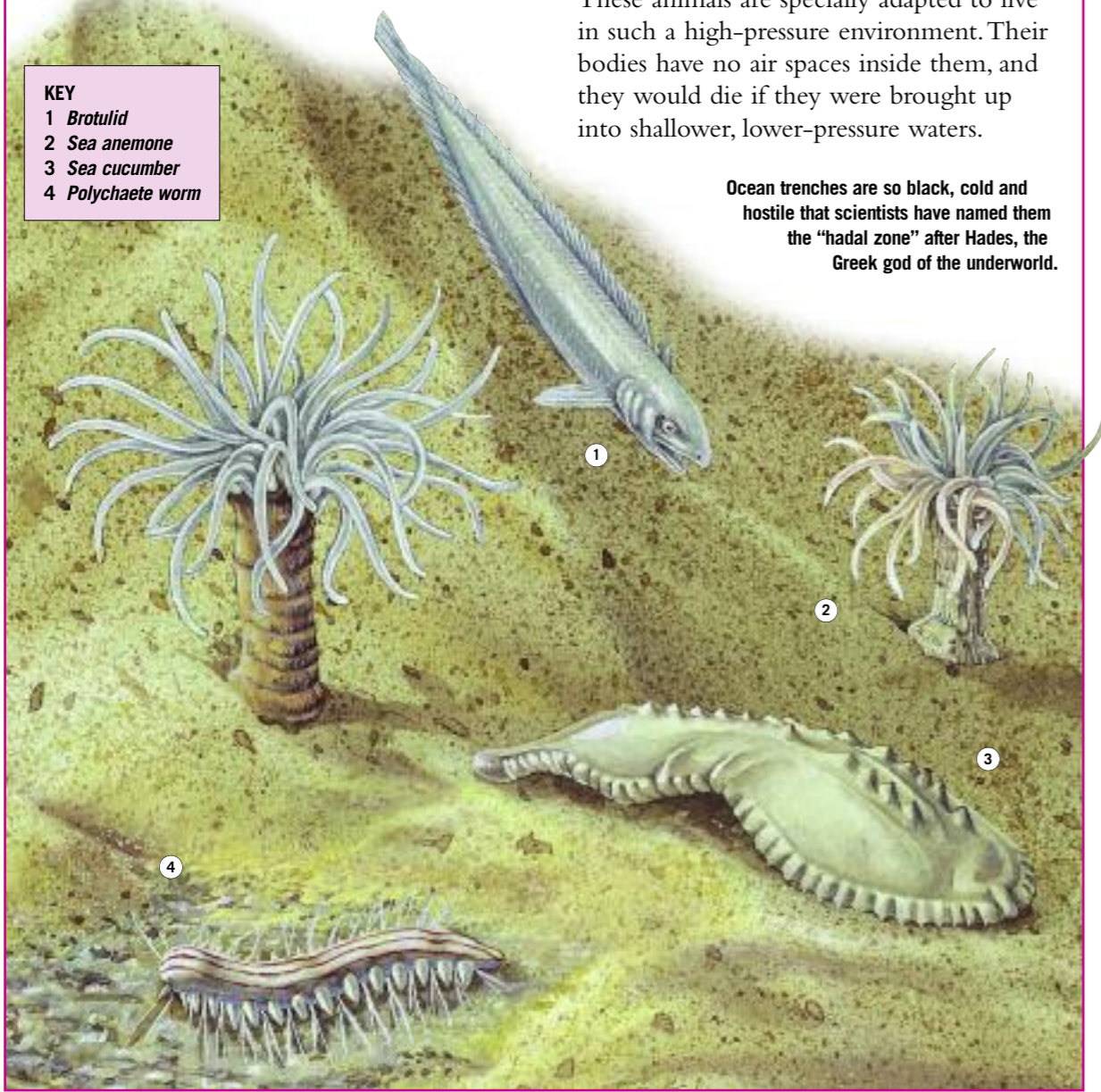


In 1960, scientists descended 10,911 metres into the Marianas Trench in the Pacific Ocean, in the submersible *Trieste*.

Sea cucumbers (see page 10) creep across the ooze that gathers at the bottom of the trench. Worms and sea anemones burrow into the sand to avoid predators such as brotulid fish, the world's deepest-living fish. These animals are specially adapted to live in such a high-pressure environment. Their bodies have no air spaces inside them, and they would die if they were brought up into shallower, lower-pressure waters.

Ocean trenches are so black, cold and hostile that scientists have named them the "hadal zone" after Hades, the Greek god of the underworld.

- KEY**  
 1 *Brotulid*  
 2 *Sea anemone*  
 3 *Sea cucumber*  
 4 *Polychaete worm*



Modern submersibles can travel to the deepest parts of the oceans. The scientists inside breathe air that is stored on board, and can direct the submersible through the water. Submersibles have strong searchlights, as the waters are pitch black below about 1000 metres. They have cameras for the scientists to take photographs or video footage. Some of the most fascinating parts of the ocean, such as hydrothermal vents (see page 12), were discovered by scientists in submersibles. Deep-sea creatures never seen before have also been photographed and identified.



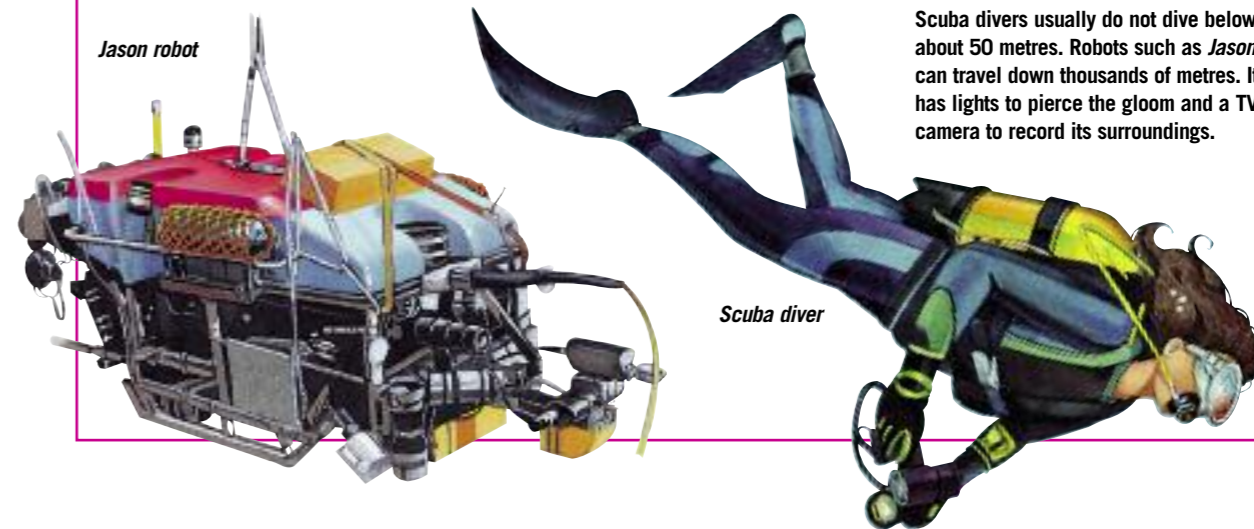
## OCEAN EXPLORATION

IN ORDER to explore the vast areas below the surface of the oceans, humans need to be able to travel to great depths without having to return to the surface every few minutes to breathe. Nineteenth-century divers wore heavy suits and dome-like helmets, with pipes leading up to the surface through which air was pumped. The invention of the scuba diving system, where air was carried in a tank on the diver's back, gave divers much more freedom.

However, below about 50 metres, water pressure makes the air in the tanks too

concentrated. Divers who want to go deeper into the oceans have to breathe a different mixture of gases. After diving in deep, high-pressure waters, they enter a diving bell to return to surface pressure before they move up through the water. This stops nitrogen bubbles building up inside their blood, giving them the "bends".

At greater depths, divers use underwater vehicles called submersibles, which have thick metal walls to withstand the pressure of the water. Robot vehicles controlled from the surface, with cameras and sample-gathering equipment, are also used.



Scuba divers usually do not dive below about 50 metres. Robots such as *Jason* can travel down thousands of metres. It has lights to pierce the gloom and a TV camera to record its surroundings.



# OCEAN GIANTS

SOME OF the largest animals in the world live in the oceans. They can grow so large because the water supports their huge bodies. On land, even air-breathing mammals such as whales would die, collapsed under their own weight. They can also grow to enormous sizes because of the abundance of food in the oceans. The vast quantities of plant and animal plankton (see pages 6-7) supports all ocean life, either by providing food for small animals that are then eaten by larger ones, or by feeding the large animals directly.

In fact, some of the largest whales and sharks in the oceans feed only on tiny zooplankton such as krill, which are only five centimetres long. The 30-metre-long

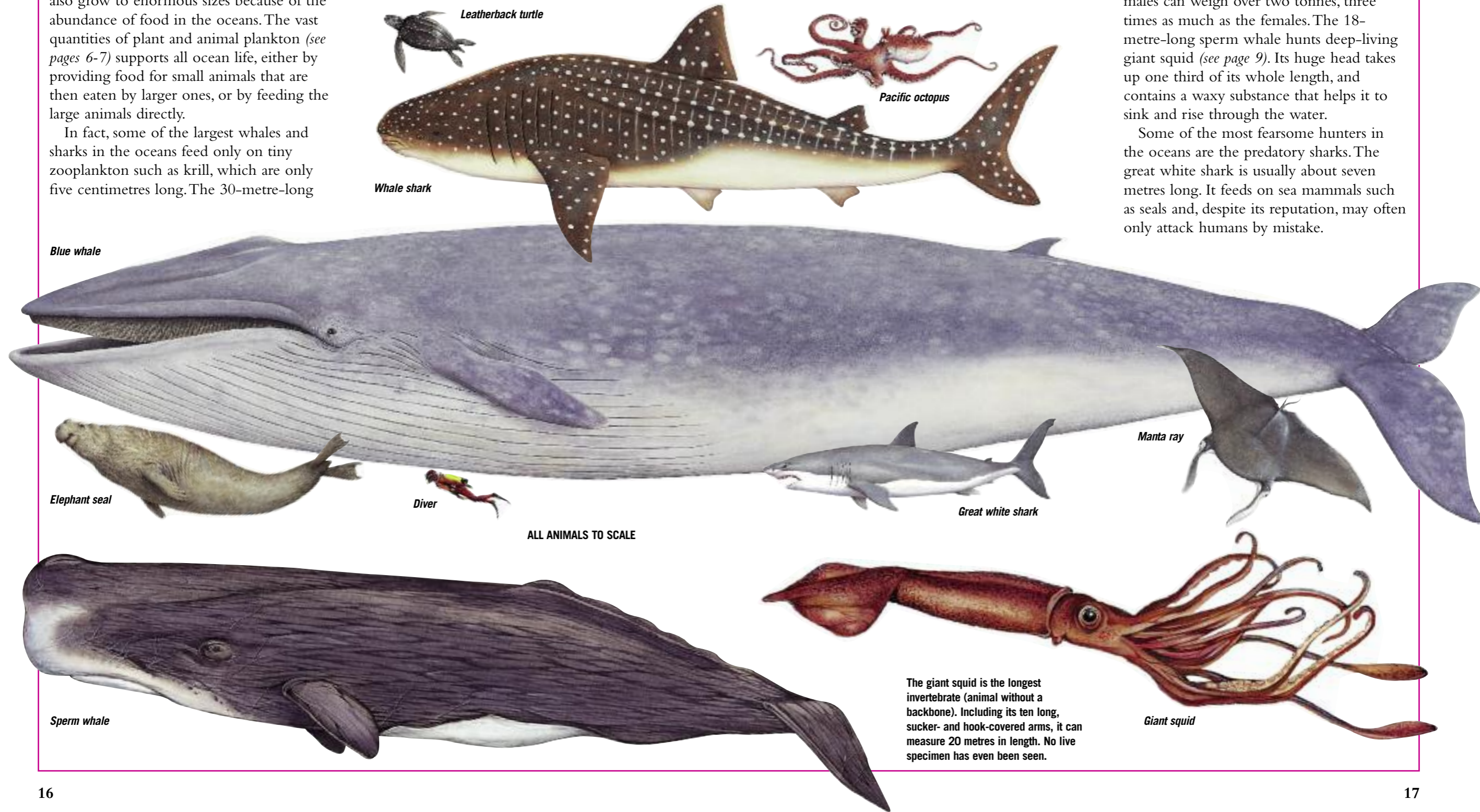
blue whale eats four tonnes of krill every day, but as krill reproduce very quickly, they remain abundant. Blue whales and other plankton-eaters migrate to the polar regions during the summer. They feed on the high densities of plant and animal plankton that build up due to the rise in temperature and long hours of sunlight.

The 15-metre-long whale shark and the six-metre-wide manta ray also feed on plankton, as well as on tiny fish. Unlike the blue whale, which filters plankton from the water through the horny plates in its mouth, these giants filter plankton through their gill slits. The whale shark has many teeth, but they are tiny and useless.

Other ocean giants are predators of larger fish and other animals. The leatherback turtle, almost two metres in length, dives to 900 metres or more in search of jellyfish to eat. The Pacific octopus lives on the ocean floor. It grabs crabs and lobsters with its long arms, which can span nine metres.

Elephant seals feed on fish and squid. The males can weigh over two tonnes, three times as much as the females. The 18-metre-long sperm whale hunts deep-living giant squid (see page 9). Its huge head takes up one third of its whole length, and contains a waxy substance that helps it to sink and rise through the water.

Some of the most fearsome hunters in the oceans are the predatory sharks. The great white shark is usually about seven metres long. It feeds on sea mammals such as seals and, despite its reputation, may often only attack humans by mistake.



Blue whale

Whale shark

Leatherback turtle

Pacific octopus

Elephant seal

Diver

Great white shark

Manta ray

Sperm whale

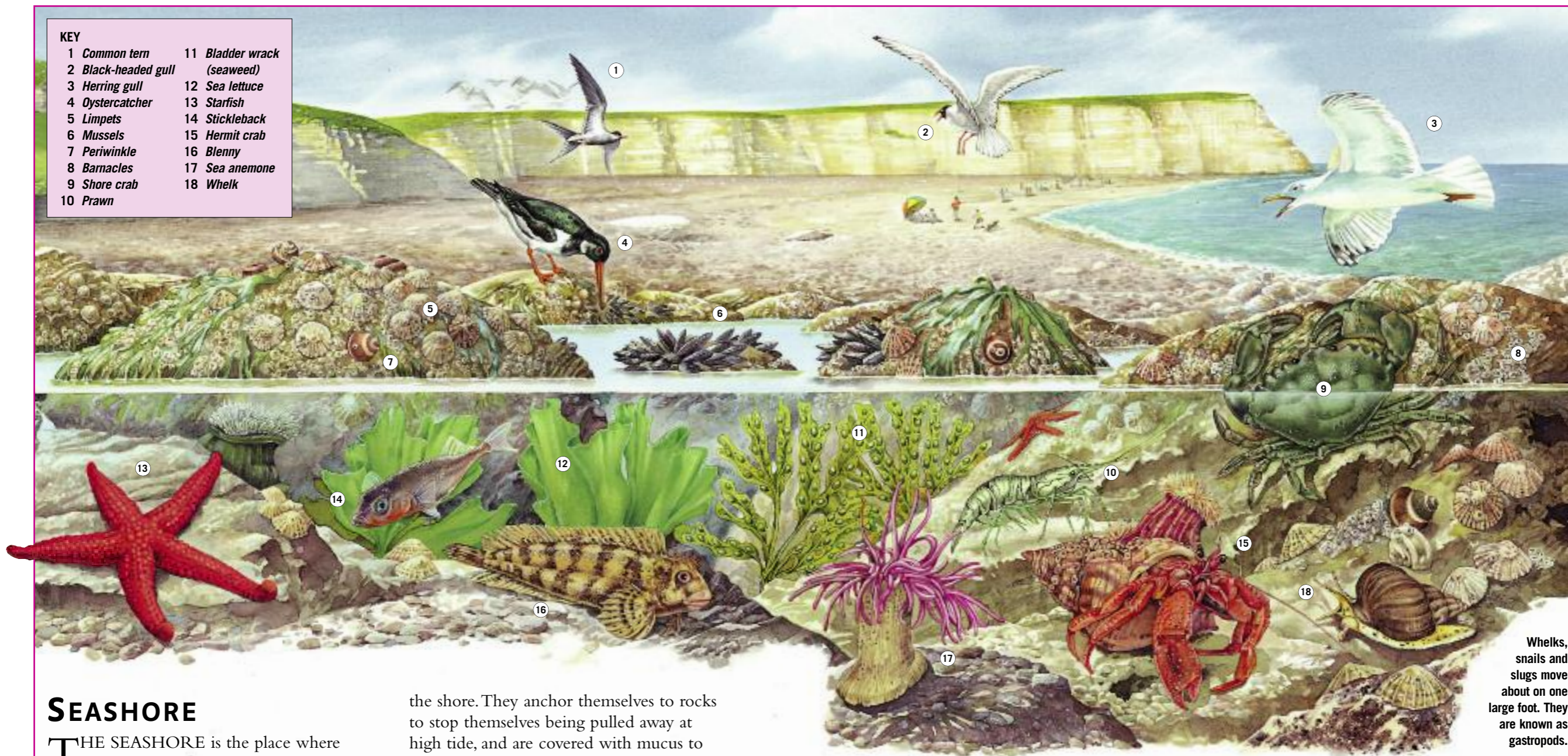
ALL ANIMALS TO SCALE

The giant squid is the longest invertebrate (animal without a backbone). Including its ten long, sucker- and hook-covered arms, it can measure 20 metres in length. No live specimen has even been seen.

Giant squid

**KEY**

1 Common tern	11 Bladder wrack
2 Black-headed gull	(seaweed)
3 Herring gull	12 Sea lettuce
4 Oystercatcher	13 Starfish
5 Limpets	14 Stickleback
6 Mussels	15 Hermit crab
7 Periwinkle	16 Blenny
8 Barnacles	17 Sea anemone
9 Shore crab	18 Whelk
10 Prawn	



## SEASHORE

**T**HE SEASHORE is the place where the land meets the sea. It can consist of rocky cliffs, a sandy beach or mudflats bordering a river mouth or estuary. The animals and plants that live there must be able to survive the tides that cover them in salt water at certain times of the day, and leave them exposed to the air at other times. They live at different levels on the seashore according to how well they can survive out of water.

Many kinds of seaweed dry out easily, and are found low down on the shore where they are covered with water all the time. Other more hardy varieties live further up

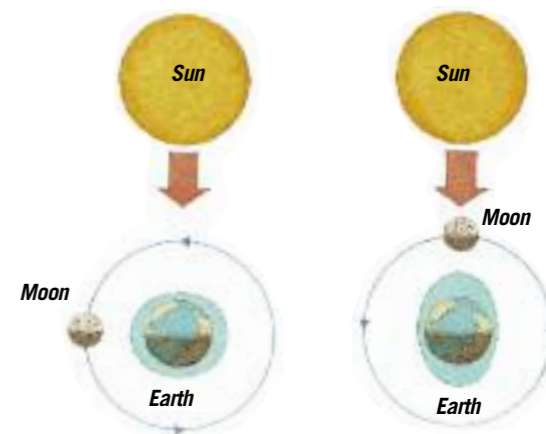
the shore. They anchor themselves to rocks to stop themselves being pulled away at high tide, and are covered with mucus to hold in moisture when the tide goes out.

Animals that live on sandy or muddy shores burrow into the ground at low tide, to keep moist and cool. On rocky shores, mussels clamp their shells tightly together, while limpets attach themselves to wet rocks to stop themselves drying out. This also prevents them from being pulled away by powerful waves when the tide comes back in. On some shores, tidal pools form between rocks. These are rich in life, including animals such as starfish, sea anemones and small fish, which could not otherwise survive so far up the shore.

In rock pools (*above*), algae growing on the rocks are eaten by limpets, snails and periwinkles, which are themselves prey for starfish and whelks. Seaweeds are also a source of food, as well as a cool, damp shelter when the tide goes out. Crabs such as the hermit crab, which takes over the shell of a dead animal, scavenge on animal debris. Birds such as oystercatchers and gulls probe the pools and shore for worms, fish and shelled animals.

Every day, sea levels rise and fall in the movement of the tides. Tides are caused by the pull of the Moon's gravity on the Earth. As the Earth rotates, the ocean waters on the side of the Earth closest to the Moon (and the opposite side) are pulled into a bulge, causing a high tide (*right*). The rest of the Earth has a low tide. When the Sun and Moon are in line, the Sun's gravity increases the pull to give extra-high and extra-low tides (*far right*).

Whelks, snails and slugs move about on one large foot. They are known as gastropods.



# CORAL REEFS

CORAL is found in tropical shallow waters around volcanic islands or close to rocky mainland coastlines. It is made from layers of the skeletons of tiny animals called polyps. Over many years, colonies of polyps can build up great banks of coral,

As fish, starfish and sea urchins feed on algae growing on corals, they break off pieces of dead coral. These form the sandy beaches often found on coral reefs.

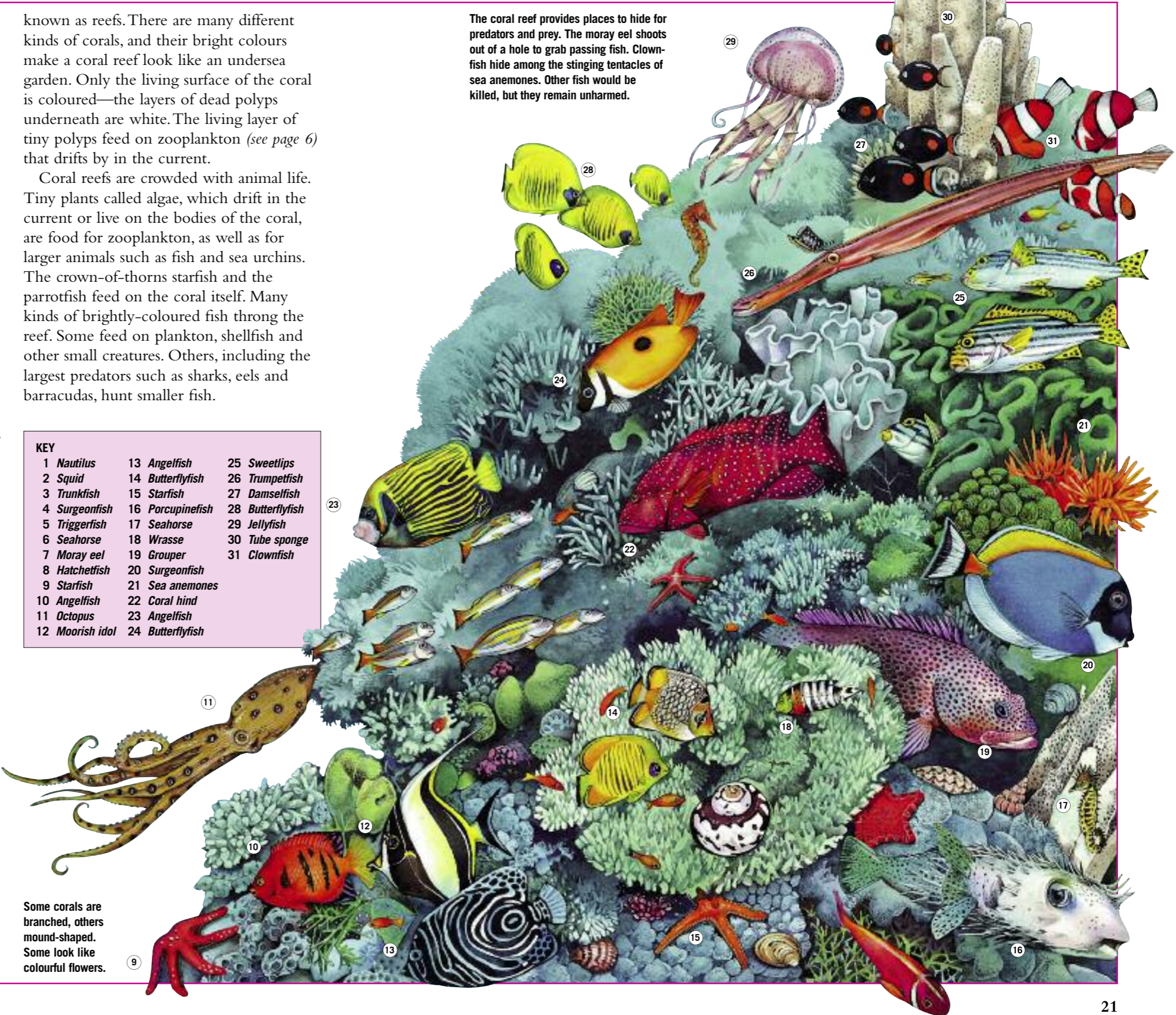
known as reefs. There are many different kinds of corals, and their bright colours make a coral reef look like an undersea garden. Only the living surface of the coral is coloured—the layers of dead polyps underneath are white. The living layer of tiny polyps feed on zooplankton (see page 6) that drifts by in the current.

Coral reefs are crowded with animal life. Tiny plants called algae, which drift in the current or live on the bodies of the coral, are food for zooplankton, as well as for larger animals such as fish and sea urchins. The crown-of-thorns starfish and the parrotfish feed on the coral itself. Many kinds of brightly-coloured fish throng the reef. Some feed on plankton, shellfish and other small creatures. Others, including the largest predators such as sharks, eels and barracudas, hunt smaller fish.

The coral reef provides places to hide for predators and prey. The moray eel shoots out of a hole to grab passing fish. Clownfish hide among the stinging tentacles of sea anemones. Other fish would be killed, but they remain unharmed.

KEY		
1 Nautilus	13 Angelfish	25 Sweetlips
2 Squid	14 Butterflyfish	26 Trumpetfish
3 Trunkfish	15 Starfish	27 Damsel fish
4 Surgeonfish	16 Porcupinefish	28 Butterflyfish
5 Triggerfish	17 Seahorse	29 Jellyfish
6 Seahorse	18 Wrasse	30 Tube sponge
7 Moray eel	19 Grouper	31 Clownfish
8 Hatchetfish	20 Surgeonfish	
9 Starfish	21 Sea anemones	
10 Angelfish	22 Coral hind	
11 Octopus	23 Angelfish	
12 Moorish idol	24 Butterflyfish	

Some corals are branched, others mound-shaped. Some look like colourful flowers.



# MANGROVES

**M**ANGROVE FORESTS are found on sheltered, tropical coastlines. They are formed in places such as the mouths of rivers, where flowing salt water lays down mud and other deposits, resulting in swampy land. The roots of mangrove trees are flooded with salt water when the tide comes in. To avoid drowning, mangrove trees have shallow root systems, that branch up above the water line. This allows for the breathe and also acts as a support for the rest of the tree. The tangled mass of roots traps nutrient-rich mud which provides food for many kinds of animals.

The trees and plants of a mangrove forest are home to numerous insects, while many kinds of fish swim through the shallow water between the tangled roots. Crabs, snails and other small creatures burrow into or crawl across the mud. These animals provide food for frogs and a wide variety of birds. Several kinds of monkey clamber between the trees, feeding on fruits and leaves. They are constantly on the lookout for large predators, such as snakes and crocodiles, which slip through the water or bask on the mudflats.

Fiddler crabs scavenge in the mud at the water's edge. Their huge claws are used to attract a mate or threaten a rival. In the shallows, the archer fish spits a jet of water at insects or spiders that are sitting on leaves above the surface, making them fall into the water.



On the coastline of South-east Asia, the rainforest merges into mangrove swampland. Wading birds such as storks feed on crabs and fish, while smaller birds hunt for insects and snails. The proboscis monkey (so-called because of the male's long, drooping nose, or proboscis) clammers through the trees. It will swim through flooded areas of forest, but must beware of hungry tigers, crocodiles and giant snakes.

In the mud left between tides, a fish called the mudskipper skips along on its fins. It breathes using water stored in a chamber near its gills, and can also take in oxygen through its skin. At high tide, most mudskippers retreat into their burrows under the mud. Those left above ground often climb trees to avoid predatory fish.

- KEY**
- 1 *Rafflesia*
  - 2 *Tiger*
  - 3 *Reticulated python*
  - 4 *Proboscis monkey*
  - 5 *Banded pitta*
  - 6 *Gavial*
  - 7 *Milky woodstork*
  - 8 *Mudskippers*



The blue-footed booby (left), nests on the steep cliff faces of the Galapagos Islands, off the coast of South America. It plunges into the water to feed on fish and squid. The male and female take it in turns to sit on their eggs.

The only lizards to feed in the sea, marine iguanas (below) are also found in the Galapagos Islands. They bask in the sun to warm up before diving into the water to graze on seaweed and algae 15 metres below the surface.

## ISLAND LIFE

CUT OFF FROM the continental land masses by stretches of ocean water, islands often have a range of plant and animal life that is uniquely their own. Some islands were once part of a larger land mass, while others are formed by underwater volcanoes. As soon as an island forms, it begins to be colonized by plants and animals. Islands close to the mainland are colonized more quickly than remote ones.

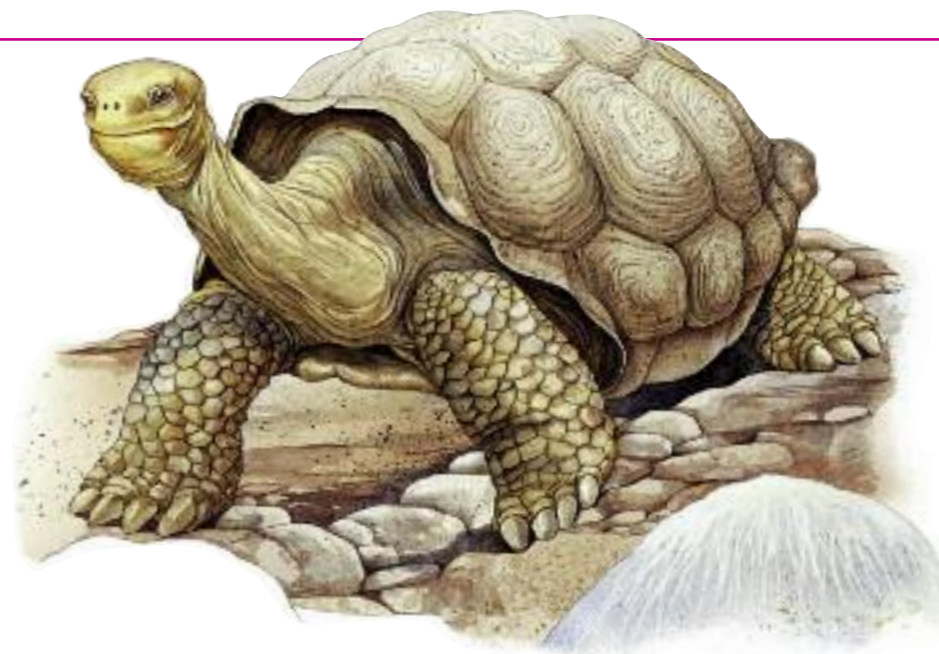
The coconut palm is one of the few trees that can disperse their seeds over long distances. The large coconuts have a waterproof outer coating that allows them to float for thousands of miles to remote islands.



Birds and swimming animals such as seals are often the first animals to arrive on a new island. As well as carrying seeds on or inside their bodies, they carry insects and other tiny creatures. Insects are also blown to islands on the winds. As they increase in population, they provide food for more and more animals.

Land animals sometimes find their way to newly-formed islands on rafts of vegetation torn from mainland coasts by savage storms. Others are brought to islands by humans. On remote islands, some animal species die out, while others are able to adapt to their new surroundings, and build up a breeding population. Over many years, new kinds of animals can evolve which are unique to their island environment.

Many kinds of island-living birds nest in large colonies on remote cliffs, to avoid predators that may steal their eggs. Puffins dig burrows to nest in, or sometimes take over deserted rabbit burrows. They dive into the water to catch tiny sand eels.

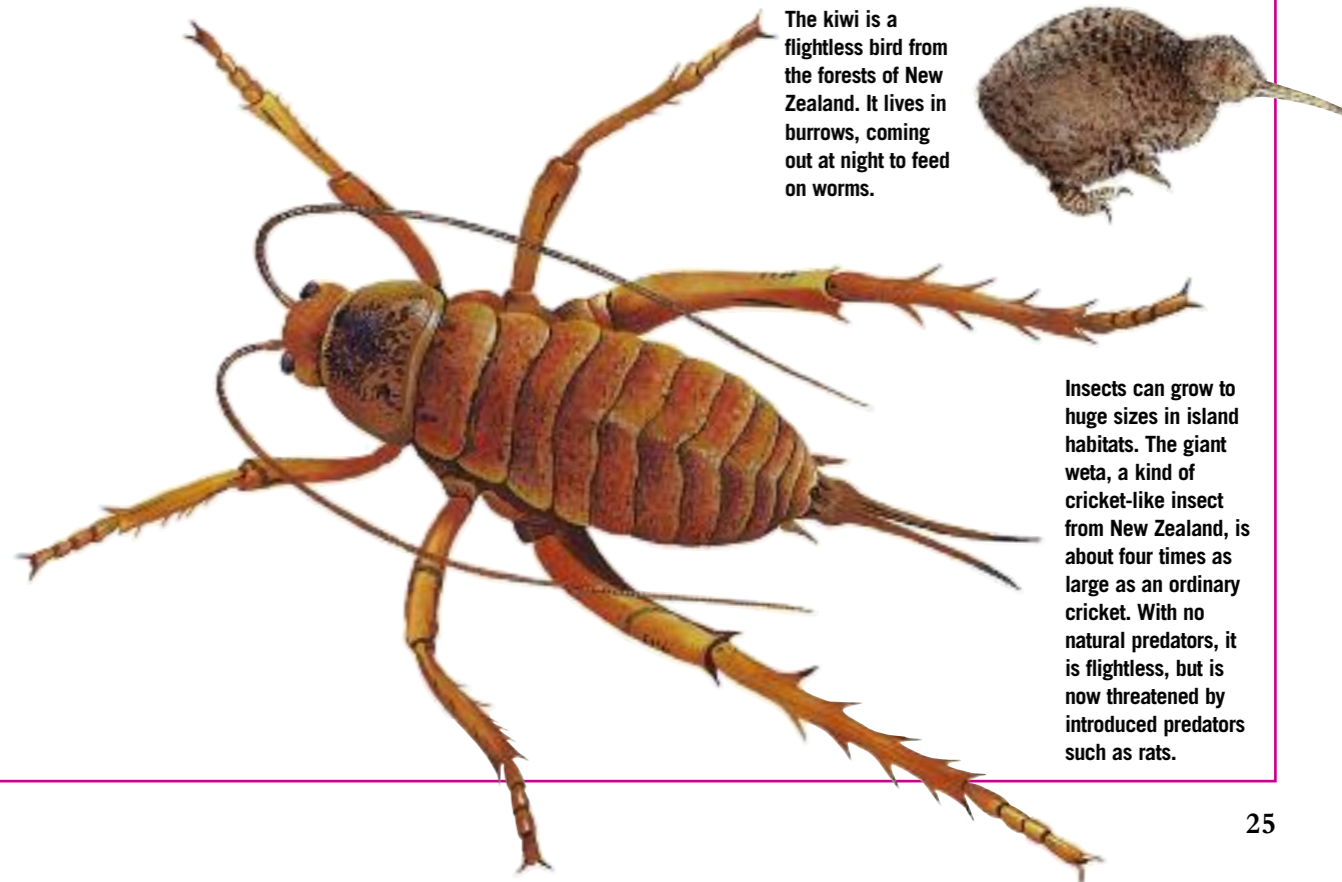


Giant tortoises (left) are found in the Galapagos Islands and also in the Seychelles, in the Indian Ocean. They have grown very large due to a lack of predators. Some giant tortoises graze on low grasses, and have a broad shell that fits close to the neck. Others have domed shells with high, arched openings, allowing them to stretch their necks up to taller vegetation. The introduction by humans of grazing animals reduces the tortoises' food supply and threatens their survival.

Large predators are often absent from islands, which means that some island animals do not need to be small and fast-moving. They can grow to larger sizes than their mainland relatives. It also means that some birds no longer need their escape mechanism of flight. Their wings become small and useless, and they spend all their time on the ground. This adaptation makes

many flightless birds, such as the kakapo, a New Zealand parrot, easy prey when predators are later introduced by humans.

With a relatively small variety of animal life, competition between island species is reduced. One bird can eat a wide range of foods, which on the mainland would "belong" to several different birds. If more animals arrive, this lifestyle is threatened.



The kiwi is a flightless bird from the forests of New Zealand. It lives in burrows, coming out at night to feed on worms.

Insects can grow to huge sizes in island habitats. The giant weta, a kind of cricket-like insect from New Zealand, is about four times as large as an ordinary cricket. With no natural predators, it is flightless, but is now threatened by introduced predators such as rats.

## ARCTIC

MUCH OF THE Arctic Ocean is covered with a thick layer of floating ice all year round. At its edges, rafts of broken ice, called pack ice, drift in the freezing cold waters. During the summer, some of the ice cracks and melts, forming waterways and large stretches of water.

No plants can grow on the Arctic ice, so most life is found in the waters around it. During the summer, the days become longer, and the sun warms the waters. Phytoplankton, tiny plant material that floats in the water, quickly grows and multiplies in these conditions, providing food for millions of tiny animals called zooplankton (see page 6).

With the sudden increase in zooplankton, many animals migrate to the Arctic during the summer to exploit this rich source of food. Fish, squid, birds and even giant whales feed on the zooplankton. A shrimp-like kind called krill is a particular favourite. Seals hunt the fish, while walrus search for shellfish and crabs on the sea bed with their sensitive whiskers. The largest predators in the waters are killer whales, which feed on fish and seals, while on the ice the huge polar bear roams. Its white coat is perfect camouflage while it waits to grab a seal as it emerges from a hole in the ice to breathe.

In winter, most of the ocean freezes over again, and the days are short and dark. Without sunshine to make food, phytoplankton cannot grow. Zooplankton sink into the depths of the ocean, where they feed on one another, or off fat reserves stored during the summer. Most of the larger animals migrate south to find new sources of food. Polar bears are among the few animals that remain. Some roam the ice or nearby land during the winter, while others dig dens in the snow to shelter from the harsh weather until the spring. Here females give birth to their cubs.



- KEY**  
 1 Arctic tern  
 2 Polar bear  
 3 Bearded seal  
 4 Narwhal  
 5 Walrus

Many whales gather in the Arctic Ocean during the summer, but the narwhal lives there all year round. Male narwhals have a long, spiralling tusk, which is actually one of their two teeth. This may be used for fighting. Narwhals eat fish, squid, crabs and shrimp.

## TUNDRA

THE LAND that borders the Arctic Ocean is treeless, and the soil is permanently frozen. For most of the year, this region, known as tundra, is a barren wilderness, where plant and animal life is scarce. During the short summer, however, the ice in the top layer of the ground melts, and small plants can grow.

Herds of caribou or reindeer (above, 1) arrive from the taiga forests to the south, to feed on the new growth. The melted ice forms boggy patches where insects thrive, providing food for migrant birds. Small mammals such as lemmings (2) that have spent the winter beneath the snow, are preyed upon by Arctic foxes and owls (3).



# ANTARCTICA

**T**HE CONTINENT of Antarctica is a huge, mountainous landmass, much of it covered by a permanent icecap almost three kilometres thick in some places. It is the coldest place in the world. In winter, the waters of the Southern Ocean surrounding the continent are covered with floating pack ice and icebergs that have broken off the edges of the coastal ice shelf. Bitter winds sweep up snow from the ground into fierce blizzards.

The only places where plants can grow on this barren land are along the coasts and around the Antarctic Peninsula. Even then, they are mostly tiny mosses and lichens growing on the rocks. There is not enough food on the land to feed anything larger than small insects, so the animals of Antarctica are clustered around the coasts and islands, where the ocean waters provide them with plenty of food.



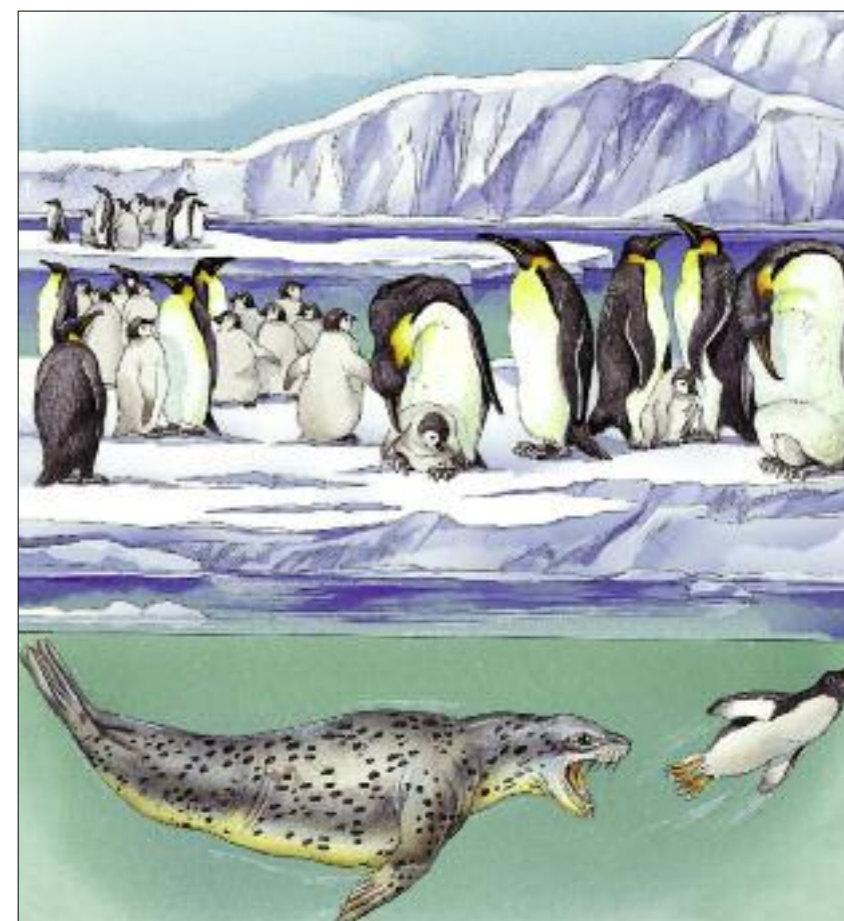
In summer, humpback whales migrate thousands of kilometres from their tropical breeding grounds to feed in the Antarctic.

Just as in the Arctic, the main source of food for many animals is plankton. Phytoplankton and zooplankton (see page 6) thrive in the Antarctic, due to nutrient-rich currents and upwellings that swirl through the cold waters. Fish throng the waters, feeding on the zooplankton. Whales also migrate to the Antarctic to feed on vast quantities of krill. Despite its name, the crabeater seal also feeds almost entirely on krill—the only seal to do so.

Other seals and penguins dive after fish, while sea birds such as albatrosses and terns pluck the fish from the surface. Penguins and seals come out on to land to breed or rest, but when they return to the water, they are in danger from hunting killer whales and the ferocious leopard seal.

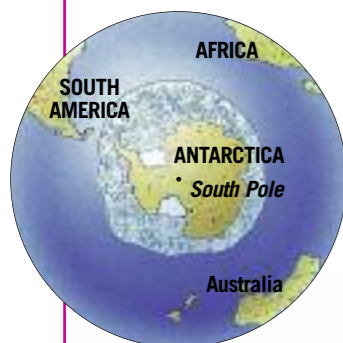
Antarctica is home to several kinds of penguins. They spend most of their lives at sea, coming ashore to breed in large colonies on the ice. Emperor penguins are the largest. After their eggs are laid, the females return to the sea to feed. The males look after the eggs, carrying them on their feet to keep them off the ice. In the coldest weather, they huddle together in circular groups. Six weeks later, the chicks hatch, the mothers return and the fathers can finally feed.

Adélie penguins are the favourite food of the leopard seal, which will also eat young seals, even of its own kind. Adélie penguins are so fearful of this hunter that they hesitate at the water's edge, none daring to be first to take the plunge.



Antarctic animals are specially adapted to survive the cold, icy conditions and winds of up to 200 kilometres per hour. They have thick fur or feathers, and many also have a layer of fat, called blubber, to keep them

warm. Some insects can survive being frozen during winter and defrosted in summer, while some kinds of fish have a natural “anti-freeze” in their blood to stop them freezing in the icy waters.



The ice cap extends across Antarctica. There are only a few small areas where the ice melts enough for plants to grow. No people live there permanently, although explorers and scientists visit. At the edge of the coastal ice shelf, colonies of penguins gather (below), feeding on fish in the cold waters.



# ENDANGERED OCEANS

**T**HE EARTH'S OCEANS contain a huge volume of water. Nevertheless, they have been subjected to extensive pollution in recent years, endangering the lives of plants and animals, and quite possibly storing up harmful consequences for the planet as a whole.

Many of the waste products that pollute the oceans come from the land. Modern chemicals that are sprayed on to crops to kill pests often do not decay naturally. Rainwater washes them into rivers, from where they eventually flow down into the ocean. Chemical fertilizers spread over fields also flow from rivers into estuaries and coastal waters. They encourage the unnatural growth of some kinds of algae, which reduce the amount of oxygen in the water and kill off other life. Raw, untreated sewage from our homes has the same effect when it is pumped out into the ocean, or taken out to sea and dumped. It also contaminates shoreline sand or mud.

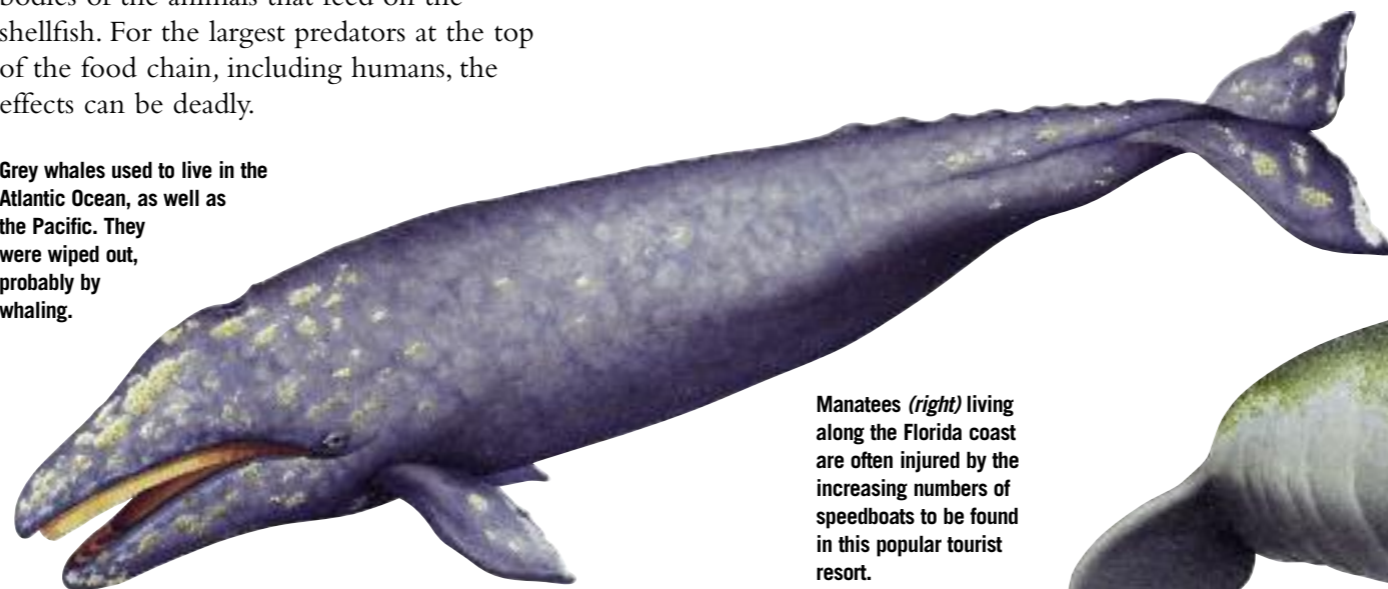
This illustration (*below*) shows some of the ways in which the oceans can be polluted. Chemicals sprayed on to fields (1) run off into rivers, and then into the sea. Some factories discharge chemicals straight into the sea (2), through large pipes. Others take it out to sea and dump it there, sometimes in large containers that fall on to the sea bed (3). A leaking oil tanker (4) can pollute whole stretches of coastline, while fishing boats (5) discard nets that are hazardous to many kinds of wildlife.



The Kemp's ridley turtle breeds mainly on one beach in Mexico. Today, the numbers of turtles arriving to breed have fallen from tens of thousands to only a few hundred.

Chemical waste from factories, including poisonous metals such as lead or mercury, is allowed to run into rivers or directly into the ocean, or is dumped at sea. The harmful chemicals collect on the sea bed, and are taken in by bottom-living animals such as shellfish. The chemicals then pass into the bodies of the animals that feed on the shellfish. For the largest predators at the top of the food chain, including humans, the effects can be deadly.

Grey whales used to live in the Atlantic Ocean, as well as the Pacific. They were wiped out, probably by whaling.



Manatees (*right*) living along the Florida coast are often injured by the increasing numbers of speedboats to be found in this popular tourist resort.



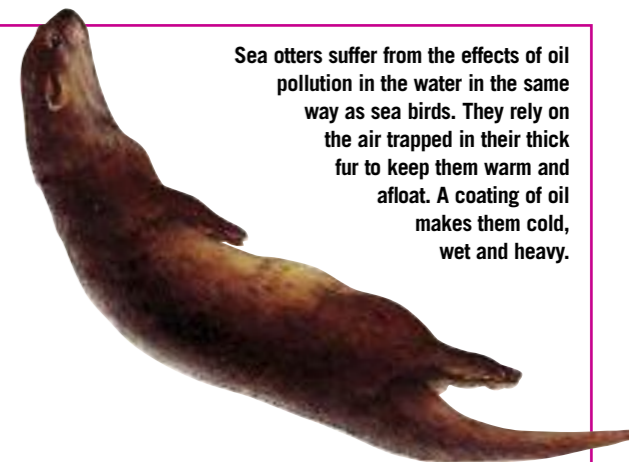
The vaquita (*right*) is a small porpoise, found only in the Gulf of California. A victim of fishing nets, there may only be a few hundred left today.



Other rubbish dumped at sea includes fishing nets and ropes from ships or boats, and household waste such as cans, bottles and plastic. This rubbish, some of which takes years to rot away, can entangle and kill ocean animals, especially birds and mammals. It also causes a hazard to people and animals when it washes up on beaches.

Another major source of ocean pollution is oil. Tankers carrying hundreds of tonnes of oil sometimes run aground, spilling their contents into the water. The oil slick may be carried ashore by the waves, polluting the coastline. Animals in the water and on the shore become coated in the sticky oil, and many die. When the feathers of sea birds become clogged with oil, they lose their warm, waterproof qualities. The birds drown, die of cold or are poisoned as they try to preen away the oil with their beaks.

Sea otters suffer from the effects of oil pollution in the water in the same way as sea birds. They rely on the air trapped in their thick fur to keep them warm and afloat. A coating of oil makes them cold, wet and heavy.



Other ocean animals have been hunted by humans. Whales were hunted for their meat and oil, while sea otters and some seals were killed for their thick fur. Sea turtles have become increasingly rare because they are killed for their meat, and their eggs are stolen to be eaten as a delicacy. Many of the beaches where they lay their eggs have been taken over by development or tourism. The turtles, along with slow-moving mammals such as manatees and whales, also suffer from collisions with boats. They can be injured or even killed by high-speed boat propellers.

Ocean life is also threatened directly, by overfishing, hunting and habitat destruction. Large-scale fishing operations, using enormous nets that can catch many fish at once, may cause some kinds of fish to decrease in number. This reduces the amount of food available for ocean animals that feed on these fish. At the same time, the nets may trap and kill animals such as dolphins and porpoises, turtles and sharks.





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