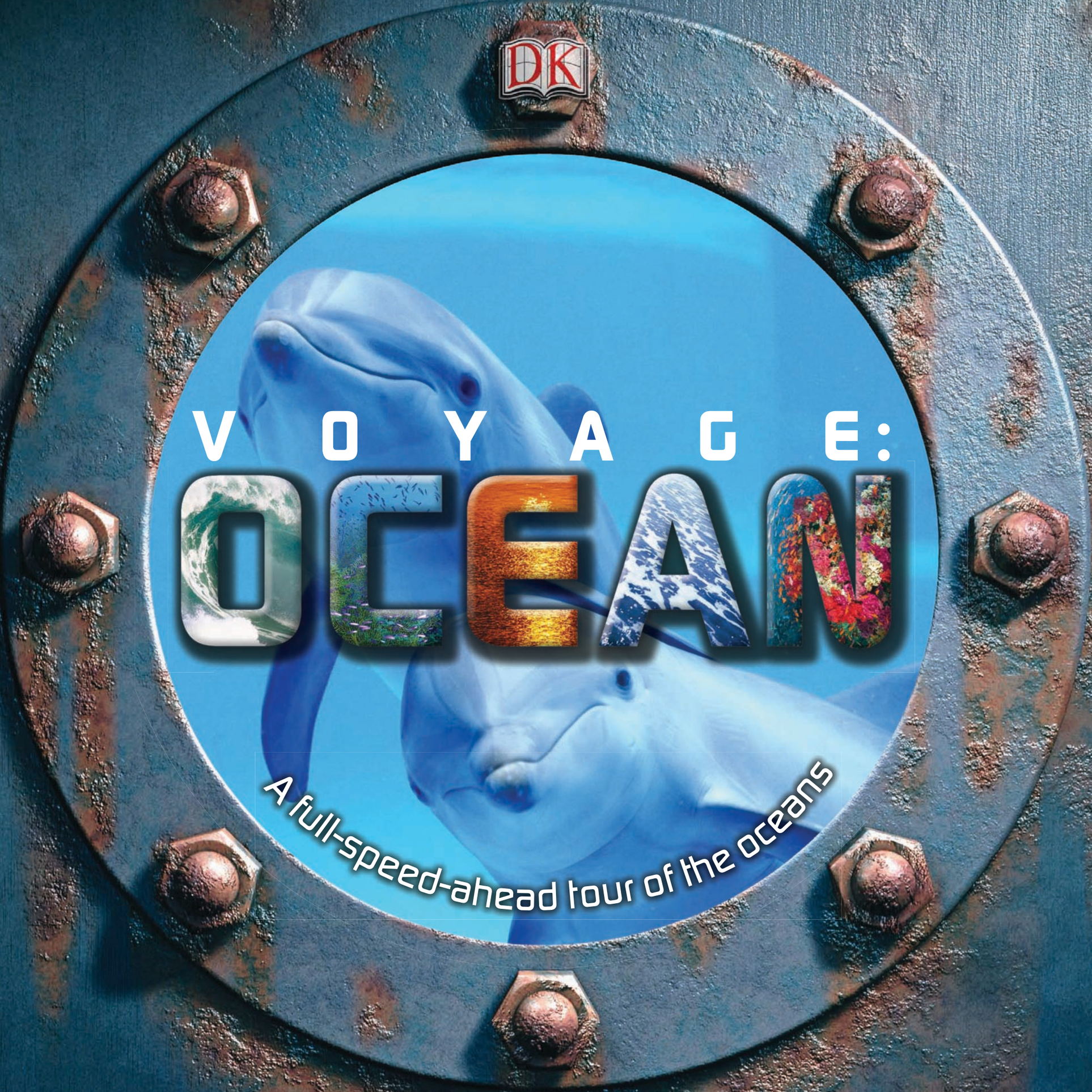
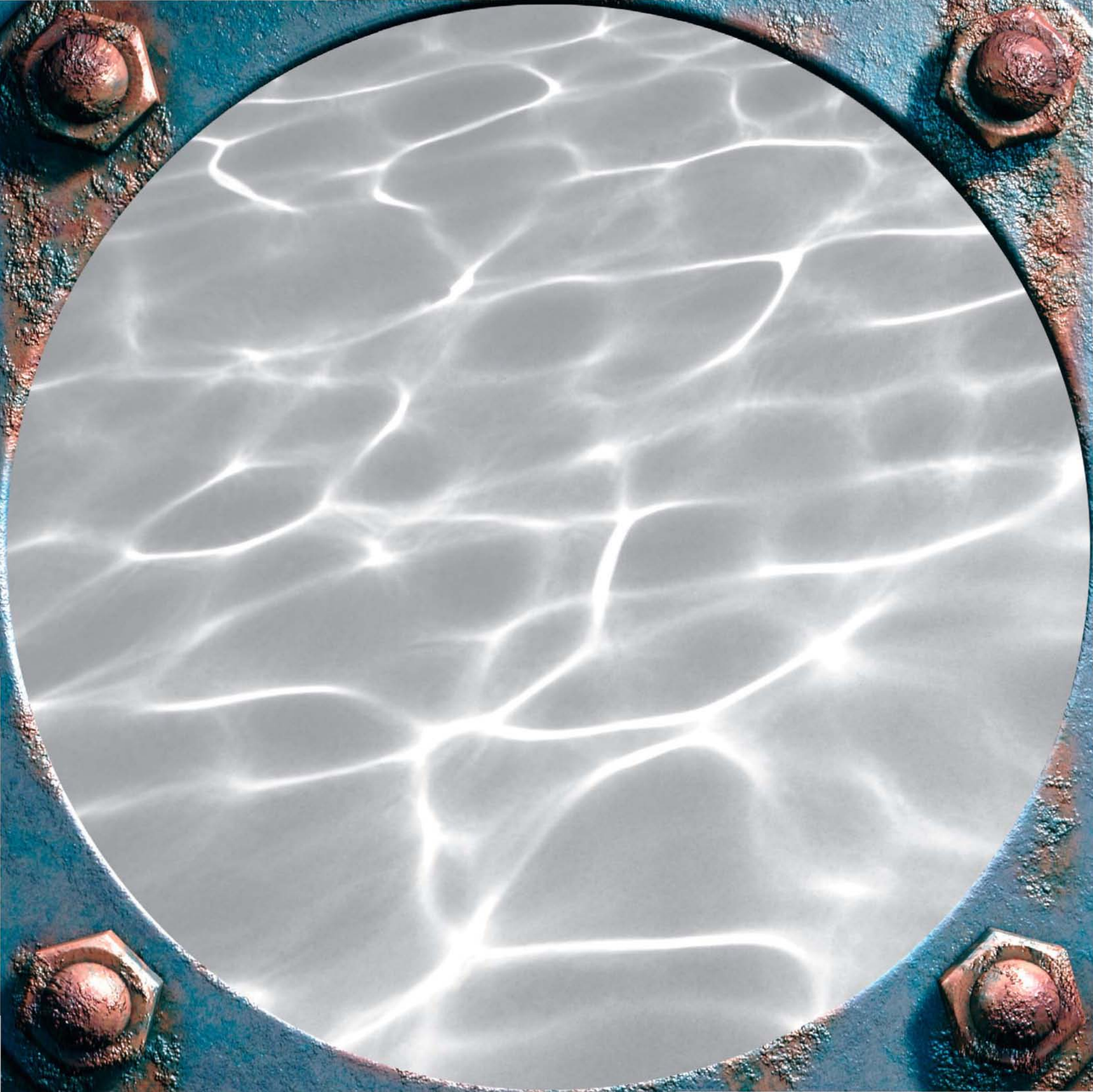
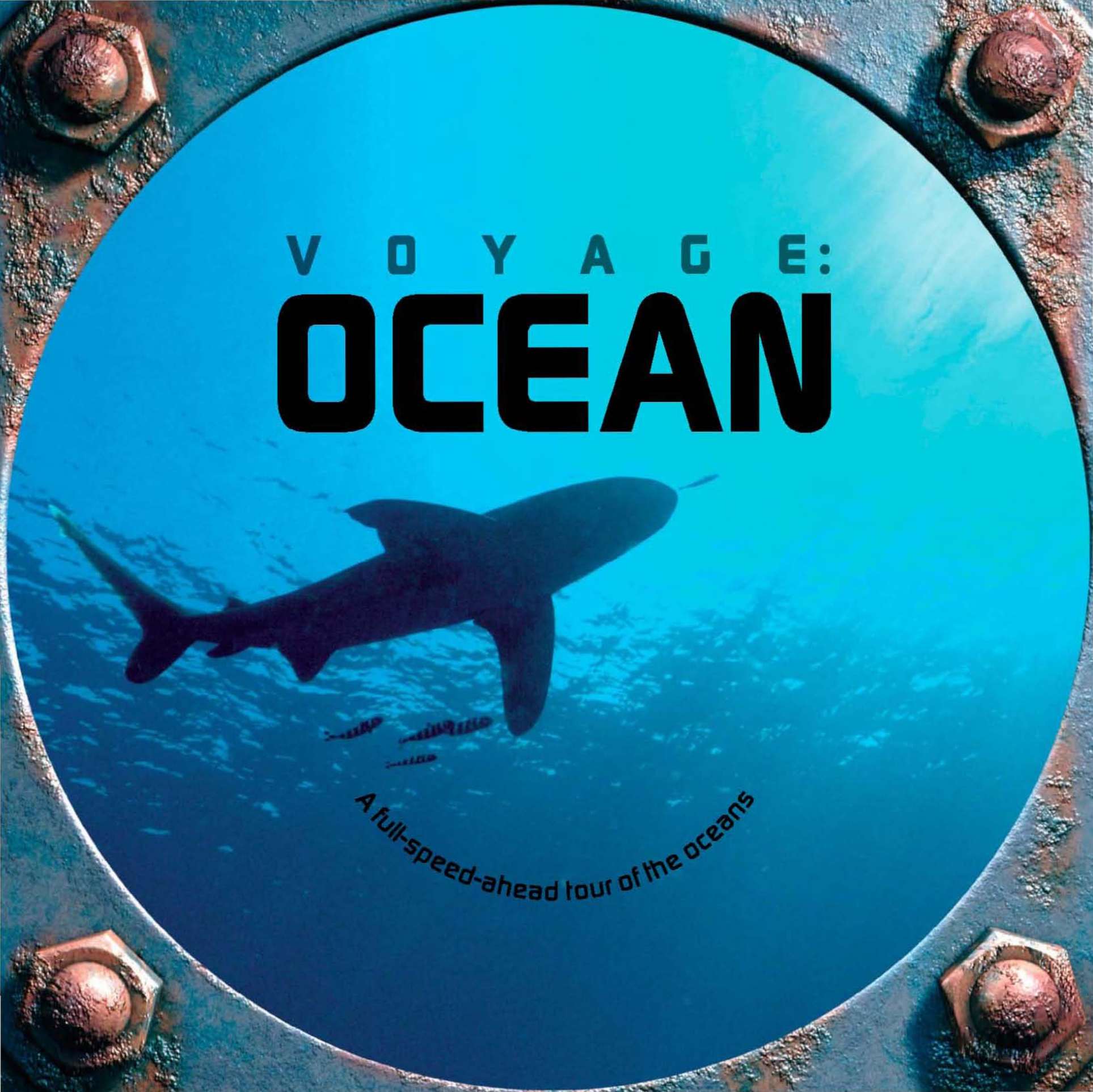

DK
VOYAGE:
OCEAN
A full-speed-ahead tour of the oceans




VOYAGE:
OCEAN
A full-speed-ahead tour of the oceans

LONDON, NEW YORK,
MELBOURNE, MUNICH, AND DELHI

Project editor Niki Foreman
Senior art editor Philip Letsu
Project art editors Spencer Holbrook, Johnny Pau
Additional editors Shaila Brown, Jenny Finch
Editorial assistant Steven Carton
Managing editor Linda Esposito
Managing art editor Diane Thistlethwaite
Publishing manager Andrew Macintyre
Category publisher Laura Buller
Picture researcher Frances Vargo
DK picture library Lucy Claxton, Romaine Werblow
Production controller Angela Graef
Production editor Andy Hilliard
Creative technical support Peter Pawsey
Jacket designer Natalie Godwin
Jacket editor Mariza O'Keeffe
Design development manager Sophia M. Tampakopoulos Turner
US editor Margaret Parrish

Consultant Professor Dorrik Stow

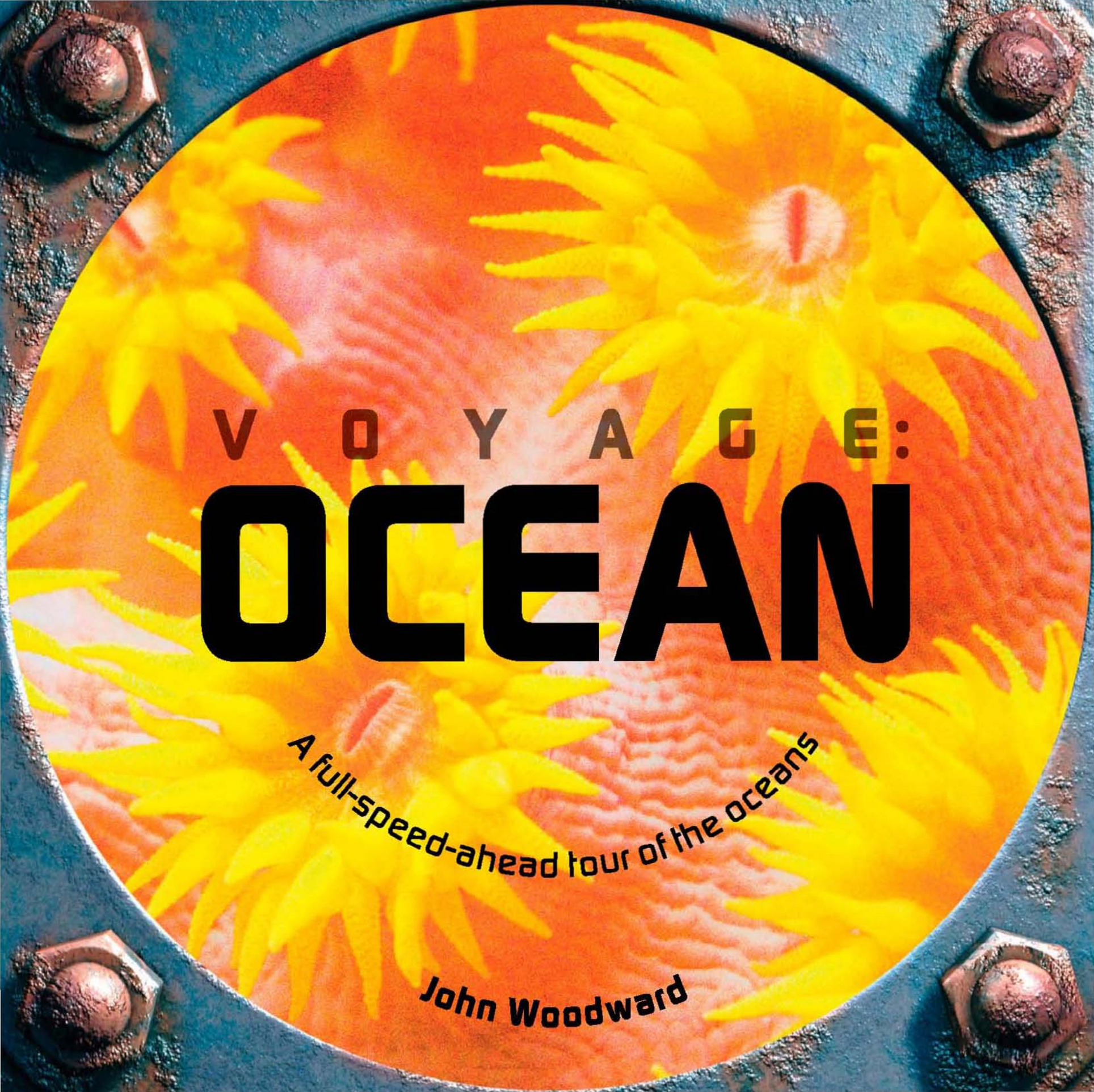
First published in the United States in 2009 by
DK Publishing, 375 Hudson Street, New York, New York 10014

09 10 11 12 13 10 9 8 7 6 5 4 3 2 1

A catalog record for this book
is available from the Library of Congress.

ISBN: 978-0-75664-548-9

Hi-res workflow proofed by MDP, UK
Design and digital artworking by
Philip Letsu and Peter Pawsey
Printed by Hung Hing, China


VOYAGE:
OCEAN
A full-speed-ahead tour of the oceans
John Woodward

CONTENTS

Porcupine Fish or Puffer Fish in its inflated state in a blue sunlit sea.

YOUR JOURNEY BEGINS

FOR THOUSANDS OF YEARS, people have been sailing across the oceans to discover new lands. But it wasn't until relatively recent times that humans started looking beneath the waves to discover a whole new hidden world, just waiting to be explored. Today, amazing technology has allowed ocean explorers to voyage into the ocean depths, unveiling a kaleidoscope of sea life, and to map the dramatic panorama of the ocean floor. Yet much of this watery world is still unknown. Now, with *Ocean*, it's time for you to embark on an exhilarating journey of the high seas and join the race to find out all there is to know about the oceans.

OCEAN PACK

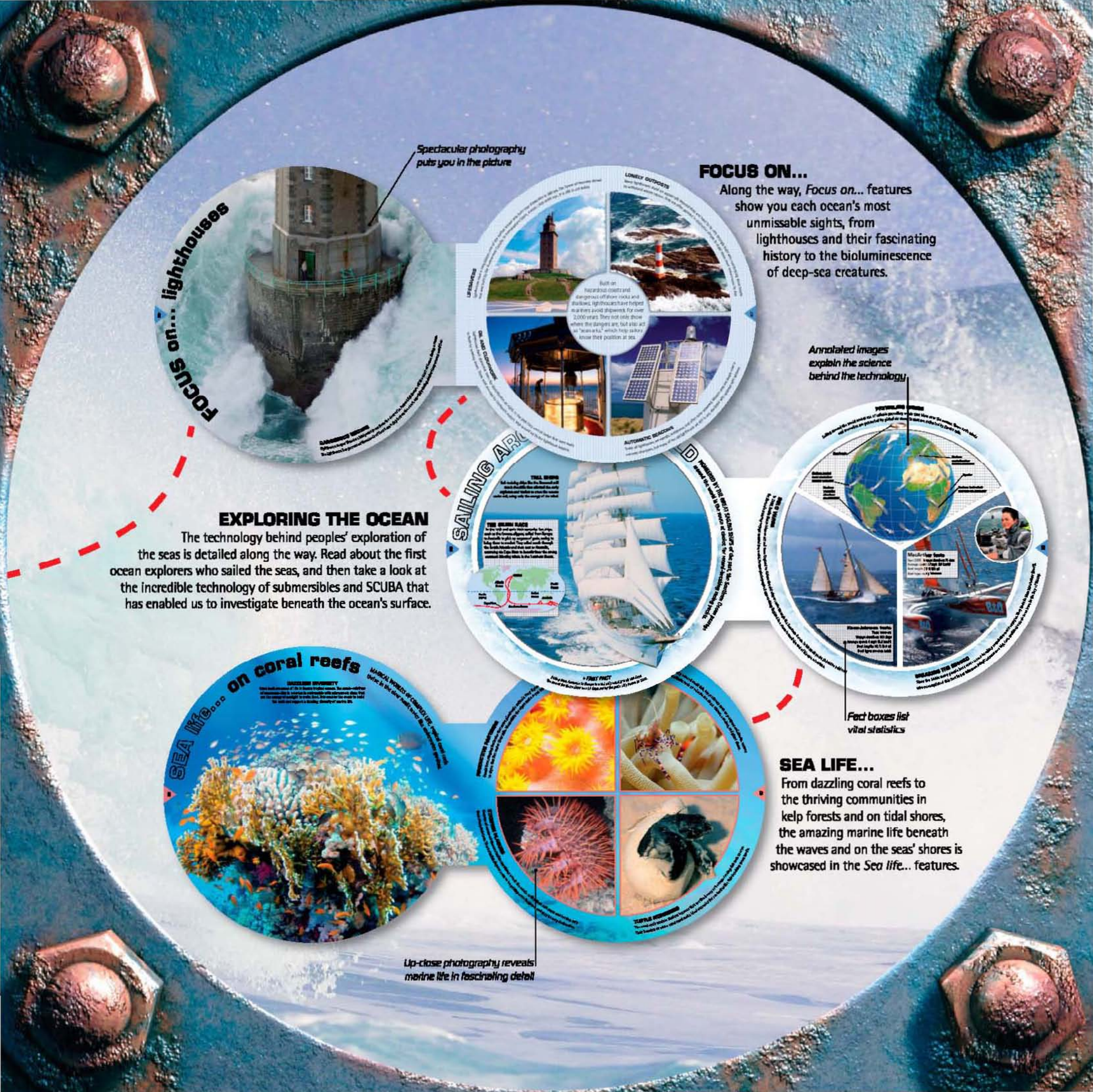
At the back of this book you will find a pack containing:

- OCEAN POSTER
- STICKERS
- POSTCARDS

DESTINATION OCEAN

Your voyage begins with a peek at the science behind the oceans, before being fully immersed in the icy waters of the Arctic. Your journey then continues around the world, guiding you through the ridges and trenches of the Atlantic and the chain of coral islands in the Indian Ocean, across the vast Pacific, to the iceberg-laden Southern Ocean.

Record breaker and Troubled waters panels highlight the oceans' biggest and best sights, and warn of problems that are occurring in the waters and their consequences for the future


Spectacular photography puts you in the picture
FOCUS ON... lighthouses
FOCUS ON...
Along the way, Focus on... features show you each ocean's most unmissable sights, from lighthouses and their fascinating history to the bioluminescence of deep-sea creatures.
Annotated images explain the science behind the technology
EXPLORING THE OCEAN
The technology behind peoples' exploration of the seas is detailed along the way. Read about the first ocean explorers who sailed the seas, and then take a look at the incredible technology of submersibles and SCUBA that has enabled us to investigate beneath the ocean's surface.
SAILING AR
SEA LIFE on coral reefs
Fact boxes list vital statistics
SEA LIFE...
From dazzling coral reefs to the thriving communities in kelp forests and on tidal shores, the amazing marine life beneath the waves and on the seas' shores is showcased in the Sea life... features.
Up-close photography reveals marine life in fascinating detail

1 OCEAN FLOOR

The ocean floors are made of a dense rock called basalt—the same rock that erupts as molten lava on Hawaii. They form a part of Earth's crust that is constantly being recycled and renewed.

2 CONTINENTS

The continents are made of lighter rocks, like the granite of this California mountain, than the ocean floors. The continents resemble huge rocky rafts that float on the deep, dense rocks of Earth's interior.

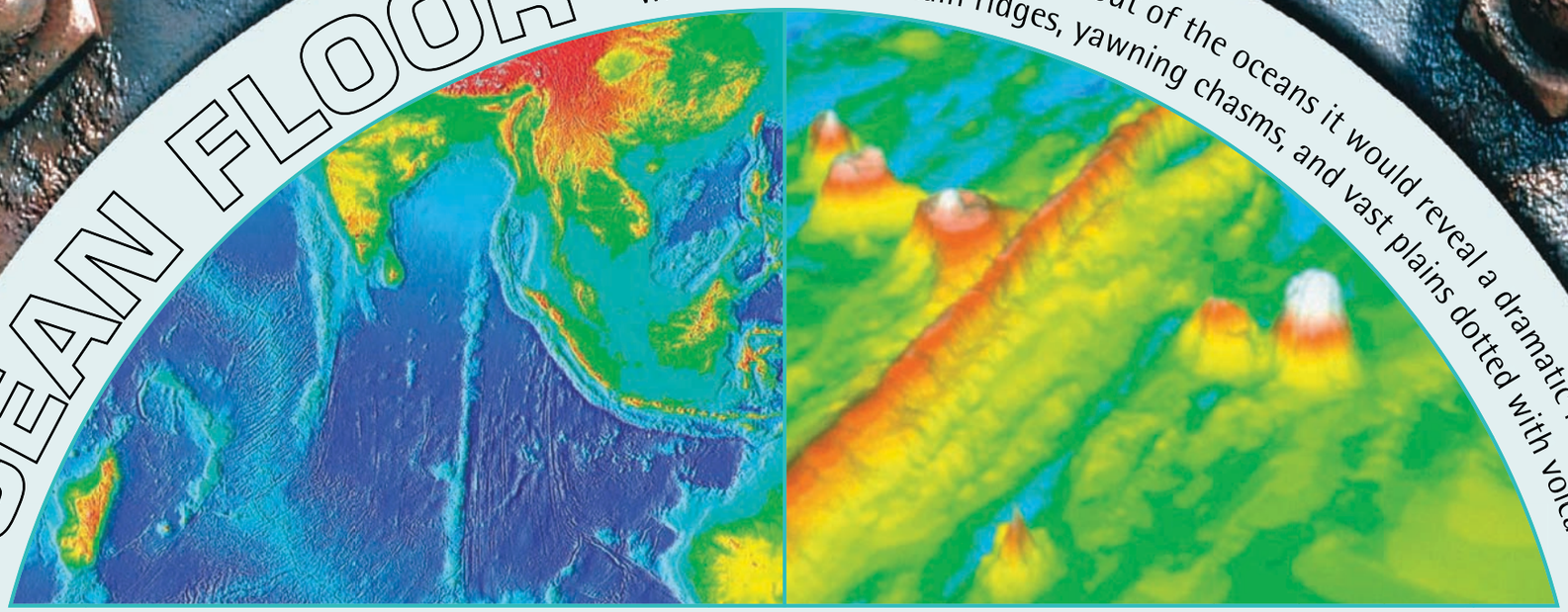
Left: the eastern Pacific • **Above:** Great Barrier Reef, Queensland, Australia

OCEAN PLANET

Earth is the only planet in the solar system that has oceans of liquid water that cover far more of Earth's surface than the land. Between the continents, the oceans lie in deep basins where Earth's crust is a relatively thin layer of heavy, dark rock.

OCEAN FLOOR

IF ALL THE WATER were to drain out of the oceans it would reveal a dramatic landscape with soaring mountain ridges, yawning chasms, and vast plains dotted with volcanoes.



SATELLITES AND SONAR

Amazing advances in technology allow us to see the hidden terrain of the ocean floor with the same clarity as the surface of the Moon. Satellite views like this false-color image of the Indian Ocean reveal the big picture, while sonar images home in on the detail.

HOTSPOTS AND SEAMOUNTS

In many places, such as Hawaii, oceanic volcanoes that have erupted over "hotspots" beneath Earth's mobile crust form volcanic islands. These eventually stop erupting, subside, and become submerged seamounts. This colored sonar image shows a chain of seamounts close to an ocean ridge.

RIDGES AND TRENCHES

The ocean floor is a thin crust of basalt covered with sediment and peppered with active and extinct volcanoes. Ocean floor is destroyed where it is dragged into ocean trenches, but new rock is created at spreading midocean ridges.

Continental shelf is the edge of the continent, which slopes down into the sea

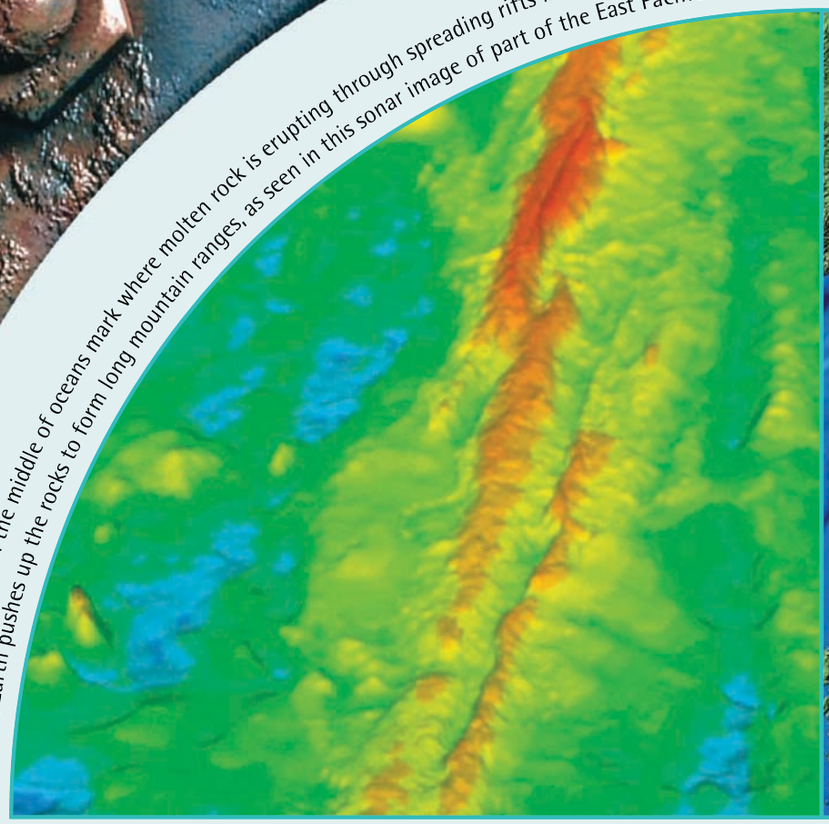
As the crust beneath the ocean floor continues to move, propelled by the activity at the midocean ridge, the volcanoes that have erupted from the stationary hotspot move with it and become extinct

Volcano erupts over the hotspot beneath the crust

Extinct, sinking hotspot volcano forms a submerged seamount

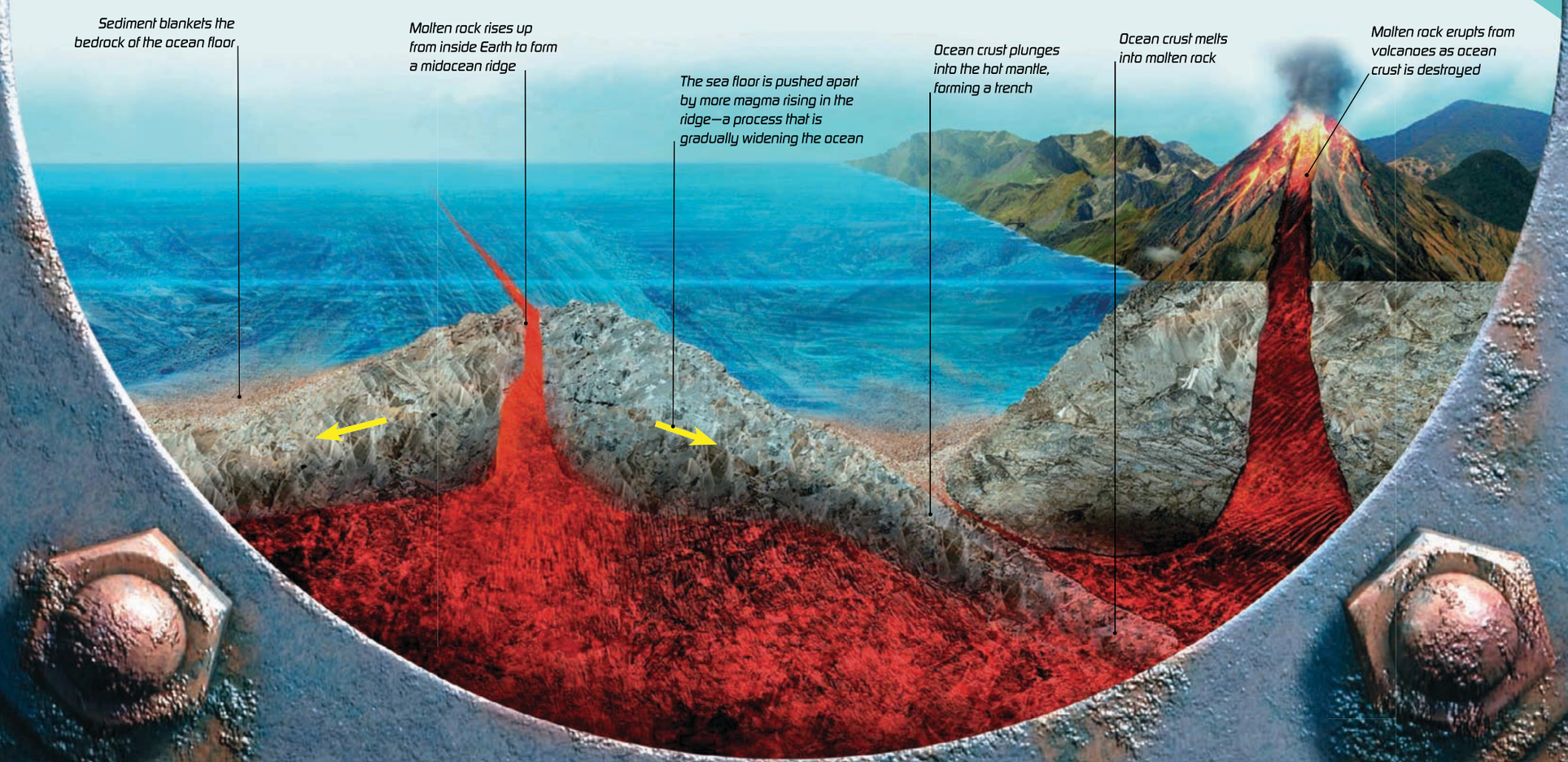
MIDOCEAN RIDGE

The ridges that extend down the middle of oceans mark where molten rock is erupting through spreading rifts in the ocean floor. The heat from inside Earth pushes up the rocks to form long mountain ranges, as seen in this sonar image of part of the East Pacific Rise.



OCEAN TRENCH

This satellite image of Japan shows deep trenches where the ocean floor is sinking back into the hot mantle below the crust. Some of the melting rock erupts to form chains of volcanoes, and the relentless movement causes regular earthquakes.



OCEAN WATER

OCEANS AND SEAS cover more than two-thirds of the planet and have an average depth of 2.4 miles (3.8 km). They contain 97 percent of the world's water, with almost half forming the vast Pacific Ocean.

GLOBAL OCEAN

The immense volume of saltwater that fills the oceans was once one huge ocean that covered most of the planet. Over time volcanic islands erupted from the ocean floor and grew into great continents. Titanic forces within Earth then shifted these around to create the oceans we know today.

FAST FACT •

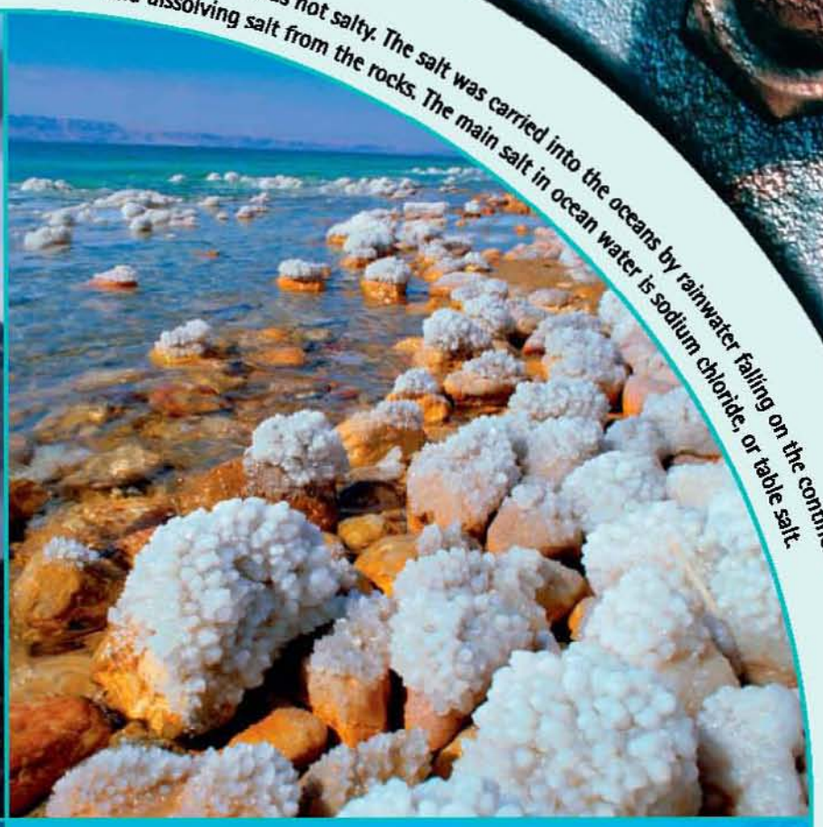
The oceans contain a total volume of approximately 319 million cubic miles (1,330 million cubic km) of salty seawater.

VOLCANIC ORIGINS

Most of the water in the oceans probably erupted from volcanoes as water vapor about four billion years ago. It billowed up to form vast clouds and fell to Earth as torrential rain that created a global ocean.

SALTY SEAS

The first ocean was not salty. The salt was carried into the oceans by rainwater falling on the continents and dissolving salt from the rocks. The main salt in ocean water is sodium chloride, or table salt.

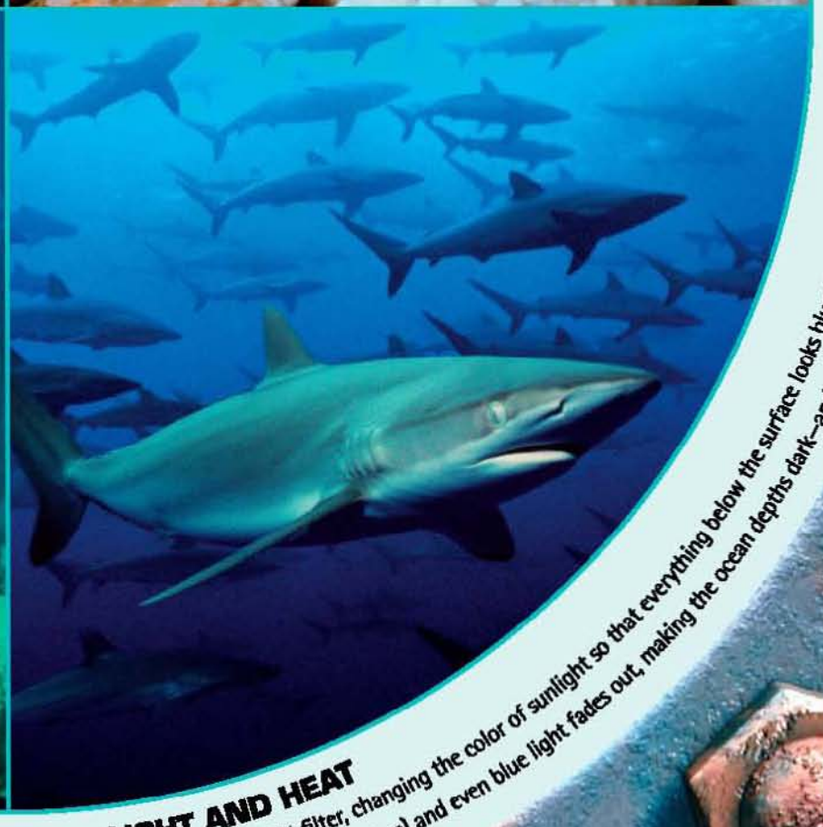


SOUND AND PRESSURE

Water is much denser than air and so transmits sound faster, enabling ocean dwellers such as whales to communicate over vast distances. Water is also heavy, which creates crushing pressure in the deep ocean, so explorers use pressure-proof submersibles like this.

LIGHT AND HEAT

Water acts as a light filter, changing the color of sunlight so that everything below the surface looks blue. Travel deeper to below 1,650 ft (500 m) and even blue light fades out, making the ocean depths dark—and very cold.



WIND AND WAVES

WINDS BLOWING OVER THE OCEAN whip the surface into waves. These start as ripples, but the farther they are blown, the bigger they get; the biggest waves build up in the broadest, windiest oceans.

RIDING A WAVE
The beaches of Hawaii, in the middle of the Pacific Ocean, are pounded by some of the biggest breaking waves on the planet.

RECORD BREAKER

GIANT WAVE
In 1995 the biggest wave ever recorded struck the ocean liner *Queen Elizabeth II* in the north Atlantic. It was at least 100 ft (30 m) high.

BUILDING WAVES

As the Sun heats the ocean surface the warm water heats the air above it. This makes the air expand and rise, carrying moisture from the ocean up into the sky to form clouds and rain. The rising air is replaced by air blowing in across the ocean as wind, building up waves as it travels.

ENERGY AND MOTION

Although waves, blown by the wind, move forward, the water that forms the waves doesn't. The wave's energy is transferred onward, but the water stays in more or less the same place, which is why floating seabirds just bob up and down as the wave passes beneath them.

BREAKING WAVES

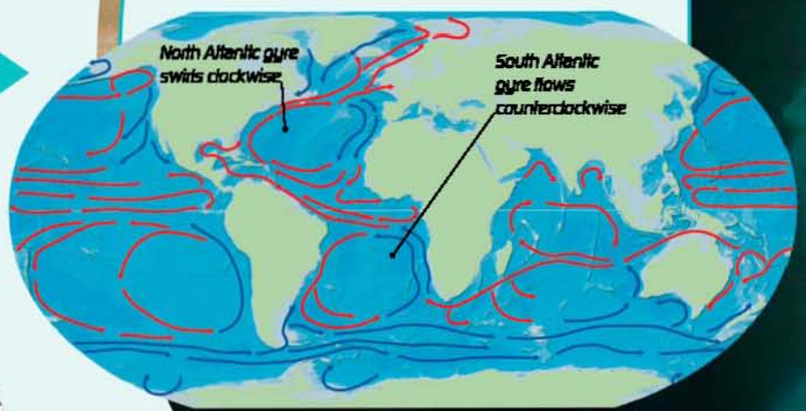
When a wave reaches shallow water it slows down and gets shorter and steeper until it breaks. As its crest finally topples forward, the water actually moves forward, too, surging up the shore and releasing its energy as a destructive force.

CURRENTS

GLOBAL WINDS DRIVE SURFACE CURRENTS that flow like vast salty rivers around the oceans of the world. Together with deep, cold currents that creep over the ocean floors, they transfer heat all around the planet.

SWIRLING GYRES

The combination of wind and Earth's spin makes surface currents swirl broadly clockwise around oceans north of the equator, and counterclockwise south of the equator—although the continents distort this pattern. These swirling oceanic gyres carry warm, tropical water (red arrows) toward the poles, and cold, polar water (blue arrows) into the tropics.

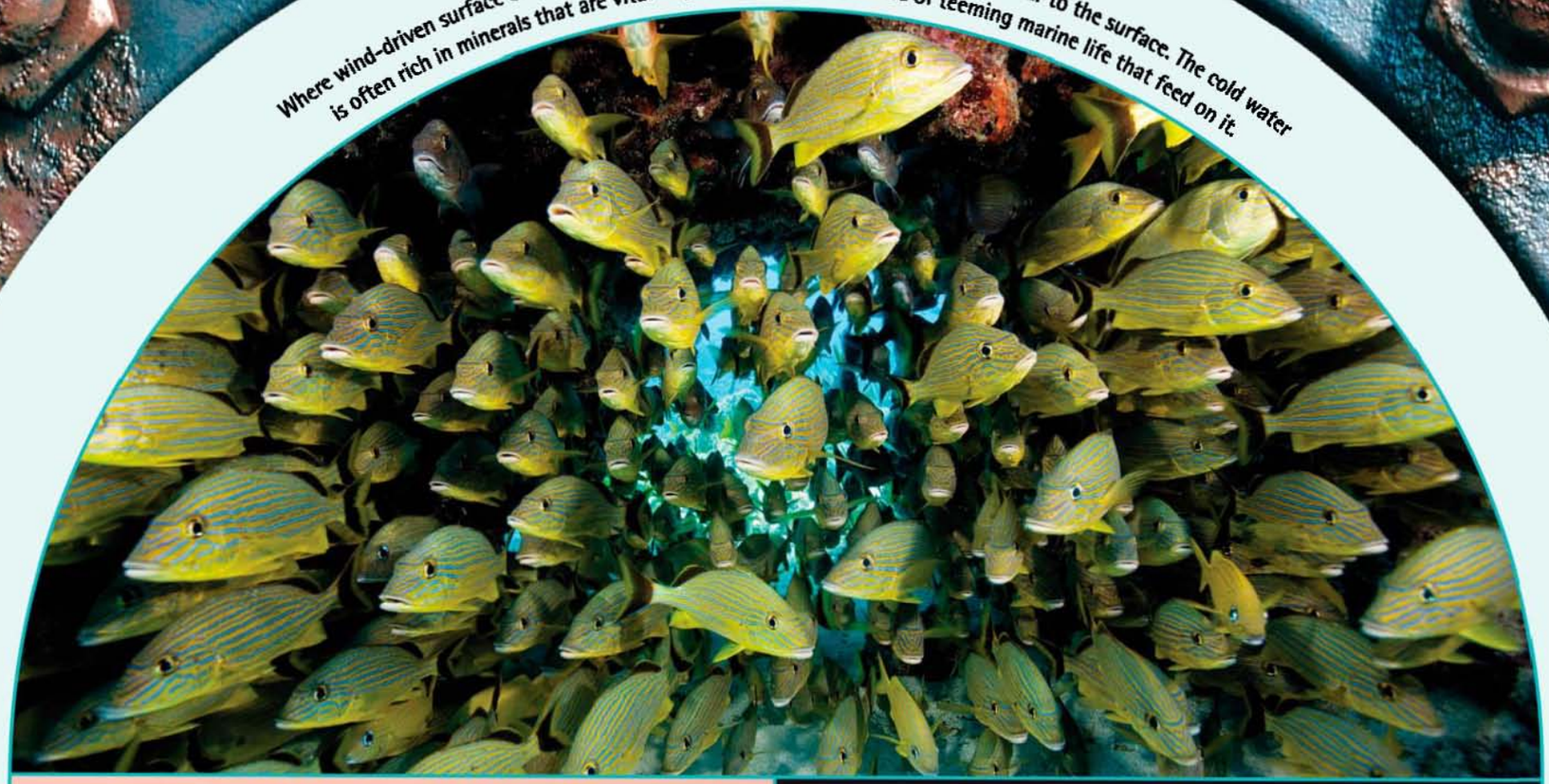


COLOR CODE

Surface currents are usually invisible, but they can be seen from space if they support clouds of colored plankton. This satellite view of the South Atlantic shows green plankton flowing north on the cold Falklands Current, and blue plankton drifting south on the warm Brazil Current.

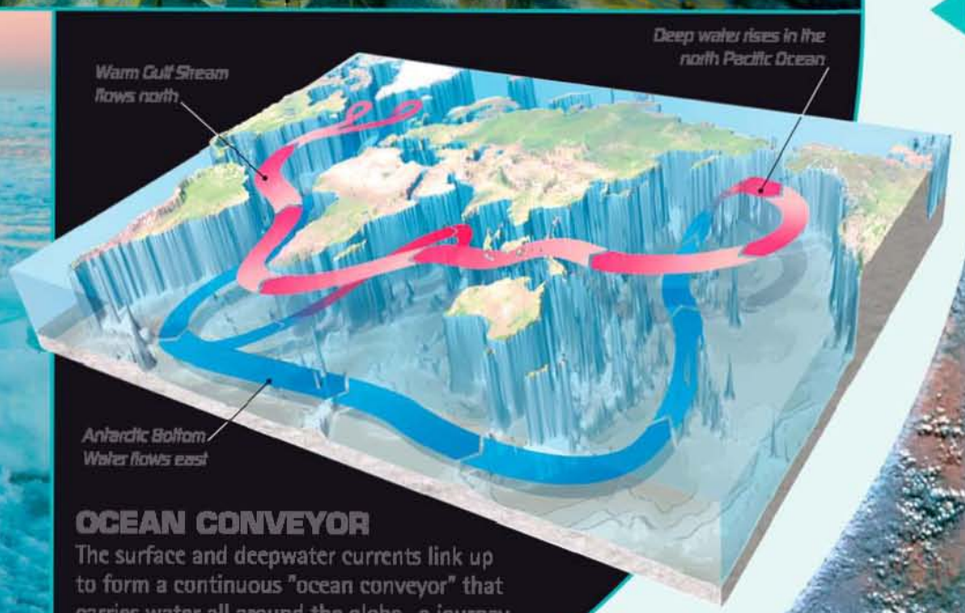
RICHES FROM THE DEEP

Where wind-driven surface currents flow away from coasts they draw deep, cold water to the surface. The cold water is often rich in minerals that are vital to plankton, creating zones of teeming marine life that feed on it.



DEEPWATER CURRENTS

As seawater freezes in icy oceans, the water beneath the ice gets colder and saltier. This makes it denser and heavier, so it sinks and flows over the ocean floors as cold deepwater currents.



OCEAN CONVEYOR

The surface and deepwater currents link up to form a continuous "ocean conveyor" that carries water all around the globe—a journey that takes thousands of years.

TIDES

THE GRAVITY OF THE MOON drags Earth's ocean water toward it as Earth spins, creating the tides. These are modified by the gravity of the Sun and local geography, so the tidal pattern is variable and always changing.

EBB AND FLOW

Most places on the coast experience one or two cycles of high and low tide a day. These tidal cycles make water flow along coasts and in and out of river estuaries, often leaving boats like these stranded on the tidal mud at low tide. The range from high to low tide varies with the shape of the coastline.

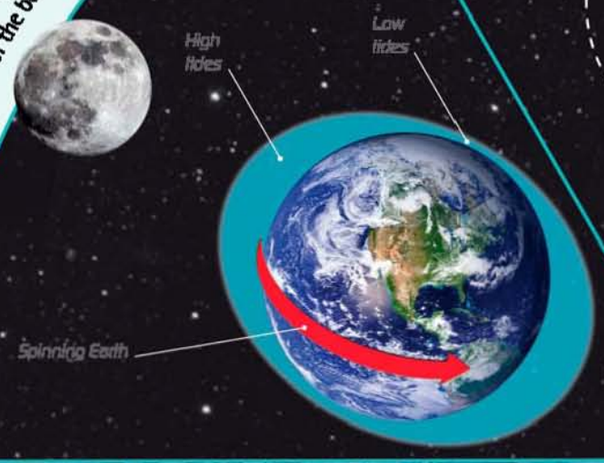
RECORD BREAKER

MONSTER TIDES

The biggest tides on Earth occur in the Bay of Fundy in eastern Canada, where the rising tidal waters funneling into the bay creep up these rocks by up to 50 ft (16 m).

LUNAR ATTRACTION

The Moon draws ocean water toward it while another "bulge" forms on Earth's opposite side. As Earth spins, coastal sites pass in and out of the bulges, causing high and low tides.

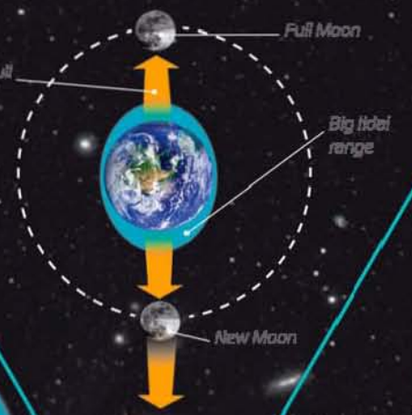


SPRING TIDES

When the Moon is in line with the Sun, their gravities combine to draw more water into the tidal bulges, so high tide has a higher water level and low tide a lower one.

FULL AND NEW MOON

Spring tides occur at the times of full and new Moon, when the Moon and Earth are in line with the Sun.

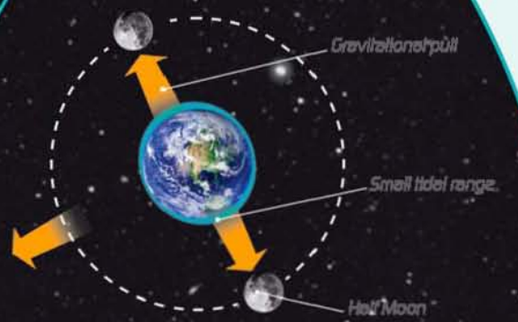


NEAP TIDES

When the Moon is at 90 degrees to the Sun, relative to Earth, the gravity of one offsets the other to cause smaller tidal bulges and smaller tidal ranges.

HALF MOON

Neap tides occur at the times of half Moon—between full and new Moon, so both spring and neap tides happen twice a month.



RACES AND WHIRLPOOLS

As the tides rise and fall, seawater flows from one place to another along the coast, causing local currents called tidal streams. Where these flow through narrow channels or around headlands they can cause dramatic tidal races—fast and turbulent flows of water, which often create whirlpools.

COASTS

DRAMATIC COASTAL LANDFORMS on the fringes of continents are created by the colossal destructive power of the sea. As ocean waves pound the land, it is gradually eroded, or worn away.

FRONTIER ZONE

Coastlines exposed to big waves, like these cliffs in southern Australia, are gradually cut back by erosion. The rocky debris is carried away by the sea and dumped on more sheltered shores, building up beaches. So while coasts are cut back in some places, they are built up in others.

SHATTERING FORCE

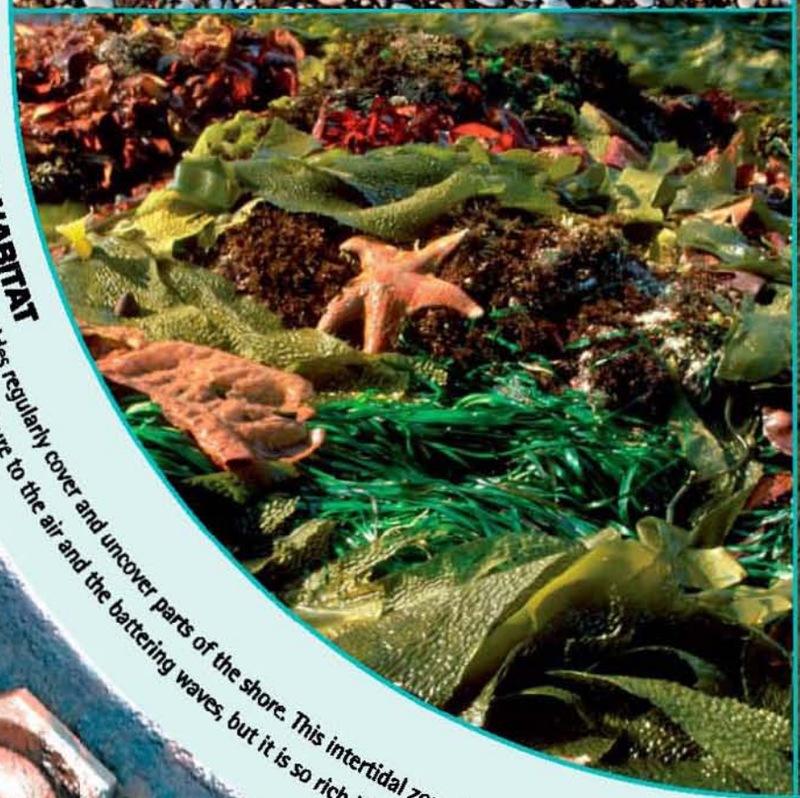
Storm waves break on exposed shores with explosive power, blasting the rock apart. They undercut rock faces to form caves, which eventually collapse to leave sheer cliffs. Softer rocks give way first, leaving seams of harder rock standing as headlands and isolated stacks.

SHINGLE AND SAND

The rock that falls from wave-battered cliffs is tossed around by the water and reduced to rounded boulders, pebbles, and sand. The heavy boulders do not move far, but lighter pebbles and sand are swept up on shore to form shingle banks and sandy beaches.

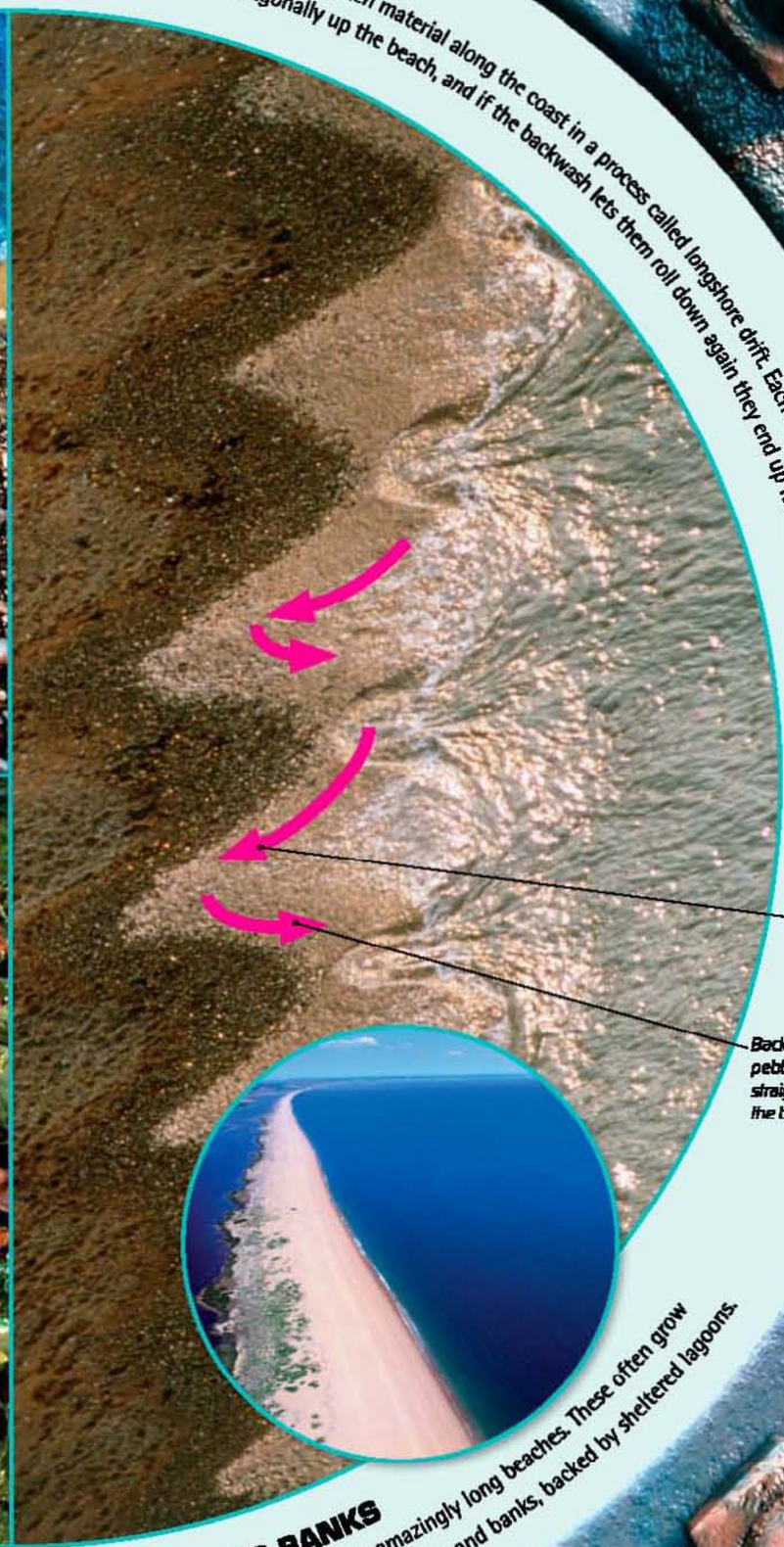
RICH HABITAT

The rising and falling tides regularly cover and uncover parts of the shore. This intertidal zone is a dangerous place for marine life, because of exposure to the air and the battering waves, but it is so rich in food that it teems with life.



LONGSHORE DRIFT

Breaking waves sweep beach material along the coast in a process called longshore drift. Each wave picks up sand and stones and moves them diagonally up the beach, and if the backwash lets them roll down again they end up farther along the shore.



SPITS AND BANKS

Longshore drift can build up amazingly long beaches. These often grow away from the land as detached spits and banks, backed by sheltered lagoons.

1 LAPTEV SEA

Much of the pack ice of the central Arctic Ocean forms in the Laptev Sea off Siberia. It then moves over the North Pole, carried by ocean currents.

2 GREENLAND ICE

Glaciers flowing off the thick Greenland ice sheet dump great blocks of ice into the sea. These icebergs may drift as far south as the Atlantic, where they can be a danger to shipping.

ASIA

Siberia

EUROPE

1 Laptev Sea

Kara Sea

Novaya Zemlya

Franz Josef Land

Barents Sea

Nansen Basin

Arctic Mid-ocean Ridge

Amundsen Basin

Lomonosov Ridge

Makarov Basin

Mendeleyev Ridge

Alpha Ridge

Chukchi Plateau

East Siberian Sea

Svalbard

North Pole

Wandell Sea

Greenland Sea

Norwegian Sea

Norwegian Basin

North Sea

ARCTIC OCEAN

Canada Basin

Beaufort Sea

Queen Elizabeth Islands

Amundsen Gulf

Greenland

Denmark Strait

Iceland

Reykjanes Ridge

Baffin Bay

2 Davis Strait

Baffin Island

Labrador Sea

Labrador Basin

ATLANTIC OCEAN

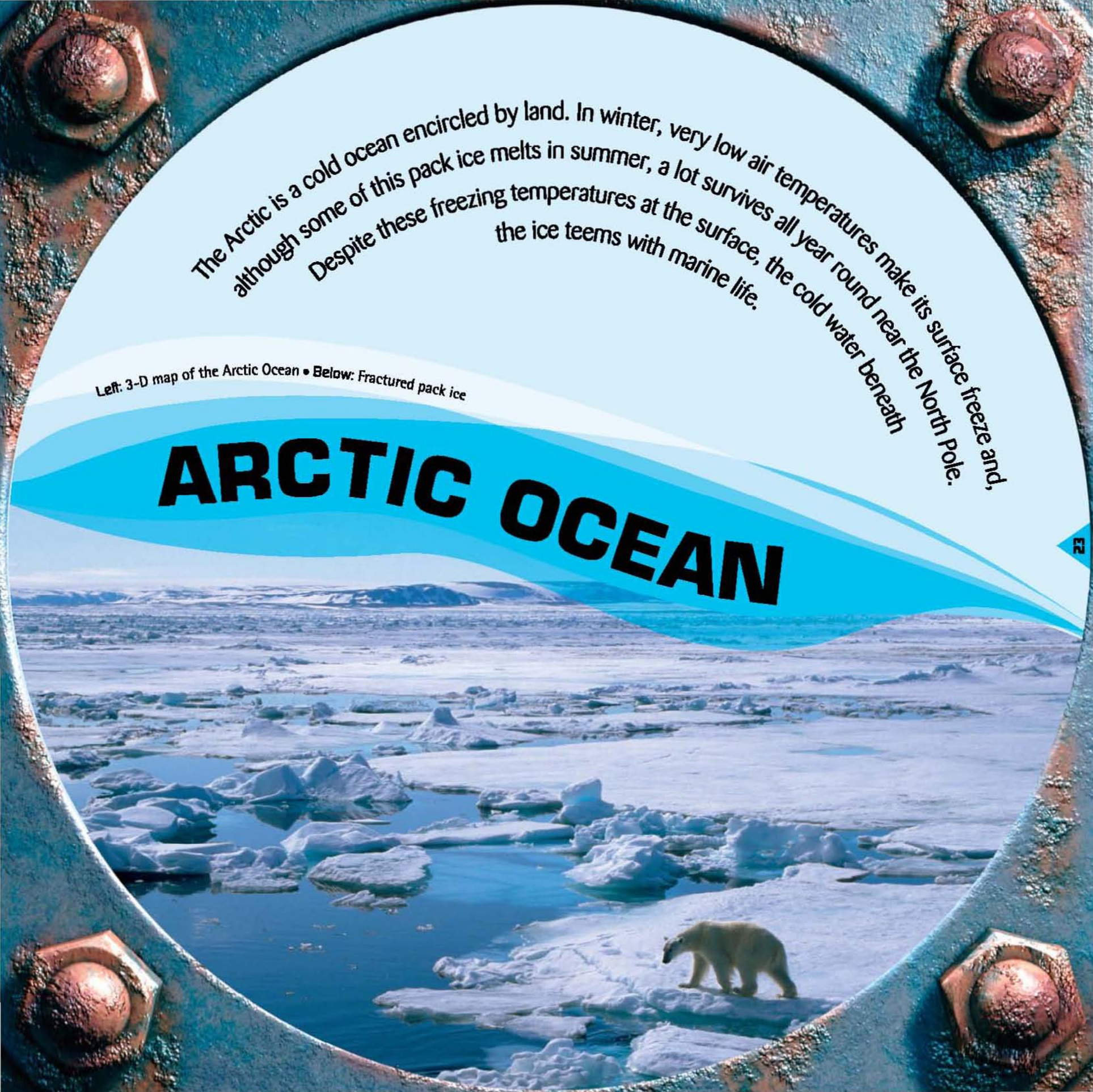
Hudson Bay

NORTH AMERICA

ARCTIC OCEAN

The Arctic is a cold ocean encircled by land. In winter, very low air temperatures make its surface freeze and, although some of this pack ice melts in summer, a lot survives all year round near the North Pole. Despite these freezing temperatures at the surface, the cold water beneath the ice teems with marine life.

Left: 3-D map of the Arctic Ocean • Below: Fractured pack ice



WINTER ICE

THERE IS ALWAYS ICE IN THE ARCTIC, but there is far more of it in winter when the floating ice sheet expands to cover almost the entire Arctic Ocean.

FROZEN OCEAN

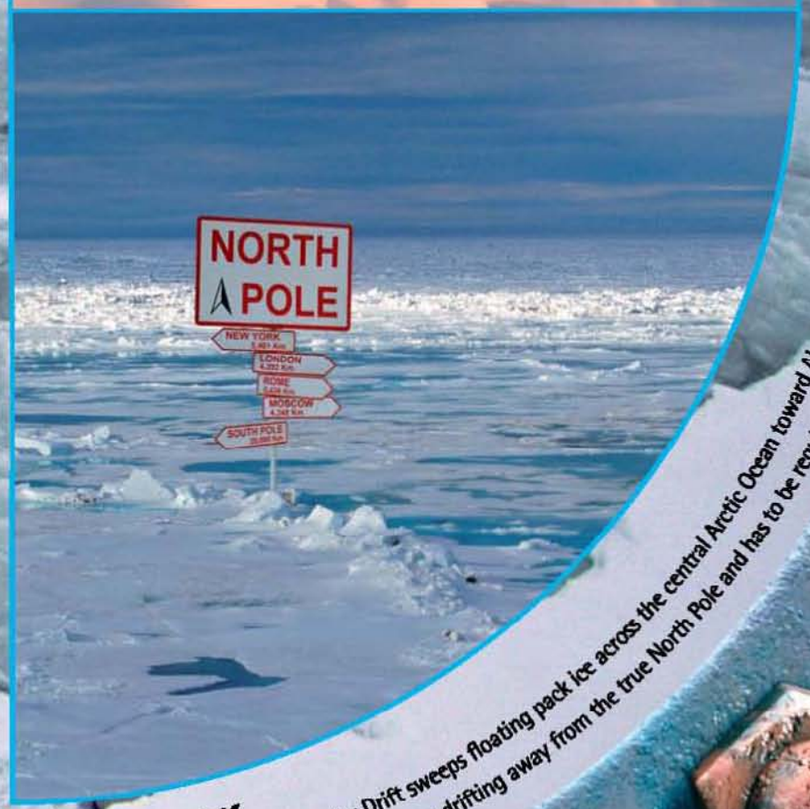
In winter the Arctic is almost permanently dark, and the air temperature can fall to a teeth-chattering -58°F (-50°C) or below. Bit by bit, most of the surface of the Arctic Ocean freezes to eventually form a mass of floating ice that is roughly the size of the US. The ice forms as a single sheet but soon breaks up into separate ice floes. These are jostled together to form a "landscape" of icy ridges, with occasional cracks that reveal the deep, dark water below. Much of this pack ice forms off Siberia and is carried clockwise by ocean currents around the central Arctic Ocean. As more seawater freezes onto its base, the ice becomes thicker, reaching a maximum thickness of 10 ft (3 m) in the central part of the ocean.

ICE FORMATION

As the temperature at the ocean surface falls below its freezing point of 28.8°F (-1.8°C), tiny ice crystals form in the water. During this freezing process the sea salt is expelled, creating ice that is almost pure water. The ice crystals clump together to form floating plates of "pancake ice," which are pushed together by the wind and currents to form thick pack ice.

FRACTURED TERRAIN AND SNOWY BLANKETS

Ocean currents push up pressure ridges in the pack ice, making polar travel difficult. The snow covering the ice stops sunlight from shining through to the water below, so tiny marine organisms that need light must lie dormant until the spring thaw.



MOVING MARK

An ocean current called the Transpolar Drift sweeps floating pack ice across the central Arctic Ocean toward Alaska. Consequently, the North Pole sign that sits on the ice is always drifting away from the true North Pole and has to be regularly moved back again.

SEA life... on the ice

THE OCEAN BENEATH FLOATING PACK ICE is rich in the nutrients that support marine life, meaning that there is plenty of food for the animals that hunt in or near the water.

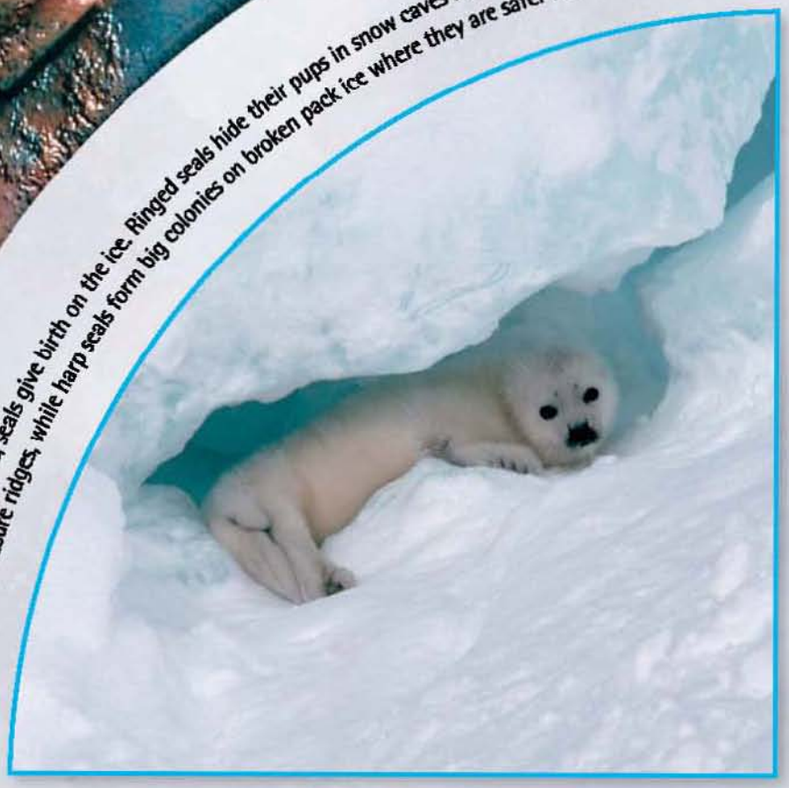
VITAL AIR
Many of the animals that feed beneath the pack ice are air-breathing mammals, so they need to stay close to holes in the ice where they can surface to breathe. Most, therefore, prefer to hunt in loose ice where there are more gaps for a breather!

PROWLING POLAR BEARS

Polar bears hunt seals on the ice, especially ringed seal pups, which they can find by sniffing out their snow caves. They get most of the food they need during the seal breeding season, and may not eat much during the rest of the year.

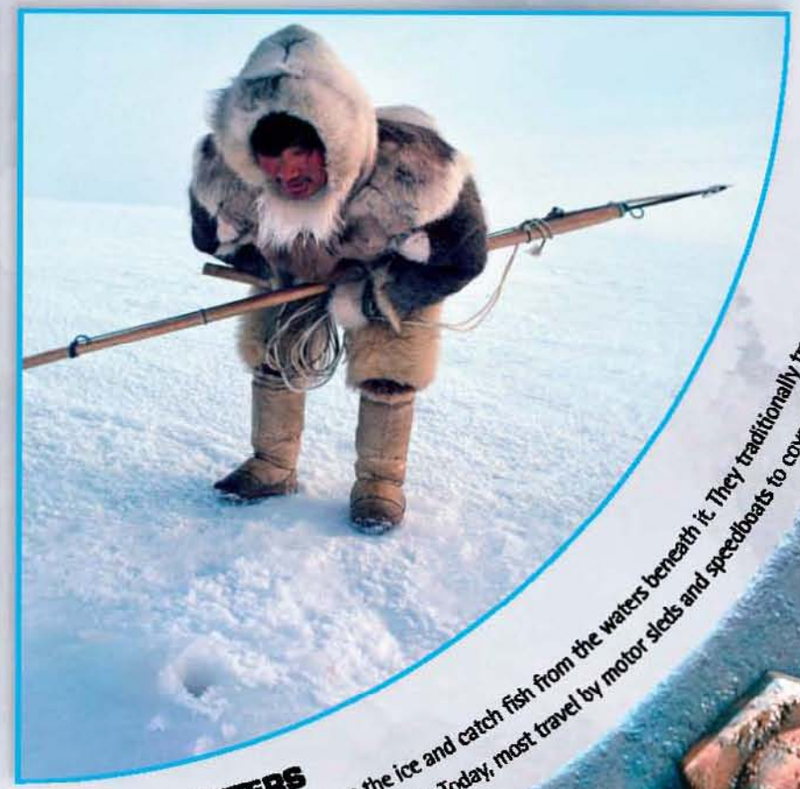
BREEDING SEALS

As springtime approaches, seals give birth on the ice. Ringed seals hide their pups in snow caves like this, beneath the tumbled ice floes of pressure ridges, while harp seals form big colonies on broken pack ice where they are safer from polar bears.



ICE HUNTERS

Inuit hunters pursue seals on the ice and catch fish from the waters beneath it. They traditionally traveled by dog sleds or kayaks and camped in igloos at night. Today, most travel by motor sleds and speedboats to cover the Arctic expanses quickly.



FANTASTIC FUR

Near the coasts, Arctic foxes trail polar bears over the ice to grab any scraps of food they can. Their white winter coats are so thick that they can cope with the worst winter weather and start to shiver only if the temperature drops to –94°F (–70°C).

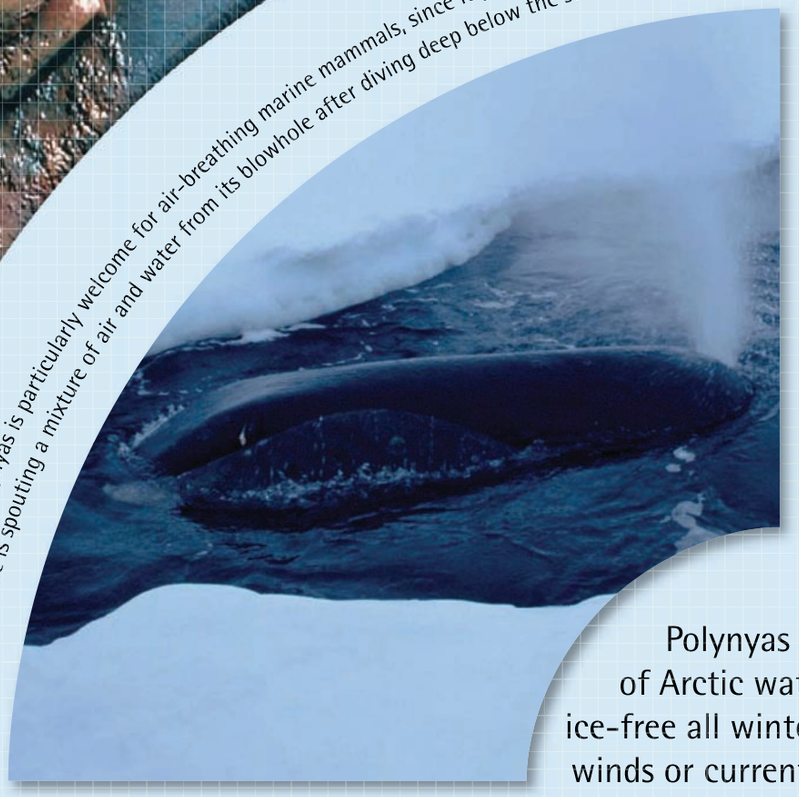
FOCUS on... polynyas

OPEN WATER
Polynyas are havens for wildlife at times when most of the Arctic Ocean is frozen over. These sunlit areas of water can support microscopic marine algae that are eaten by masses of tiny animals, which in turn provide food for bigger animals, like these eider ducks.

Polynyas are areas of Arctic water that stay ice-free all winter due to strong winds or currents. They form in the same places every year, such as Northwater in Baffin Bay, which lies between Greenland and Ellesmere Island.

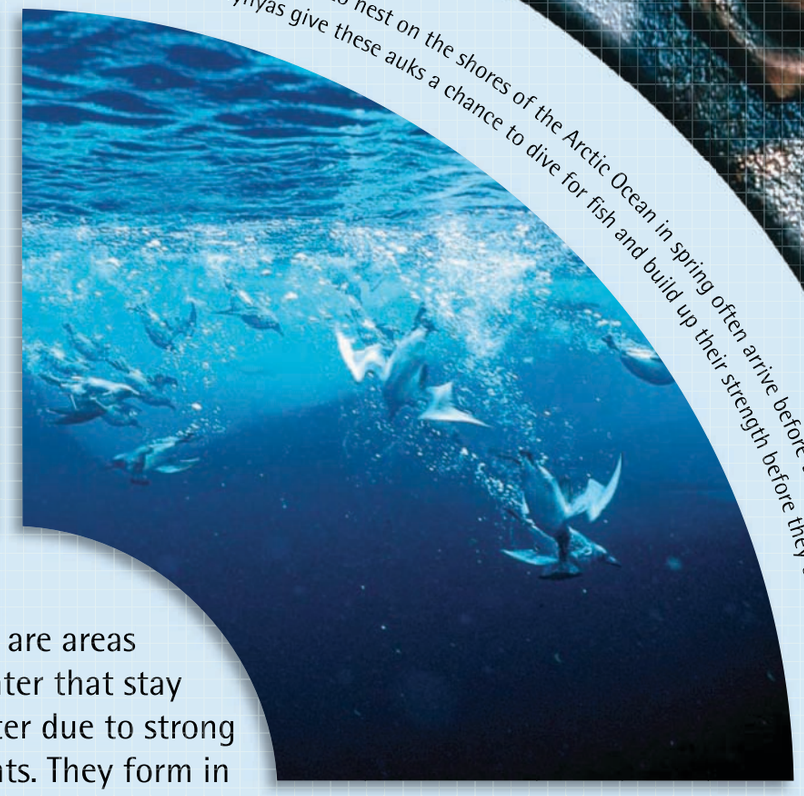
SPOUTING WHALES

The open water of polynyas is particularly welcome for air-breathing marine mammals, since it gives them easy access to air. This whale is spouting a mixture of air and water from its blowhole after diving deep below the surface for food.



DIVING SEABIRDS

Seabirds that fly north to nest on the shores of the Arctic Ocean in spring often arrive before the ice melts. The open waters of polynyas give these auks a chance to dive for fish and build up their strength before they breed.

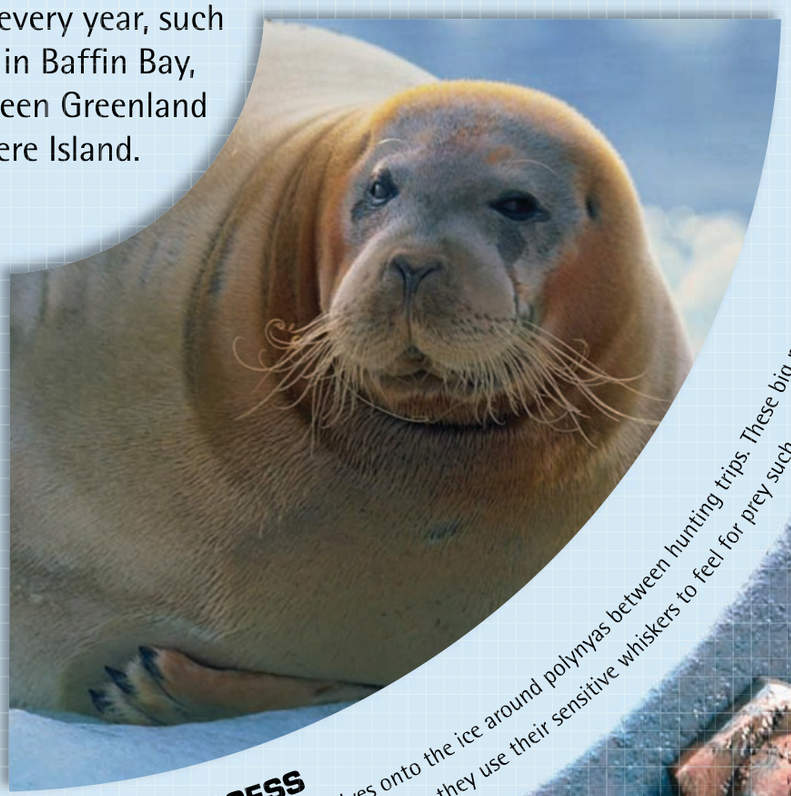


MIGRATION ROUTES

Large groups of whales like these white belugas often gather in polynyas and nearby waters in late spring, waiting for the ice to crack up or melt. As long "leads"—or channels—open up in the ice, the whales are able to swim to new feeding areas.

EASY ACCESS

Bearded seals haul themselves onto the ice around polynyas between hunting trips. These big marine mammals dive right down to the darkness of the seabed where they use their sensitive whiskers to feel for prey such as fish, crabs, marine worms, and octopus.



SUMMER SEAS

IN SUMMERTIME the fringes of the Arctic Ocean are transformed as the sea ice retreats north and the longer daylight hours trigger an explosion of life in the sunlit summer seas.

SUMMER SEA ICE

In spring the pack ice around the edges of the Arctic Ocean starts breaking up and melting away from the surrounding coasts. The ice edge shrinks north, leaving a central area of apparently permanent summer ice in the central Arctic Ocean. In fact, since the pack ice drifts slowly across the North Pole toward Alaska, every part of this "permanent" ice sheet melts away after a few years, so it is known as multiyear ice. In September this area of summer ice is roughly half the size of the winter ice. The sinking cold, salty water beneath the ice stirs up vital minerals for plantlike, microscopic algae. As soon as the ice melts they start multiplying fast in the sunlit water, creating masses of food for Arctic marine life.

TROUBLED WATERS

ICE-FREE

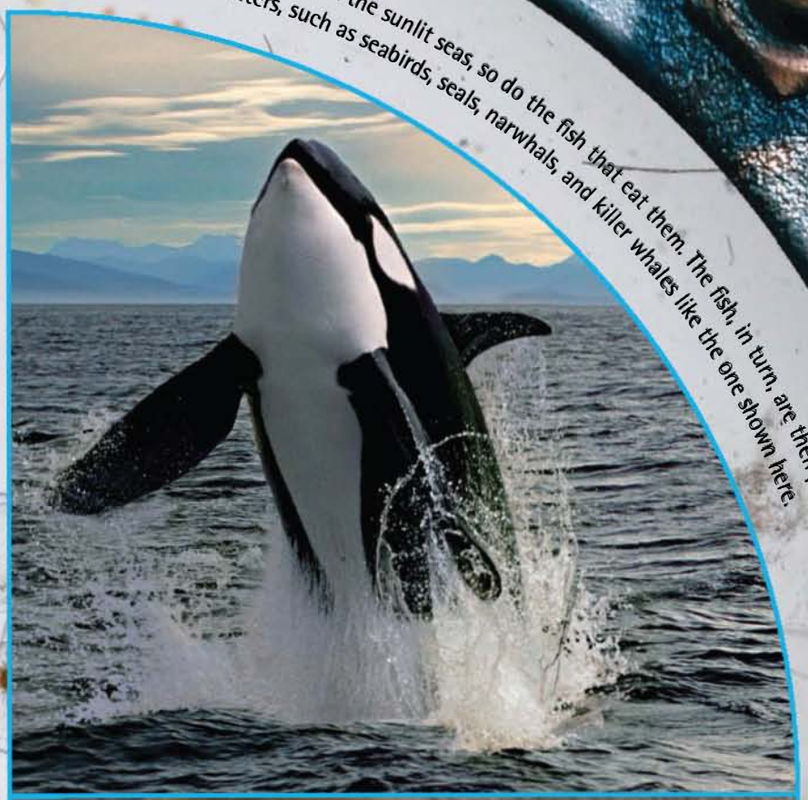
Rising temperatures are reducing the Arctic's summer ice. Since 1979, this has dwindled by an area twice the size of Texas. By 2030, summer in the North Pole may be totally ice-free.

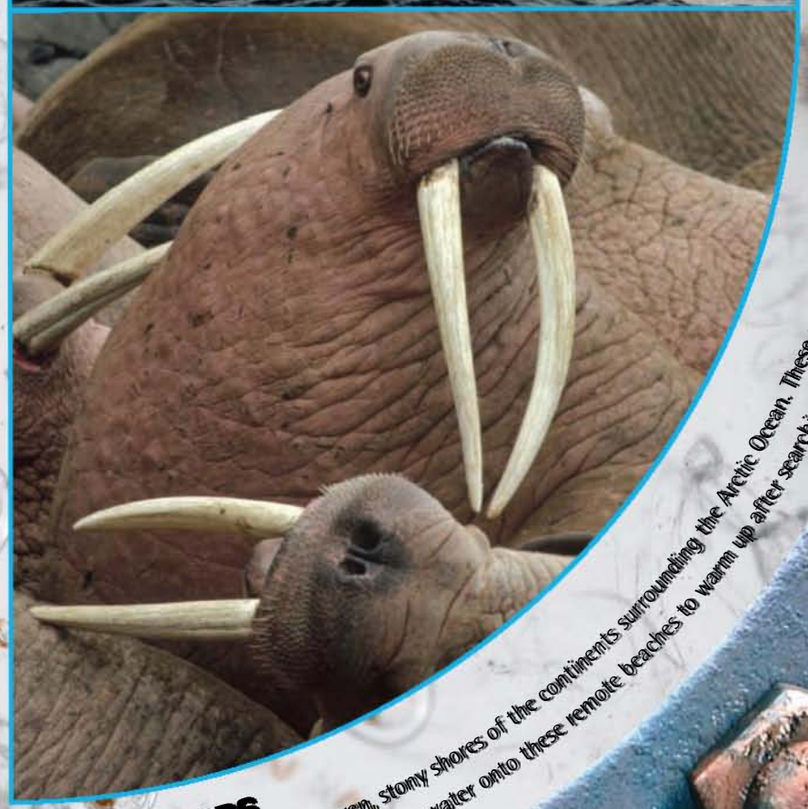
PLANKTON BLOOM

Microscopic plantlike algae multiply fast and support a mass of tiny, drifting animals. Together they form dense swarms of plankton, eaten by fish and even huge whales.

RICH PICKINGS

As the plankton swarms multiply in the sunlit seas, so do the fish that eat them. The fish, in turn, are then preyed upon by a variety of hunters, such as seabirds, seals, narwhals, and killer whales like the one shown here.





WALRUS HERDS

As the ice retreats it reveals the barren, stony shores of the continents surrounding the Arctic Ocean. These provide refuges for walruses, which heave themselves out of the water onto these remote beaches to warm up after searching for clams on the seabed.

ICEBREAKERS

True icebreakers are specially designed to smash ice, but many ships have ice-strengthened hulls. One of the earliest was the Fram, used by Norwegian explorer Fridtjof Nansen to cross the Arctic Ocean between 1893 and 1896. It became trapped in drifting pack ice.

Icebreaker facts

Power: Often nuclear
Crew: Up to 200
Length: Up to 535 ft (160 m)
Max speed: 23 mph (37 km/h)
Speed in ice: 12 mph (19 km/h)
Max ice thickness: 8 ft (2.4 m)

THE FRAM

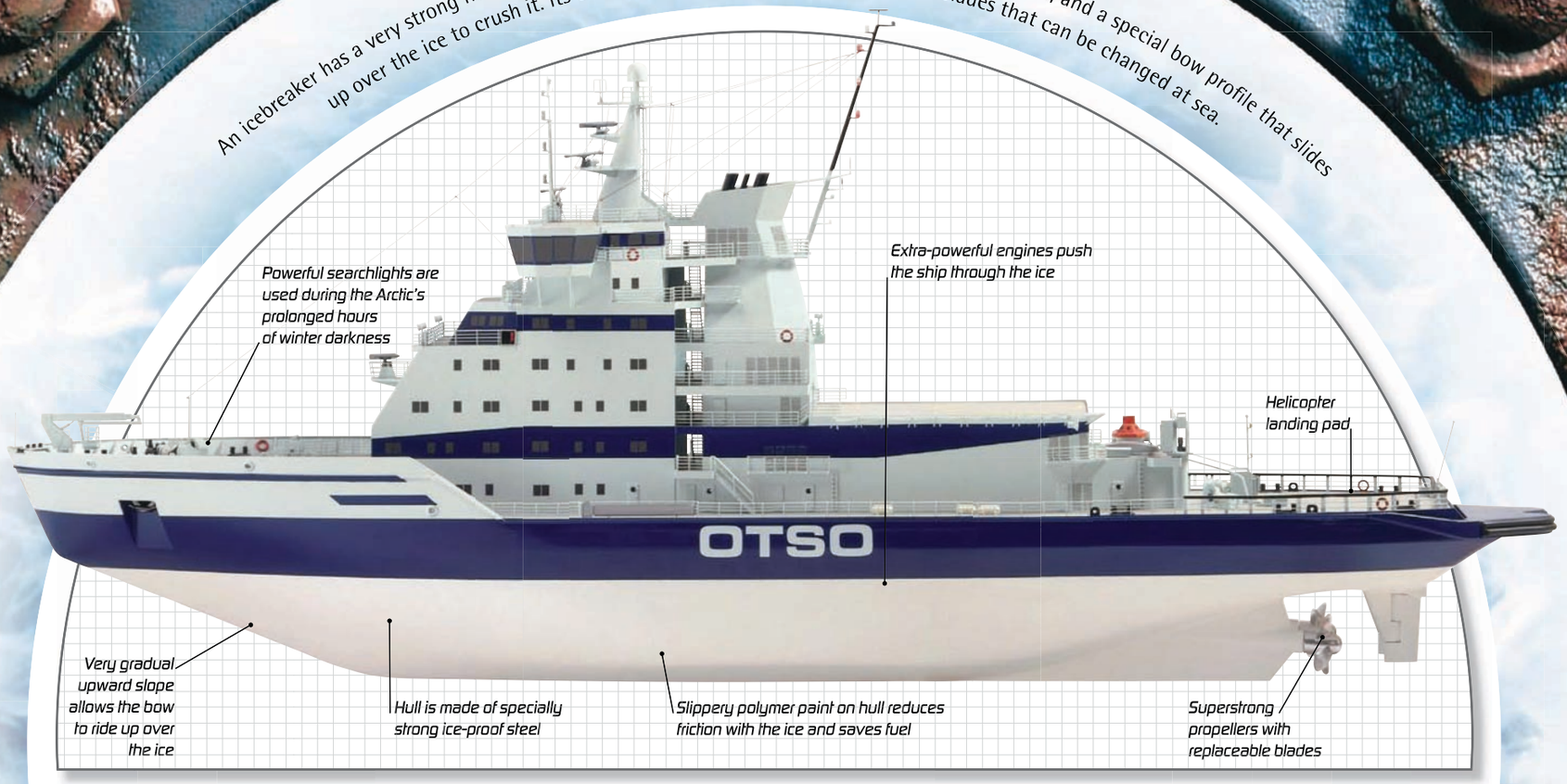
IN SUMMER, ships can reach the northern ports through the Arctic's ice-free coastal waters. When they start to freeze over, icebreakers clear channels through the pack ice.

CRUSHING POWER

Icebreakers are heavy ships with reinforced, ramplike bows that ride up over the ice as they push forward. Their great weight then shatters the ice. This uses a lot of diesel fuel, so many of the biggest icebreakers are nuclear-powered.

DESIGNED FOR THE JOB

An icebreaker has a very strong hull with no exposed projections that could be damaged by the ice, and a special bow profile that slides up over the ice to crush it. Its extra-strong propellers have replaceable blades that can be changed at sea.



ON TOW

The immense power of an icebreaker allows it to tow another ship while breaking through thin ice. Here, the Finnish icebreaker *Apu* is towing a freighter, while a smaller ship follows in the cleared path.

EYES IN THE SKY

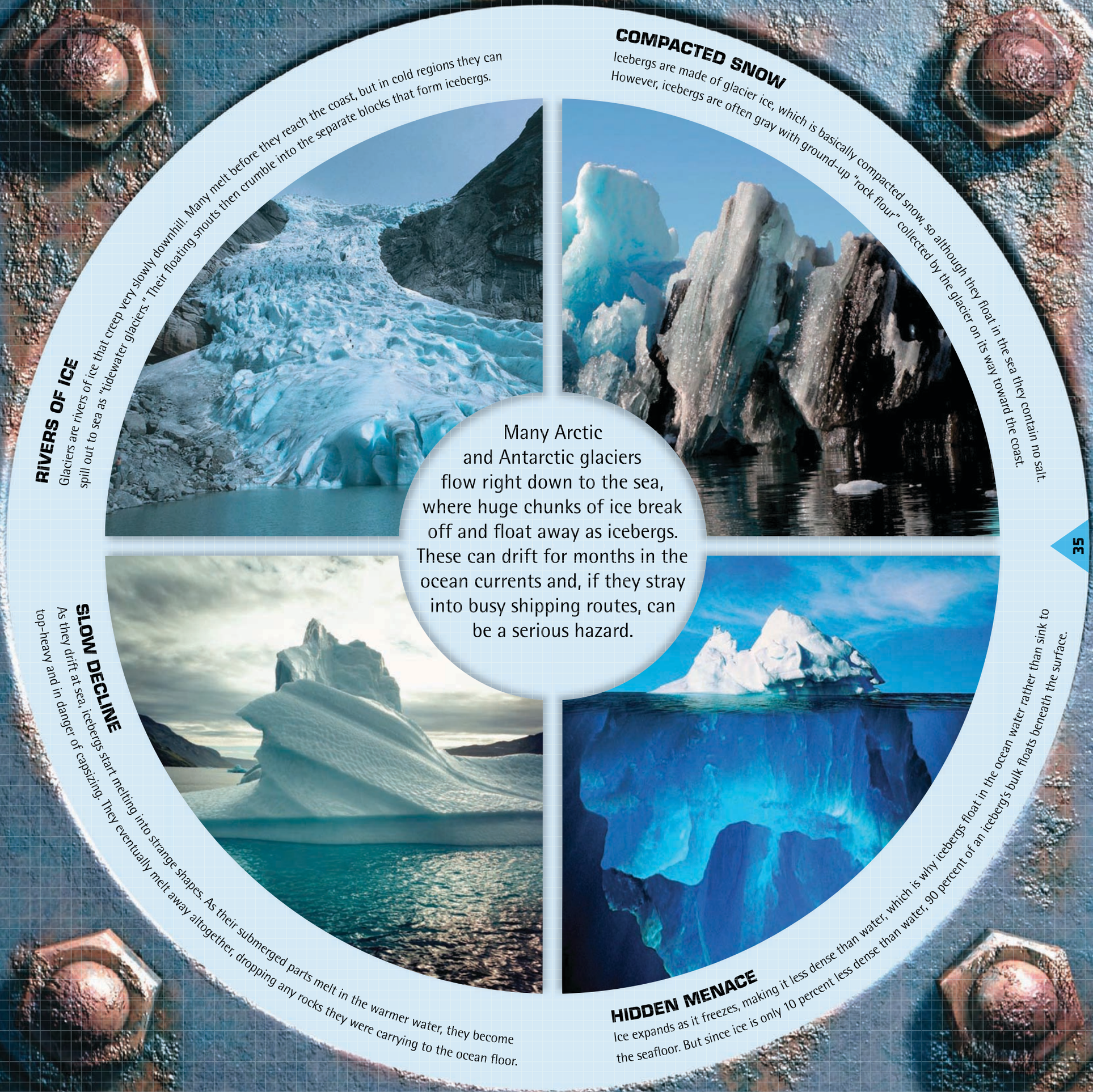
Most icebreakers carry helicopters to ferry supplies and help to locate open leads in the ice.

SATELLITE DATA

Onboard computer systems, linked to special receivers, can download data on sea ice gathered by spacecraft like this Envisat environmental satellite. This helps the icebreaker crew plan the best route through the ice.

FOCUS on... icebergs

DRIFTING ICE
Stranded on the coast of northwest Greenland, this iceberg is starting to melt away in the 24-hour sunshine of an Arctic summer. Many icebergs do not travel far before they run aground in shallow water.



RIVERS OF ICE

Glaciers are rivers of ice that creep very slowly downhill. Many melt before they reach the coast, but in cold regions they can spill out to sea as "tidewater glaciers." Their floating snouts then crumble into the separate blocks that form icebergs.

COMPACTED SNOW

Icebergs are made of glacier ice, which is basically compacted snow, so although they float in the sea they contain no salt. However, icebergs are often gray with ground-up "rock flour" collected by the glacier on its way toward the coast.

Many Arctic and Antarctic glaciers flow right down to the sea, where huge chunks of ice break off and float away as icebergs. These can drift for months in the ocean currents and, if they stray into busy shipping routes, can be a serious hazard.

SLOW DECLINE

As they drift at sea, icebergs start melting into strange shapes. As their submerged parts melt in the warmer water, they become top-heavy and in danger of capsizing. They eventually melt away altogether, dropping any rocks they were carrying to the ocean floor.

HIDDEN MENACE

Ice expands as it freezes, making it less dense than water, which is why icebergs float in the ocean water rather than sink to the seafloor. But since ice is only 10 percent less dense than water, 90 percent of an iceberg's bulk floats beneath the surface.

1 AMAZON WATER

Vast amounts of muddy water pour into the Atlantic from the mouth of the Amazon River. This single mighty river accounts for nearly a fifth of the river water that flows into the world's oceans.

2 VOLCANO

Ascension Island is the peak of a vast volcano that has erupted from near the Mid-Atlantic Ridge. The volcano is dormant, but black lava-flows mark the sites of past eruptions.

Left: 3-D map of the Atlantic Ocean ● **Above:** Striped dolphins traveling fast

ATLANTIC OCEAN

The Atlantic has developed from a spreading rift that lies between Europe and Africa on one side, and North and South America on the other. This rift is marked by the Mid-Atlantic Ridge and is still spreading at up to 1 ½ in (4 cm) a year—about as fast as your fingernails grow.

NORTH ATLANTIC

THE ARCTIC FRINGES of the north Atlantic are cold, gray, and dangerous, but have an abundance of marine life because winter storms stir up vital nutrients into the sunlit surface water.

WARM CURRENT

In the far north Atlantic, cold, salty water sinks in "downwelling zones" to drive a deepwater current that flows south over the ocean floor. As the water sinks it draws surface water north to create the North Atlantic Drift—a branch of the warm, salty, fast-flowing Gulf Stream. This carries warm water toward Iceland, warming the northern seas and contributing to the mild climate of northern Europe. Meanwhile, cold currents flow south, delivering cold but nutrient-rich water to coastal North America.

TROUBLED WATERS

DWINDLING FISH STOCKS

Many of the fish targeted by commercial fishing fleets are now rare, and some fisheries—including the Grand Banks in the north Atlantic—have collapsed.

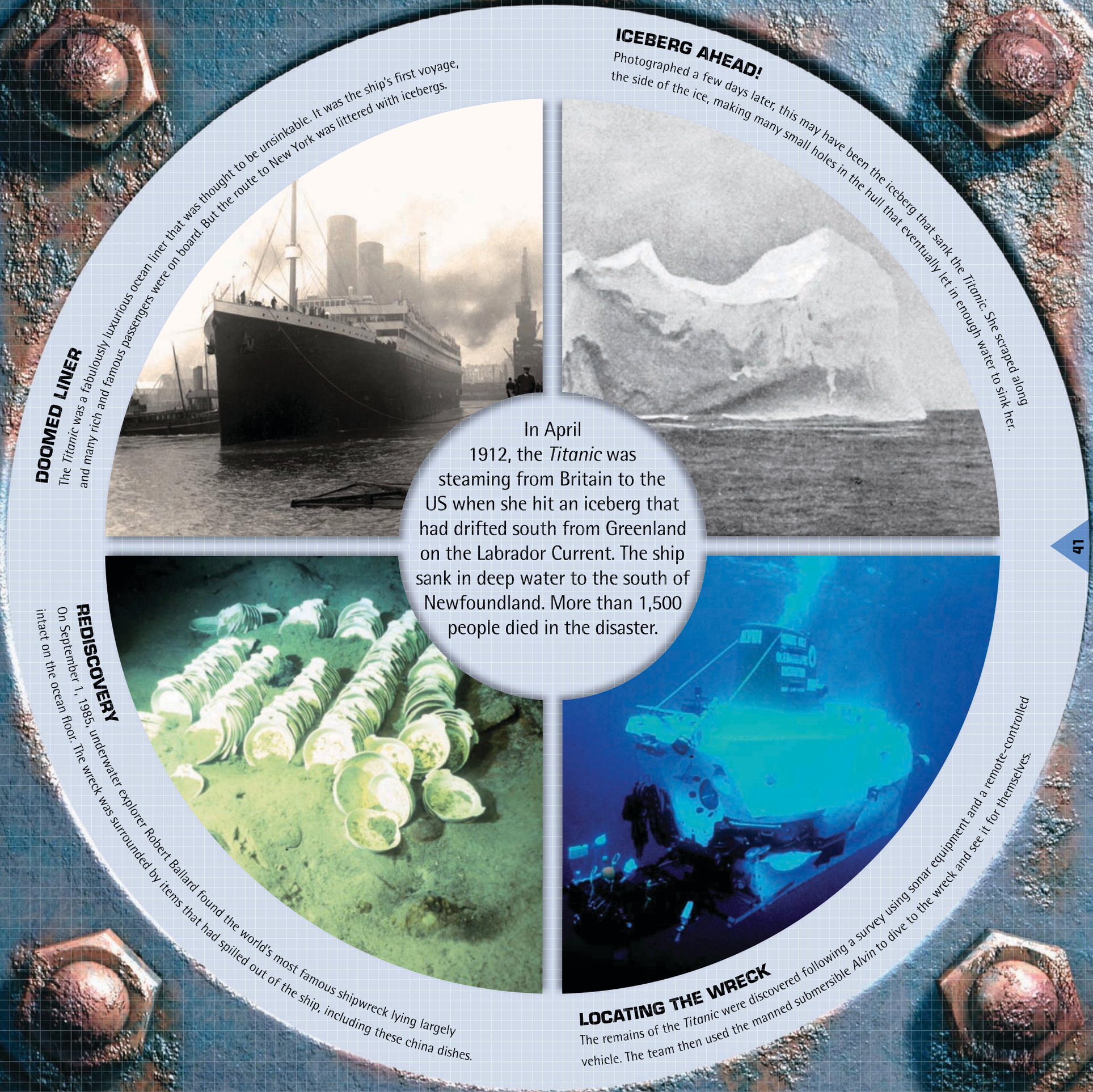
STORMY SEAS
Depressions, or cyclones, that develop in the north Atlantic whip up high winds and huge waves. Many ships have been wrecked on the rocky coasts of northern Europe during such storms.

OCEANIC RICHES
Vast numbers of seabirds like this puffin breed on the rocky coasts of the north Atlantic, where the cold but food-rich water provides them with plenty of fish for their young.

VOLCANIC ISLAND
Volcanoes erupting from a highly active part of the Mid-Atlantic Ridge on the ocean floor have created the strange landscape of Iceland, with its fields of black, solidified lava, cavernous craters, and explosive geysers.

FOCUS on... the Titanic

FAMOUS WRECK
Draped in debris and rust, the bow rail of the wrecked *Titanic* looms out of the cold, dark water on the ocean floor nearly 2.5 miles (4 km) below the surface of the north Atlantic.



In April 1912, the *Titanic* was steaming from Britain to the US when she hit an iceberg that had drifted south from Greenland on the Labrador Current. The ship sank in deep water to the south of Newfoundland. More than 1,500 people died in the disaster.

DOOMED LINER

The Titanic was a fabulously luxurious ocean liner that was thought to be unsinkable. It was the ship's first voyage, and many rich and famous passengers were on board. But the route to New York was littered with icebergs.

ICEBERG AHEAD!

Photographed a few days later, this may have been the iceberg that sank the *Titanic*. She scraped along the side of the ice, making many small holes in the hull that eventually let in enough water to sink her.

REDISCOVERY

On September 1, 1985, underwater explorer Robert Ballard found the world's most famous shipwreck lying largely intact on the ocean floor. The wreck was surrounded by items that had spilled out of the ship, including these china dishes.

LOCATING THE WRECK

The remains of the *Titanic* were discovered following a survey using sonar equipment and a remote-controlled vehicle. The team then used the manned submersible *Alvin* to dive to the wreck and see it for themselves.

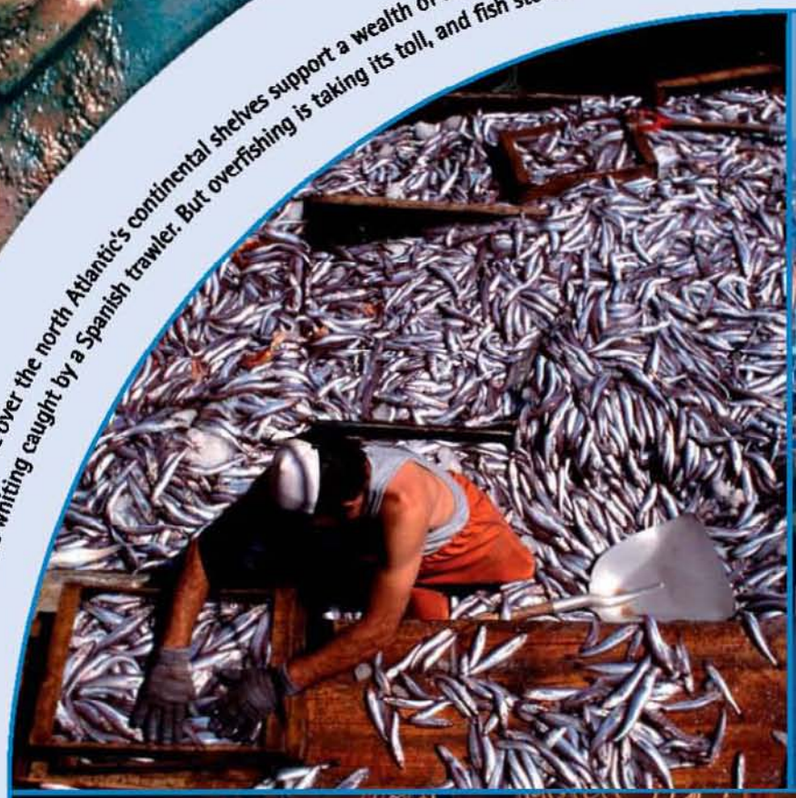
NORTHERN SEAS

THE COASTAL SEAS fringing the north Atlantic have been productive fishing grounds for centuries. They have also provided important trade routes between the historic cities of Europe and, more recently, North America.

WARM WATERS
Swept by moist oceanic winds that have been warmed by the Gulf Stream, these rocky islands in Brittany, northern France, have a much milder climate than would normally be expected for a region that lies so far north.

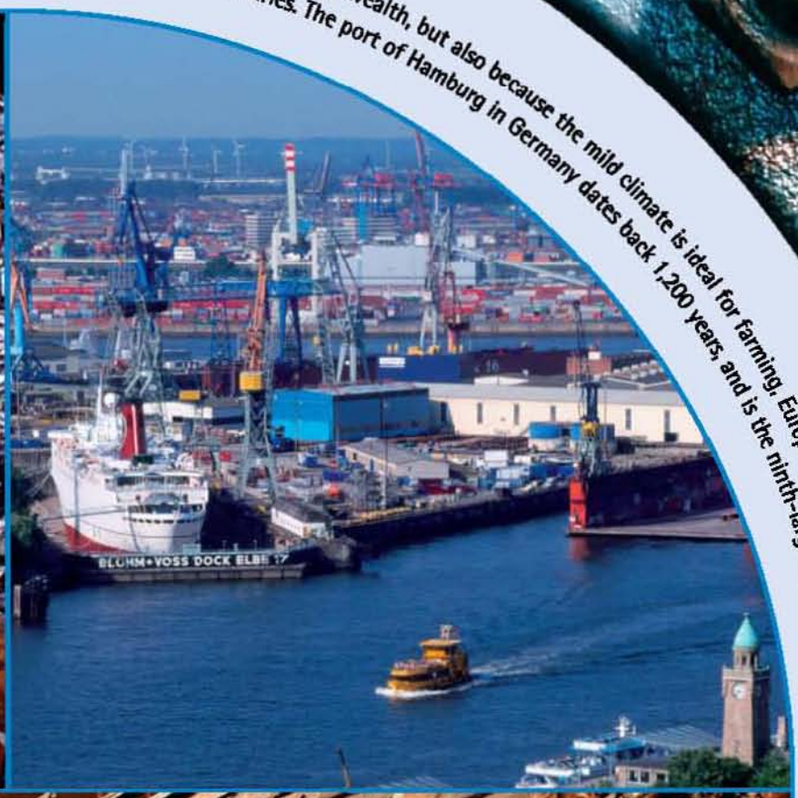
RICH HARVEST

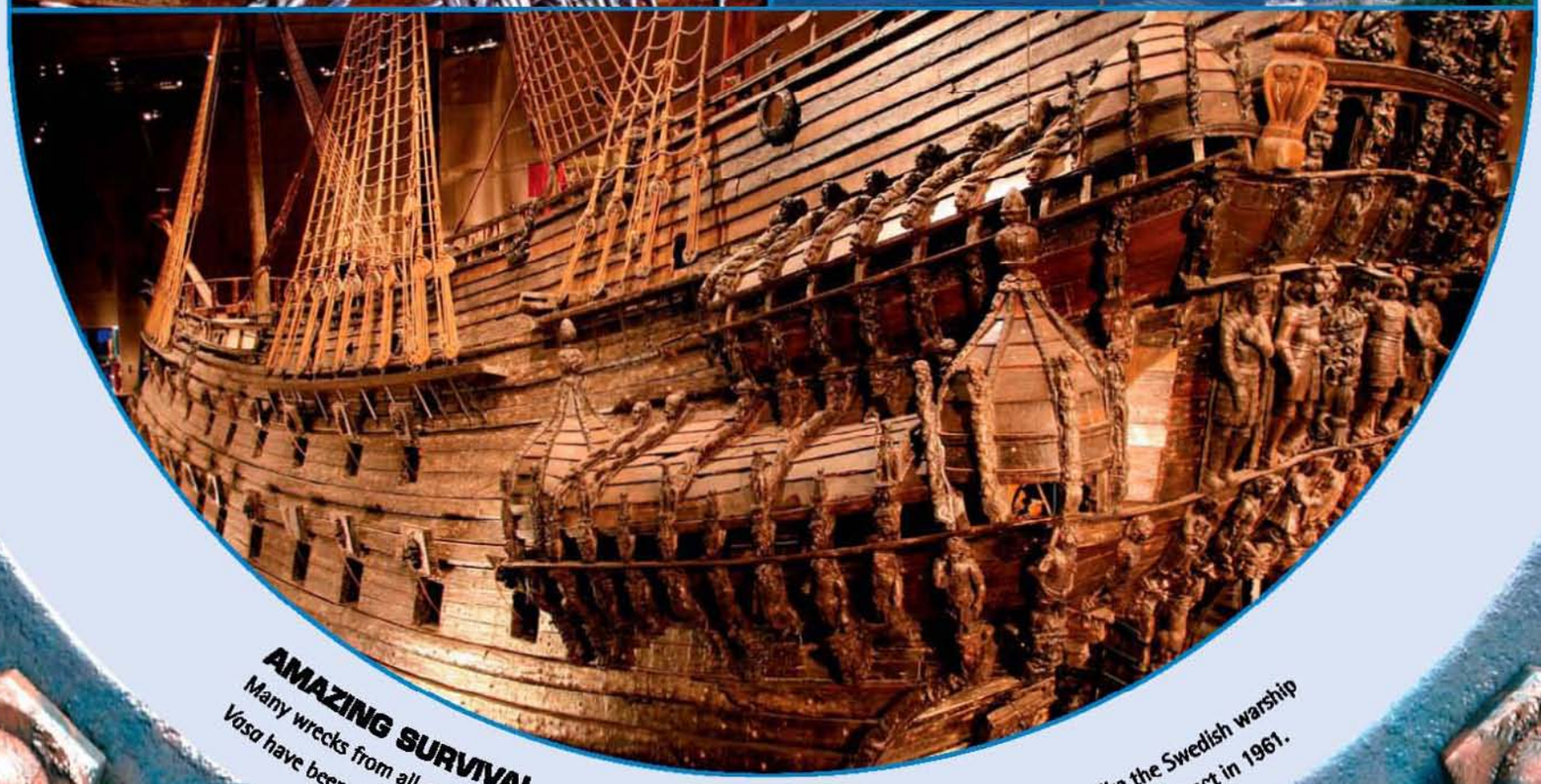
The shallow waters that lie over the north Atlantic's continental shelves support a wealth of marine life, including shoals of fish like these whiting caught by a Spanish trawler. But overfishing is taking its toll, and fish stocks are dwindling.



TRADING WEALTH

Partly because of fishing wealth, but also because the mild climate is ideal for farming, Europe's waters have been busy trade routes for centuries. The port of Hamburg in Germany dates back 1,200 years, and is the ninth-largest port in the world.





AMAZING SURVIVAL

Many wrecks from all ages are scattered along the coasts of Europe. In the Baltic, wooden ships like the Swedish warship *Vasa* have been preserved by the cold, brackish (salty) water. The ship sank in 1628 but was raised virtually intact in 1961.

SEA life... on tidal shores

LIFE ON TIDAL SHORES is very difficult for sea creatures, so only a few species survive there. Yet the water contains so much food that those few species can often flourish in enormous numbers.

ROCK POOL
Exposed rocky shores are colonized by seaweeds and tough-shelled animals, such as barnacles, limpets, and crabs, that can survive both battering by the waves and tidal exposure. Many find refuge in rock pools at low tide.

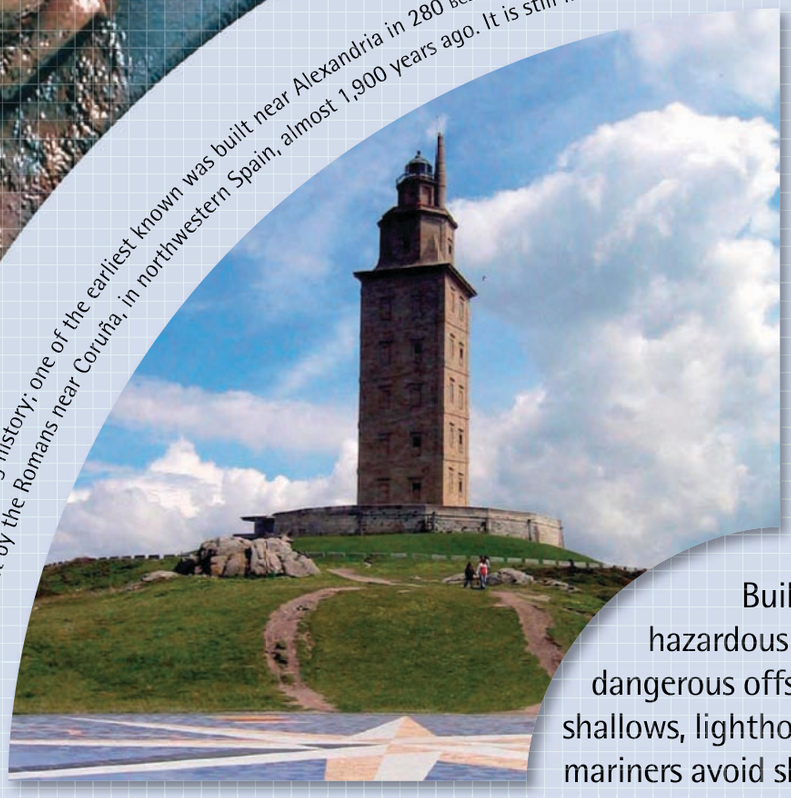

SANDY SHORES
Sheltered beaches provide homes for animals like these peacock worms, which retreat into tubes or burrows in the sand at low tide. They emerge to catch plankton when covered by water again at high tide.
BEACHCOMBING
Adaptable, mobile marine animals like these ghost crabs scavenge for scraps on the shore at low tide. They carry supplies of oxygenated water in sacs around their gills that enable them to breathe.
HUNGRY FLOCKS
The worms, clams, and other animals that burrow beneath beaches attract vast flocks of shorebirds like these knot and dunlin.
SEASIDE PLANTS
Salt-tolerant plants grow close to rocky shores, where they have little competiton for space because most flowering plants cannot survive the salt spray.

FOCUS on... lighthouses

DANGEROUS WATERS
Lighthouse keeper Theodore Malgorne peers from the door of La Jument lighthouse off the coast of France during a storm. The lighthouse has prevented thousands of lives from being lost on the coast, especially during similar tempestuous conditions.

LIFESAVERS

Lighthouses have a long history; one of the earliest known was built near Alexandria in 280 BCE. The Tower of Hercules shown here was built by the Romans near Coruña, in northwestern Spain, almost 1,900 years ago. It is still in use today.



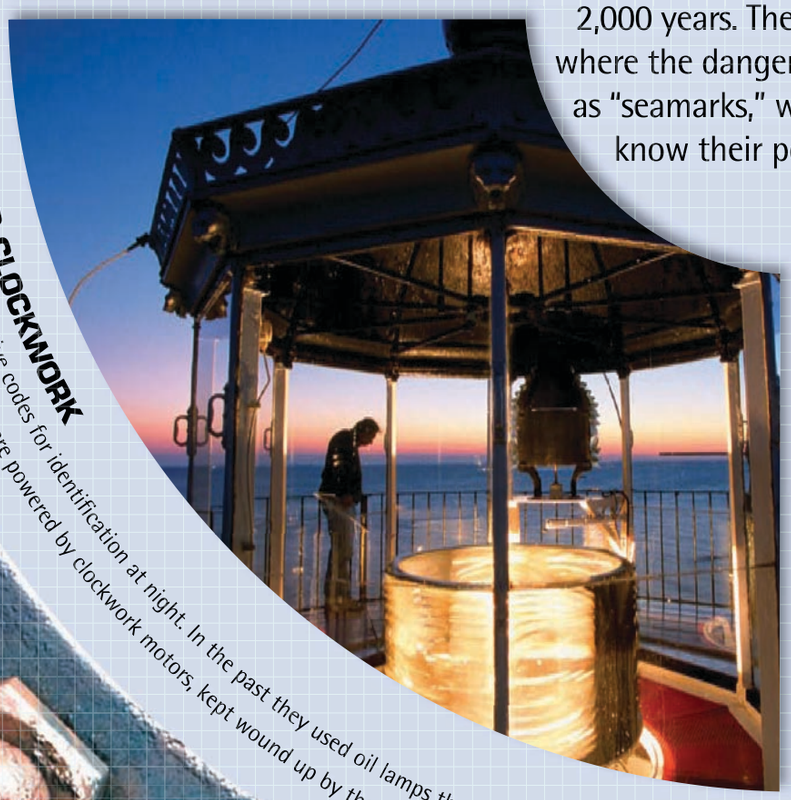
LONELY OUTPOSTS

Many lighthouses stand on appallingly exposed sites and have to be very strongly built with interlocking stone blocks to withstand winter storms. They are often painted in distinctive stripes to make them more conspicuous by day.

Built on hazardous coasts and dangerous offshore rocks and shallows, lighthouses have helped mariners avoid shipwreck for over 2,000 years. They not only show where the dangers are, but also act as "seamarks," which help sailors know their position at sea.

OIL AND CLOCKWORK

Lighthouses flash distinctive codes for identification at night. In the past they used oil lamps that were made to flash by rotating lenses. These were powered by clockwork motors, kept wound up by the lighthouse keepers.



AUTOMATIC BEACONS

Today all lighthouses are electric, automated, and often solar-powered. Modern ones are simply steel or concrete structures, but many of the old lighthouses are still in use, equipped with updated light systems.

THE MEDITERRANEAN

A VIRTUALLY LANDLOCKED SEA, the Mediterranean is surrounded by ancient cities and seaports. Many of these date back more than 2,000 years and have made the Mediterranean famous as the cradle of western civilization.

DEADLY VOLCANOES

Although known for its peaceful beauty, the Mediterranean is dotted with destructive volcanoes. The biggest is Mount Etna on Sicily, seen here during a dramatic eruption in 2002, but the most famous is Mount Vesuvius in central Italy, which buried and preserved the Roman city of Pompeii in 79 CE.

FLOURISHING PORTS

Some of the earliest seafarers traded between ports on the Mediterranean, and the seafloor is littered with shipwrecks dating back thousands of years. These amphorae (wine jars) found off the coast of Israel mark the wreckage of two Phoenician ships lost in a storm in about 750 BCE.

FABLED SHORES

The Mediterranean is the source of some of the world's earliest art, including Homer's epics—the *Iliad* and *Odyssey*, the first-known books of western literature. In Homer's time the Mediterranean was seen as the center of the world, and this is the meaning of its name.

FAST FACT •

The explosion of the volcano Santorini in 1650 BCE destroyed the Minoan civilization on nearby Crete, and may be the origin of the myth of Atlantis—a wealthy land that was drowned beneath the sea in a devastating tragedy.

COLLISION ZONE

The Mediterranean is the remains of a much larger ocean, which has closed up as Africa has moved north to collide with Europe. Africa is still creeping north, and this relentless pressure causes regular violent earthquakes, especially in Greece and Turkey.

ANCIENT CIVILIZATIONS

Western civilization began in the Mediterranean more than 2,000 years ago and the earliest democracies evolved here. The philosophers who lived in the city-states produced work that is still read and studied today. Many buildings survive from this period, including the Parthenon in Athens, seen here.

THREATENED PARADISE

Virtually cut off from the ocean, the Mediterranean suffers badly from pollution that cannot escape into the Atlantic. This is threatening native wildlife like the critically endangered Mediterranean monk seal. Yet despite this, the water in some places is still crystal clear and teeming with marine life.

SEA life... in the sunlit zone

NEARLY ALL OCEANIC LIFE relies on food made by microscopic drifting algae using the energy of sunlight. So most of the animals in the sea live in the top 650 ft (200 m) of the ocean.

UNFUSSY EATERS
Animals like this fried egg jellyfish drift among the plankton in search of food, eating just about anything they come across.


DRIFTING SWARMS
Swarms of zooplankton like these tiny jellyfish feed on the algae. Many of the drifting animals are the larvae of crabs, clams, and other large creatures.
NETTING A MEAL
Many animals can survive by staying put in one place and trapping any food that drifts or swims their way. This anemone, for example, has caught a shrimp.
FOOD FACTORIES
Tiny plantlike algae, or phytoplankton, use solar energy to turn carbon dioxide and water into sugar. They also make proteins from nutrients dissolved in the water.
HUNGRY SHOALS
Huge shoals of small fish like these anchovy feed on the plankton by straining water through their gills to trap the tiny organisms.
OCEAN HUNTER
Hunters such as tuna, marlin, and sharks cruise the sunlit zone in search of a meal of fish or squid. This blue shark has caught a mackerel.
FILTER-FEEDING GIANTS
Big animals like the manta ray and this basking shark plow through the swarming plankton, using their sievelike gills to filter it from the water.

SARGASSO SEA

LYING NEAR THE CENTER of the tropical north Atlantic, the Sargasso Sea is an almost windless zone of warm, clear water, famous for the floating seaweed of the same name that covers its surface.

SWIRLING CURRENTS

The floating weed is concentrated in the Sargasso Sea by a huge, swirling "gyre" of ocean currents. The water flows west near the equator, then heads north near Florida to become the Gulf Stream that flows across the north Atlantic toward Europe. Here it turns south as the Canary Current, before flowing west again.

FLOATING GARDEN

The sargasso weed floats on the very surface of the water where it can soak up the sunlight it needs.

TROUBLED WATERS

STORM WARNING

Above-average ocean surface temperatures in the tropical north Atlantic have led to an increased intensity of the area's storms. 2005 was a record year for major hurricanes.

VITAL EDDIES

Tropical oceans often contain few plant nutrients near the surface, so they cannot support much life. But the weed in the Sargasso Sea seems to rely on nutrients drawn up from deeper water by swirling circular currents called eddies.

WEEDY NURSERY

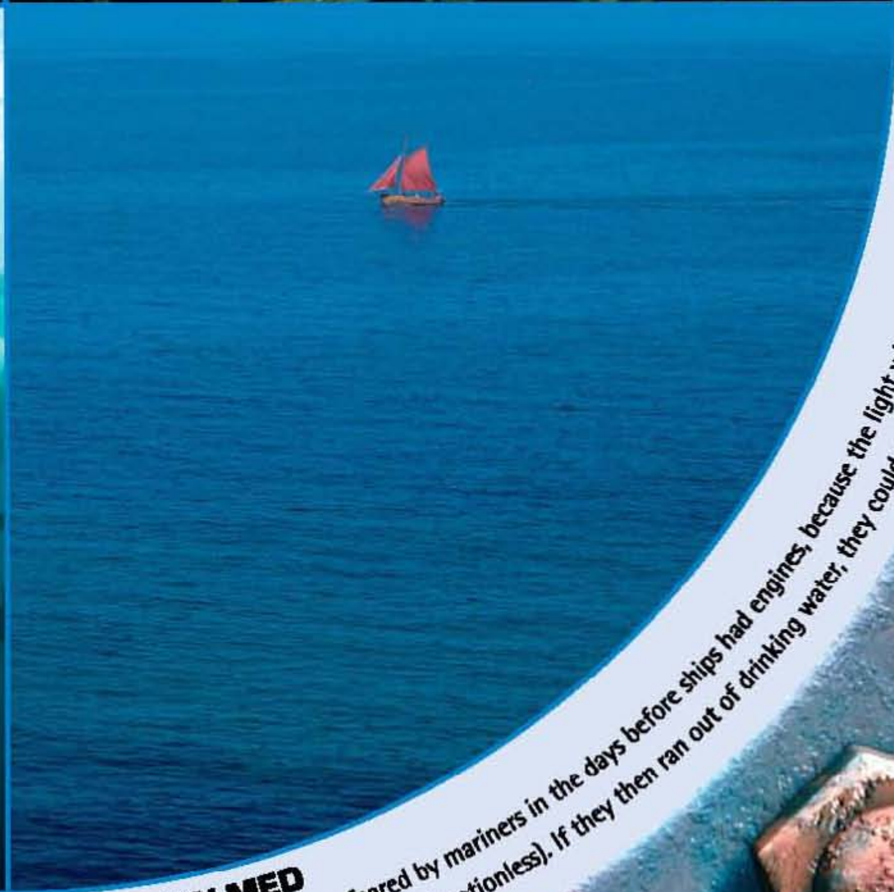
Sargasso weed provides a home for small shellfish and other animals, such as flying fish and young sea turtles. They include the highly camouflaged sargassum fish, which looks just like a frond of floating weed.

DOLPHIN SCHOOLS

Although there is not much to eat in the clear blue water of the Sargasso Sea and similar deep tropical oceans, there are isolated hotspots of life. These attract fast-swimming oceanic hunters like these dolphins, which are able to travel long distances in search of prey.

BECALMED

The Sargasso Sea was feared by mariners in the days before ships had engines, because the light winds could fail and leave them becalmed (motionless). If they then ran out of drinking water, they could die of thirst.



THE CARIBBEAN

CUT OFF FROM THE ATLANTIC by the Florida peninsula and a string of islands, the Caribbean and Gulf of Mexico are stormy but beautiful seas of tropical blue water.

SAVAGE STORMS

The Caribbean is often hit by hurricanes that brew up in the tropical Atlantic in late summer, when the ocean is at its warmest. The hurricanes are carried west by global air currents and batter the islands and coastal cities. This satellite image shows Hurricane Katrina over the Gulf of Mexico in 2005.

DEAD ZONE

Many parts of this region suffer from badly planned coastal development and pollution, which is a serious problem in the Gulf of Mexico. Here, fertilizers draining off the farmlands of North America have created a huge "dead zone" around the Mississippi Delta, where the river water pours into the Gulf.

TROPICAL SEAS

Many of the islands and coasts of the Caribbean and Gulf of Mexico are fringed with coral reefs and mangrove forests. Beautiful stretches of white coral sand turn the clear blue water turquoise in the shallows.

FAST FACT •

Puerto Rico in the Caribbean was where Christopher Columbus landed after crossing the Atlantic in 1492.

GULF OIL

The Gulf of Mexico has rich oil deposits beneath the seabed. They are exploited by at least 800 offshore oil rigs, which drill deep into the rock to extract the oil. The industry has a good safety record, but pollution is a problem—as here, where burning waste gas is creating a plume of black smoke.

SUNKEN TREAURE

Spanish treasure galleons once sailed through these waters. Many were wrecked by hurricanes or poor navigation, scattering their cannons and precious cargo over the seabed. The region was also notorious for piracy, and Port Royal in Jamaica was virtually controlled by pirates until its destruction by an earthquake in 1692.

UPWELLING ZONE

Off the coast of Namibia in southwest Africa the wind carries surface water away from the shore and out to sea. This draws deep water and nutrients from the seabed to the surface, fueling the growth of plankton. The plankton supports swarms of tiny animals and big shoals of fish, which are hunted by seabirds, sharks, and sea lions.

GLITTERING SHORE

Rivers draining off southern Africa carry masses of sand and other mineral sediments into the shallow ocean water at the coast. These minerals include high-quality diamonds, which are dredged from the seafloor and even collected from beaches where they are swept up by waves.

SOUTH ATLANTIC

COLD CURRENTS flowing north from the Antarctic carry fertile water into the tropical south Atlantic to support flourishing ocean life.

VOLCANIC ISLANDS

The south Atlantic has several remote volcanic islands that have erupted from near the Mid-Atlantic Ridge. They include Ascension Island and Tristan da Cunha, seen here. Tristan is basically one huge volcano, which last erupted in 1961. The islanders had to be evacuated and could only return after two years.

BREEDING COLONIES

South Atlantic islands are—or were—important breeding sites for oceanic wildlife. Ascension Island used to have large colonies of seabirds like these frigate birds, but today these breed only on nearby Boatswain Bird Island, where they are safe from rats accidentally introduced to the main island by ships.

FOG DESERT

The cold offshore current in the south Atlantic cools the air over the ocean, turning all its water vapor into sea fog. By the time the air blows over the land it is too dry to carry any rain, creating the Namib Desert—a stark contrast with the living waters offshore.

SAILING AROUND THE WORLD

PIONEERED BY THE GREAT SAILING SHIPS of the past, the Southern Ocean around the world is the route of choice for record-breaking racing yachts.

TALL SHIPS

Sail-training ships like the *Danmark* still teach the skills that allowed the early explorers and traders to cross the oceans under sail, using only the energy of the wind.

THE GRAIN RACE

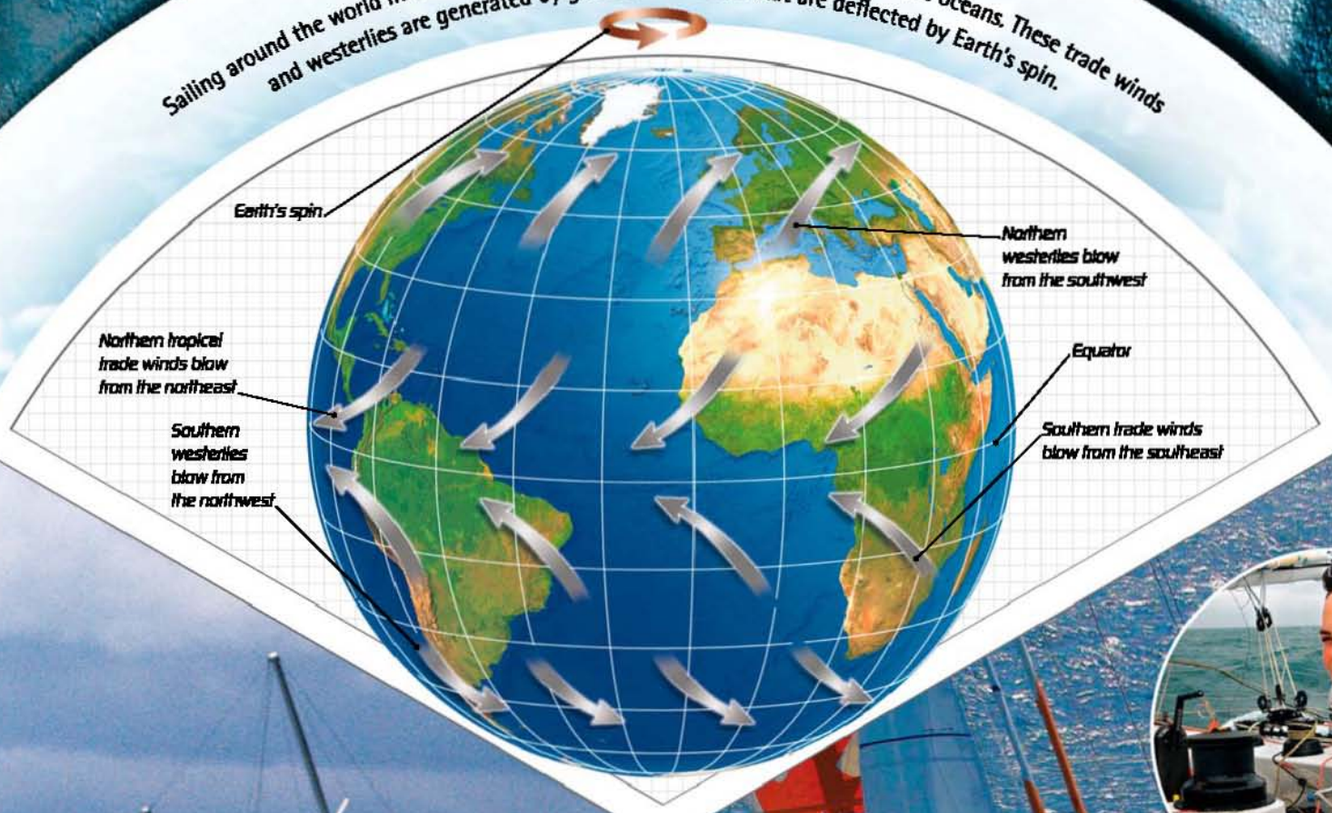
In the 19th and early 20th centuries fast ships, such as the famous clippers, sailed from Europe to Australia to pick up cargoes of grain, racing to bring them to market. They sailed south through the South Atlantic and then east to Australia, returning via Cape Horn to benefit from the strong eastward-blowing winds in the Southern Ocean.

• FAST FACT

Sailing from Australia to Europe in a tall ship usually took 100 days. The record for these ships was 83 days, set by the grain ship Parma in 1933.

PREVAILING WINDS

Sailing around the world makes use of reliable prevailing winds that blow over the oceans. These trade winds and westerlies are generated by global air currents that are deflected by Earth's spin.



SOLO VOAGE

In 1968, Robin Knox-Johnson set sail from England to follow the old clipper route through the Southern Ocean. In his small yacht *Suhaili* he achieved the first solo nonstop voyage around the world. He was photographed approaching England in a storm toward the end of his epic adventure.

Knox-Johnson facts

Year: 1968–69
Voyage duration: 313 days
Average speed: 4 mph (6.4 km/h)
Boat length: 32 ft (9.8 m)
Boat type: wooden ketch

MacArthur facts

Year: 2005 Voyage duration: 72 days
Average speed: 17 mph (28 km/h)
Boat length: 75 ft (23 m)
Boat type: racing trimaran

BREAKING THE RECORD

Since the 1960s many people have made record-breaking round-the-world voyages. They include Ellen MacArthur (inset), who accomplished this feat in her trimaran B&Q/Costorama—a big, fast, multihull vessel—seen here in the Bay of Biscay.

1 GANGES DELTA

The low-lying delta at the mouth of the Ganges River is the surface of a vast "fan" of soft sediment. This submarine fan extends for up to 1,500 miles (2,500 km) across the floor of the Bay of Bengal.

2 HIMALAYAS

The highest mountains in the world form a vast crumple zone marking where India has collided with Asia. The same movement has also created the deep Sunda Trench and the islands of Java and Sumatra.

About 120 million years ago India split off from Africa and started moving north, eventually colliding with Asia. The Indian Ocean opened up behind it and is still spreading slowly from the Mid-Indian Ridge and Carlsberg Ridge. Other ridges marking ancient volcanic activity are capped with chains of coral islands.

Left: 3-D map of the Indian Ocean • Below: Fishing boats at Matawe, Zanzibar Island

INDIAN OCEAN

EAST AFRICAN SEAS

THE TROPICAL INDIAN OCEAN is a magical world of clear blue waters, remote oceanic islands, and strange wildlife.

LIVING FOSSIL

In 1938 a strange fish was discovered near South Africa. It was identified as a coelacanth—a "living fossil" fish similar to the ancestors of all reptiles, mammals, and birds. It was thought to have become extinct at least 100 million years ago, but is now known to live in deep water around the Comoro islands near Madagascar.

TRADING PORT

Zanzibar island off the coast of Tanzania was once a thriving trading port for spices and ivory, but it was most notorious as the center of the 19th-century African slave trade. The rulers of Zanzibar grew rich on the profits, building many palaces that still stand in the ancient city center, Stonetown—now a World Heritage Site.

PARADISE ISLANDS

The islands of the Seychelles are renowned for their spectacular seascapes and glorious beaches of coral sand.

GIANT TORTOISE

The giant tortoises of Aldabra are among the many curious animals that live on the islands of the western Indian Ocean. There used to be numerous other species, but hunting drove many into extinction, including the dodo—a large, flightless pigeon that once lived on Mauritius.

STORMY SEAS

The Agulhas Current flows southwest around the coast of South Africa, where it runs into storm waves coming from the opposite direction. This conflict builds up some of the steepest, most dangerous "rogue waves." They have probably sunk many ships, but nobody can be sure, since the ships simply disappear.

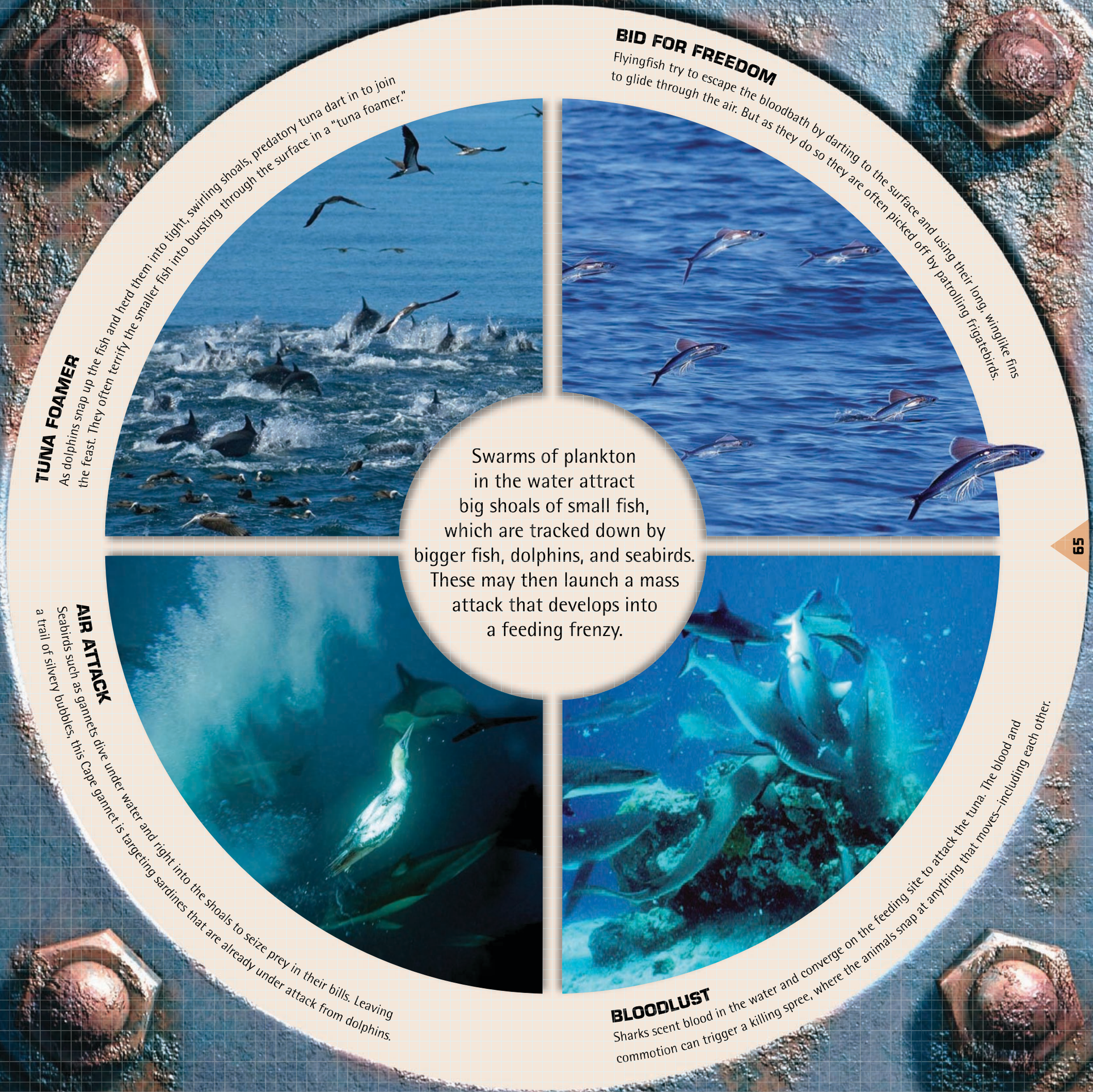
KILLER SHARKS

South African seas have a sinister reputation for shark attack because of the many great white sharks that prowl its coastal waters. They prey mainly on seals but have also killed several people. Despite this, many divers pay good money for the thrill of a close encounter with a great white shark, protected by the steel mesh of a shark cage.

FOCUS on... feeding frenzy

BAITBALL

Attacked by dolphins, tuna, and diving seabirds, small fish form a tight, spinning "baitball" as they try to hide behind each other. The hunters will pick them off one by one until there are none left.



Swarms of plankton in the water attract big shoals of small fish, which are tracked down by bigger fish, dolphins, and seabirds. These may then launch a mass attack that develops into a feeding frenzy.

TUNA FOAMER
As dolphins snap up the fish and herd them into tight, swirling shoals, predatory tuna dart in to join the feast. They often terrify the smaller fish into bursting through the surface in a "tuna foamer."

BID FOR FREEDOM
Flyingfish try to escape the bloodbath by darting to the surface and using their long, winglike fins to glide through the air. But as they do so they are often picked off by patrolling frigatebirds.

AIR ATTACK
Seabirds such as gannets dive under water and right into the shoals to seize prey in their bills. Leaving a trail of silvery bubbles, this Cape gannet is targeting sardines that are already under attack from dolphins.

BLOODLUST
Sharks scent blood in the water and converge on the feeding site to attack the tuna. The blood and commotion can trigger a killing spree, where the animals snap at anything that moves—including each other.

INDIAN SEAS

SWEPT BY CURRENTS that change direction with the monsoon winds, the northern Indian Ocean has hotspots of oceanic life that attract some of the biggest animals in the seas.

CORAL ISLANDS

The Maldives to the southwest of India are coral islands that have formed on top of a submerged rocky ridge.

FAST FACT

There are 1,196 islands in the Maldives, but most of them are too small to live on.

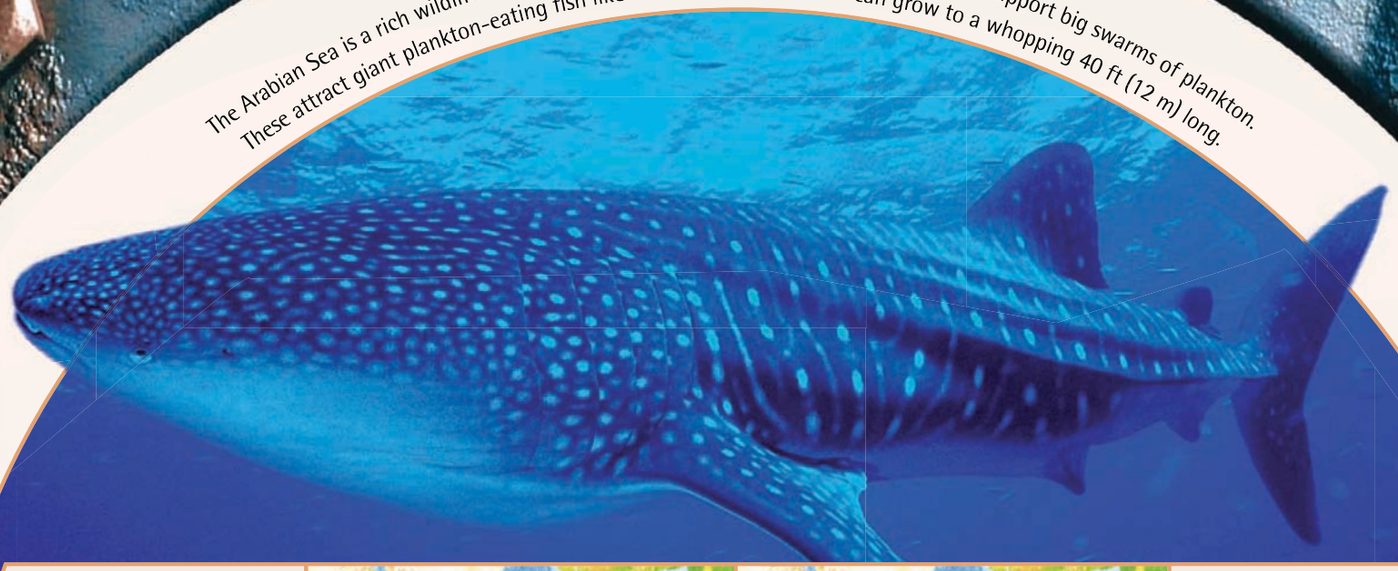
TROUBLED WATERS

THREATENED NATION

Most of the islands of the Maldives, like its capital Male, are less than 6 ft (1.8 m) above sea level, making them extremely vulnerable to rising sea levels caused by climate change.

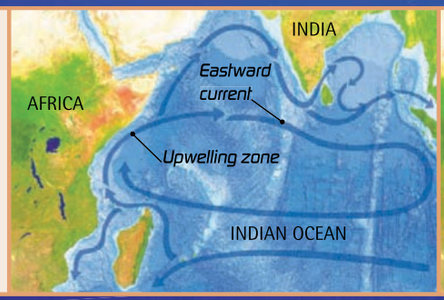
PLANKTON SWARMS

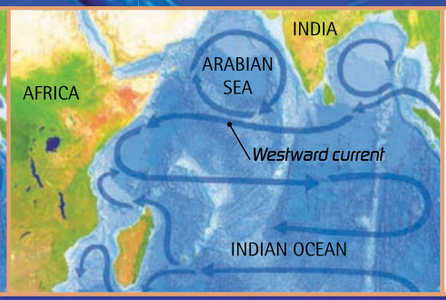
The Arabian Sea is a rich wildlife zone because upwelling currents off the Gulf of Aden support big swarms of plankton. These attract giant plankton-eating fish like this whale shark, which can grow to a whopping 40 ft (12 m) long.



SUMMER

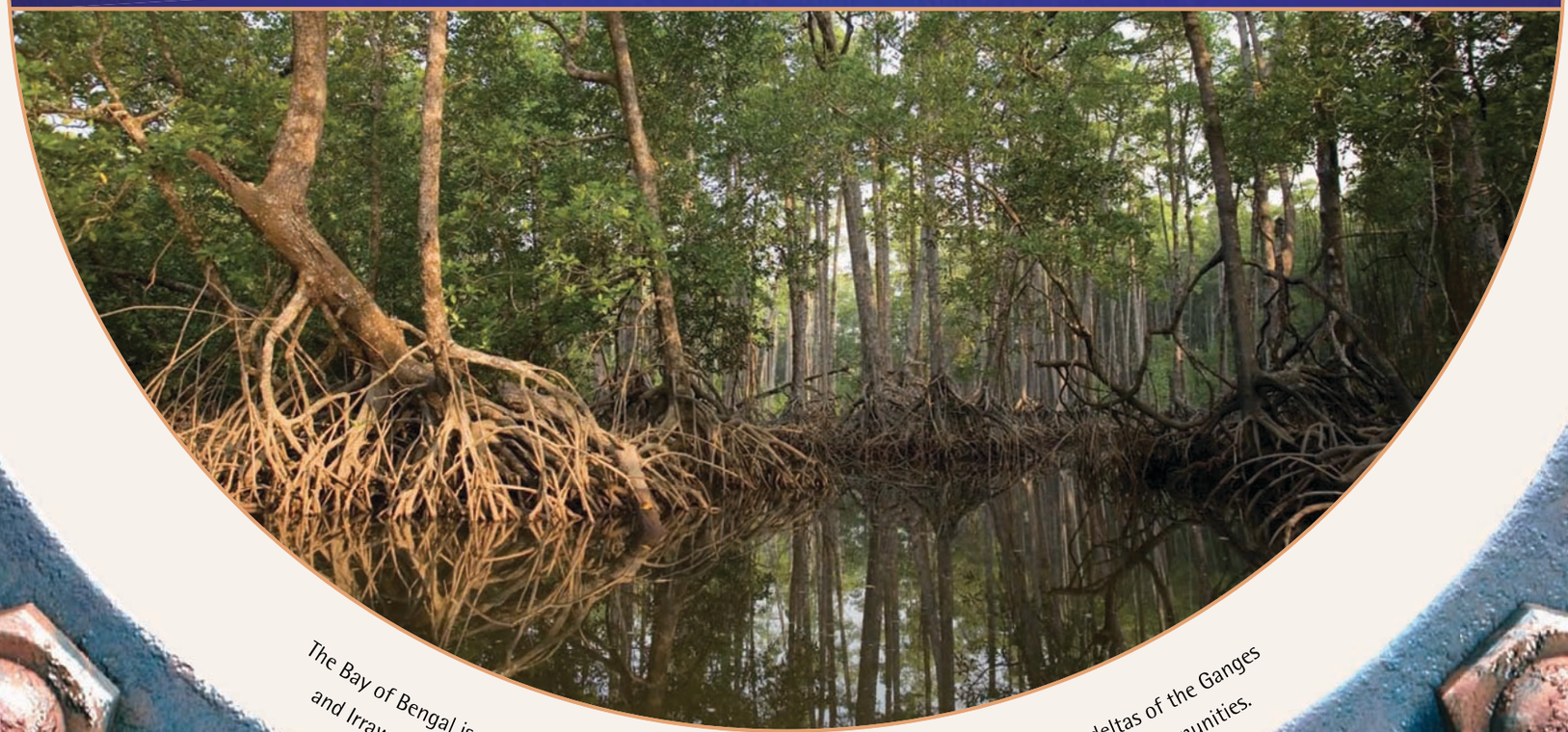
In summer rising air over Asia draws moist, oceanic winds northeast over India to cause monsoon rain. The winds drag the surface water of the northern Indian Ocean eastward, causing nutrient-rich water to well up.





WINTER

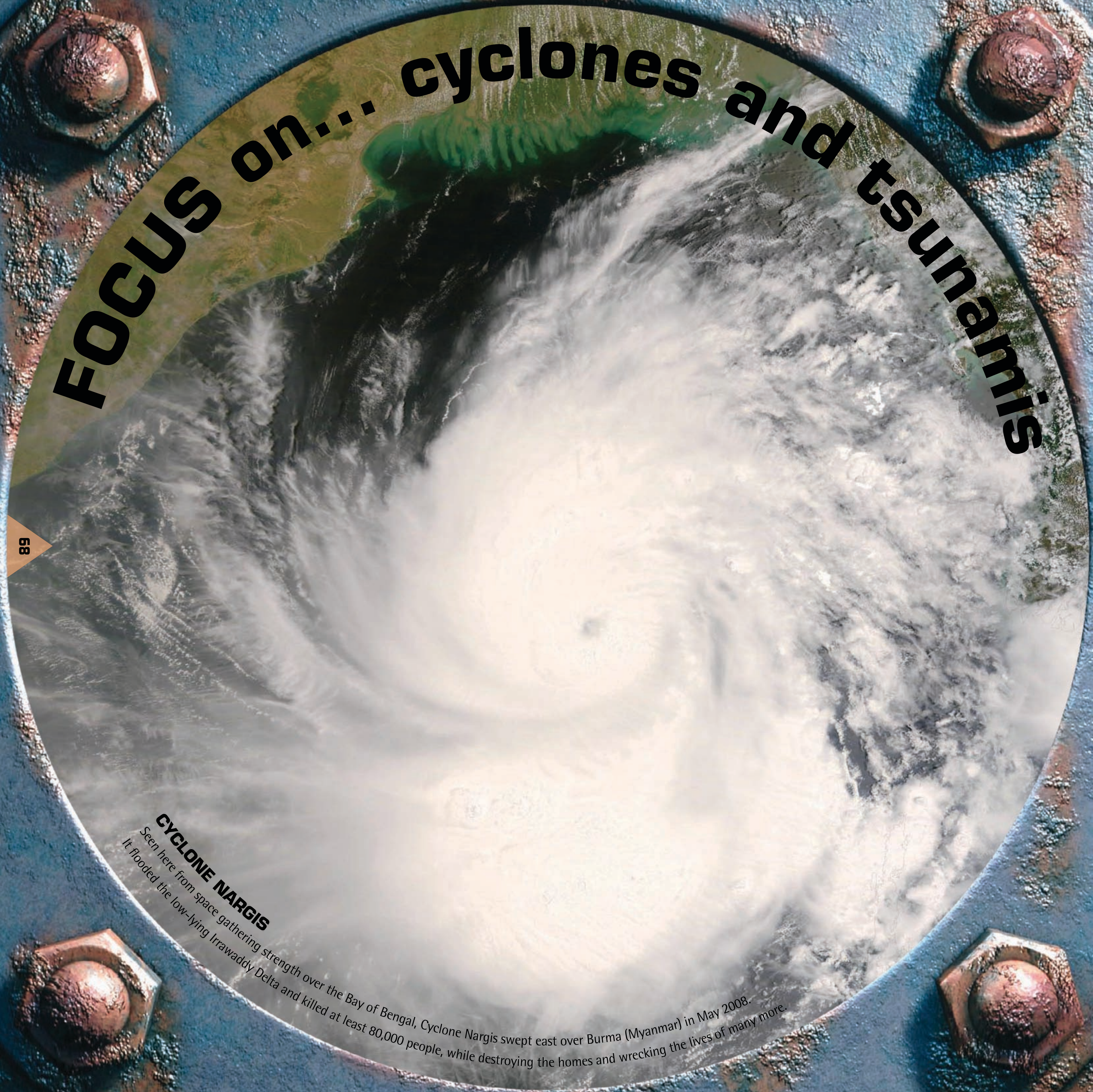
Cold, sinking air over Asia in winter pushes dry air southwest over India, reversing the wind direction and the ocean currents. This stops the deep water welling up near Africa, but stirs up food-rich waters in the Arabian Sea.



STORM ZONE

The Bay of Bengal is notorious for storms and huge waves that flood the low-lying river deltas of the Ganges and Irrawaddy. Mangrove forests like these growing on the delta mud help to protect coastal communities.

FOCUS on... cyclones and tsunamis



CYCLONE NARGIS
Seen here from space gathering strength over the Bay of Bengal, Cyclone Nargis swept east over Burma (Myanmar) in May 2008. It flooded the low-lying Irrawaddy Delta and killed at least 80,000 people, while destroying the homes and wrecking the lives of many more.

HOWLING WINDS
In a tropical cyclone or hurricane, vast amounts of warm air and water vapor rise rapidly to form huge storm clouds. Surrounding air rushes in to replace the rising air, creating howling winds that swirl around a central calm zone.

STORM SURGE
Very low air pressure within the storm allows the wind to push ocean water up into a moving heap—a storm surge. This can strike the shore as a colossal wave, causing flooding of the kind that devastated New Orleans in 2005.

Tropical cyclones are hurricanes that build up in the Indian Ocean, where the water is warm enough to generate masses of rising water vapor. This can cause storm surges of ocean water, resembling the tsunamis that are triggered by oceanic earthquakes.

TSUNAMIS
Earthquakes on the seafloor can generate huge waves known as tsunamis. These waves stay long and low at sea, but they cover a vast area—as can be seen in this satellite view of Asian tsunami waves approaching Sri Lanka in 2004.

DEVASTATION
When a tsunami approaches the coast it piles up into a wall of water that overwhelms the shore. This coastline in Sumatra was devastated by the 2004 Asian tsunami, which killed at least 130,000 people.

SEA life... in the ocean depths

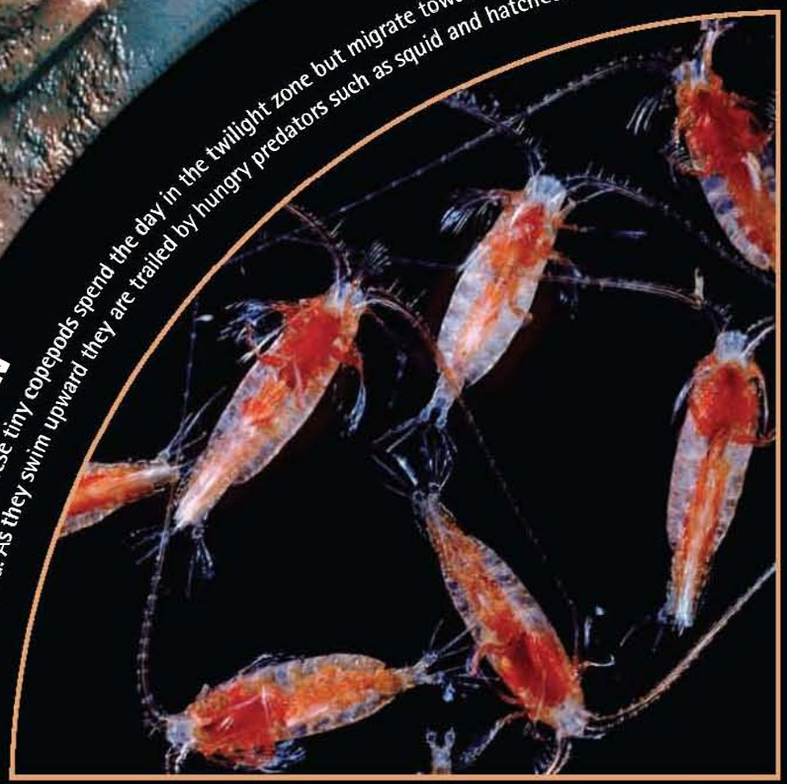
THERE IS LITTLE OR NO LIGHT in the ocean below 650 ft (200 m), so plankton cannot make any food. Many of the animals visit the surface to feed. Others live on scraps, or simply eat each other.

LIVING IN THE DARK

There are weird-looking creatures aplenty in the deep ocean. This ghostly female angler fish has two males fused to her underside. They are sucking her blood for nourishment.

VERTICAL MIGRATION

A lot of animals like these tiny copepods spend the day in the twilight zone but migrate toward the surface at night to feed. As they swim upward they are trailed by hungry predators such as squid and hatchetfish.

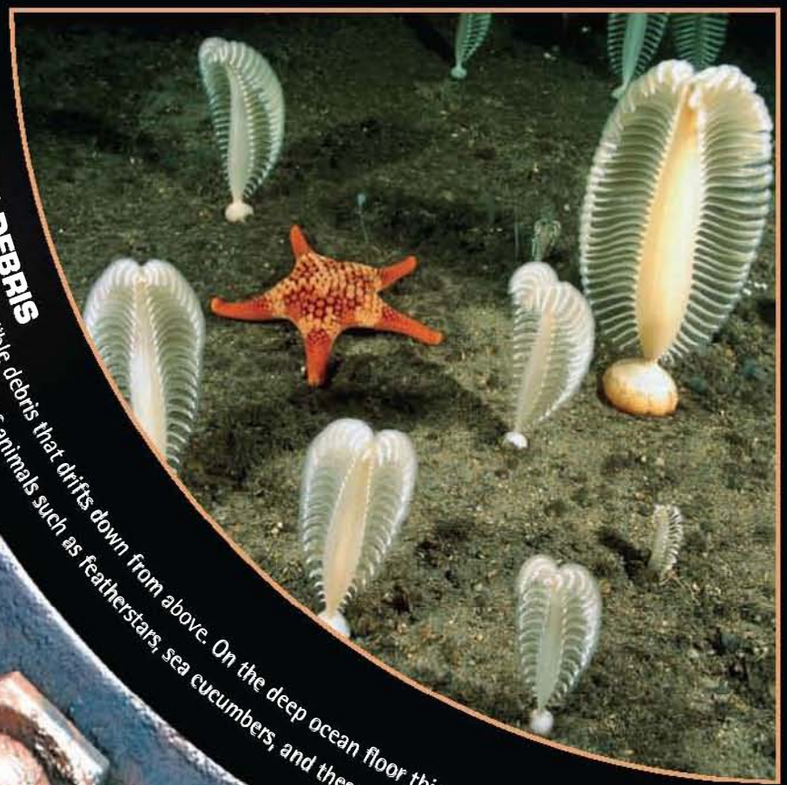


NIGHTMARE HUNTERS

Some fish stay deep in the gloom and prey on other animals. Victims are so scarce that hunters like this viperfish have huge mouths, dagger teeth, and balloonlike stomachs to ensure they can eat virtually anything.

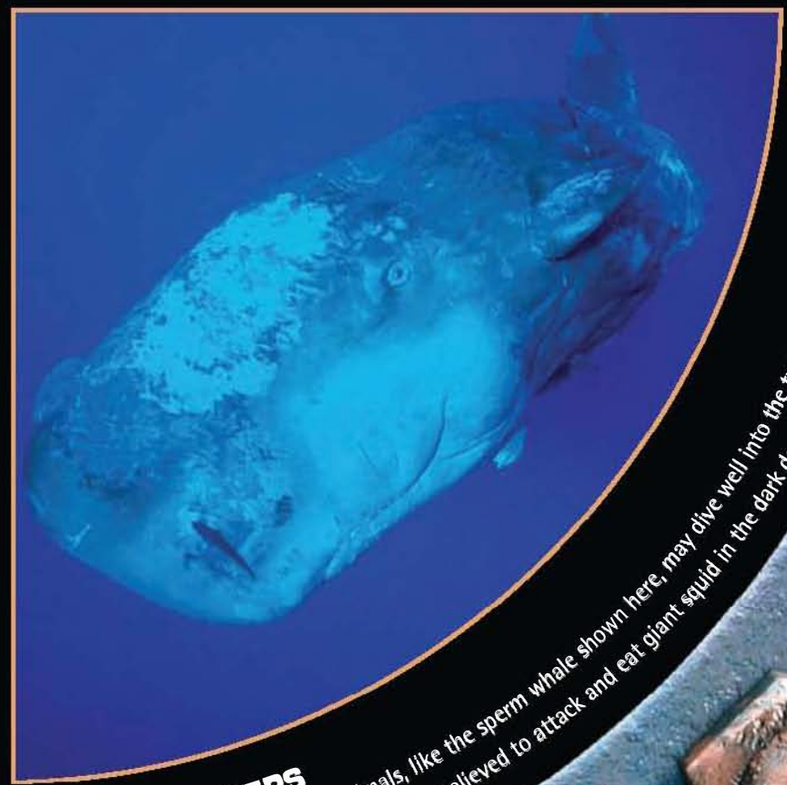
EDIBLE DEBRIS

Many animals eat the edible debris that drifts down from above. On the deep ocean floor this serves to feed a sparse but diverse variety of animals such as featherstars, sea cucumbers, and these quill-like sea pens.

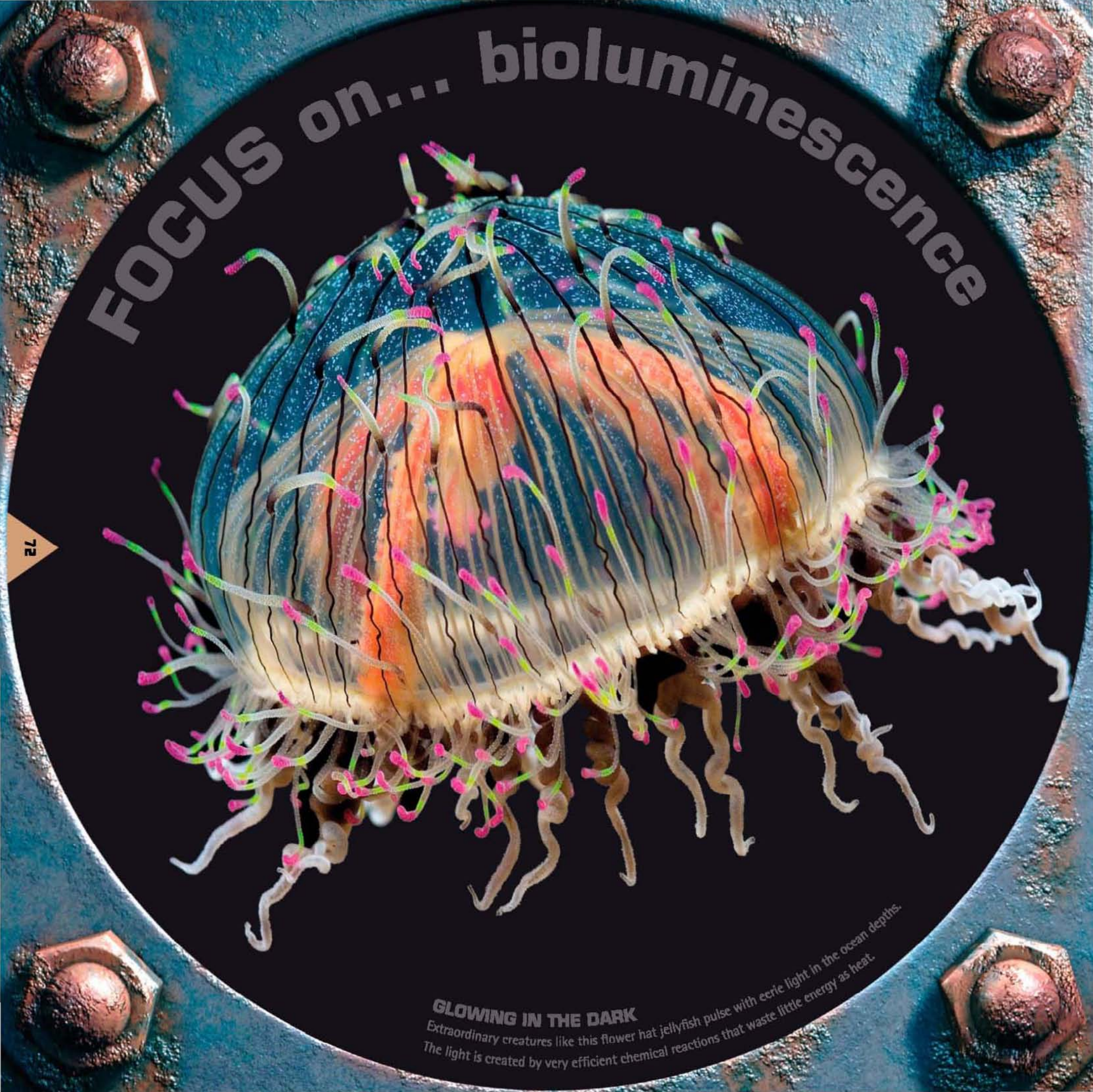


DEEP DIVERS

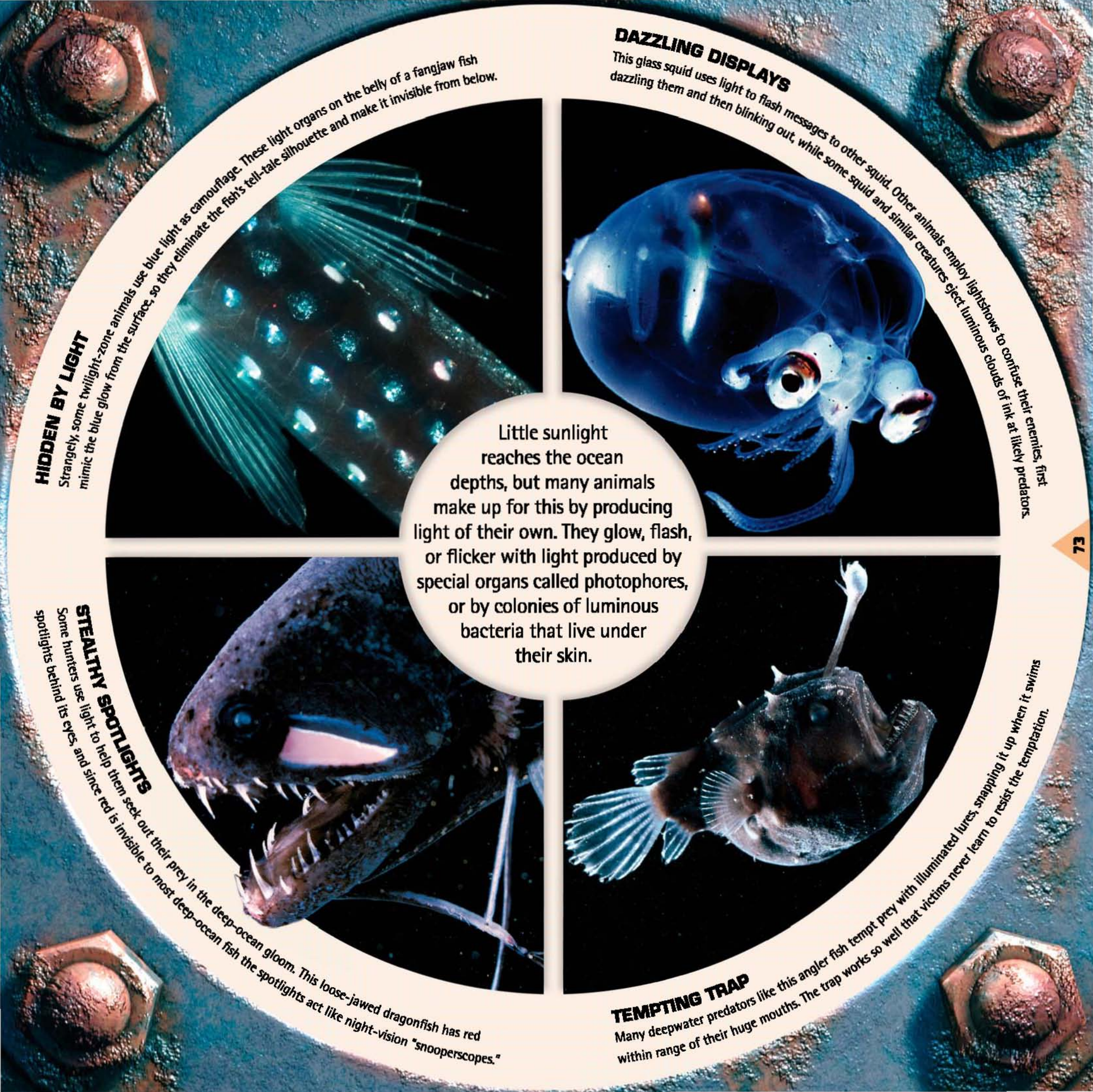
Some big surface-living animals, like the sperm whale shown here, may dive well into the twilight zone in search of prey. Sperm whales are believed to attack and eat giant squid in the dark depths of the ocean.



FOCUS on... bioluminescence



GLOWING IN THE DARK
Extraordinary creatures like this flower hat jellyfish pulse with eerie light in the ocean depths. The light is created by very efficient chemical reactions that waste little energy as heat.



Little sunlight reaches the ocean depths, but many animals make up for this by producing light of their own. They glow, flash, or flicker with light produced by special organs called photophores, or by colonies of luminous bacteria that live under their skin.

HIDDEN BY LIGHT
Strangely, some twilight-zone animals use blue light as camouflage. These light organs on the belly of a fangjaw fish mimic the blue glow from the surface, so they eliminate the fish's tell-tale silhouette and make it invisible from below.

DAZZLING DISPLAYS
This glass squid uses light to flash messages to other squid. Other animals employ lightshows to confuse their enemies, first dazzling them and then blinking out, while some squid and similar creatures eject luminous clouds of ink at likely predators.

STEALTHY SPOTLIGHTS
Some hunters use light to help them seek out their prey in the deep-ocean gloom. This loose-jawed dragonfish has red spotlights behind its eyes, and since red is invisible to most deep-ocean fish the spotlights act like night-vision "snooperscopes."

TEMPTING TRAP
Many deepwater predators like this angler fish tempt prey with illuminated lures, snapping it up when it swims within range of their huge mouths. The trap works so well that victims never learn to resist the temptation.

THE SUNDA ARC

INDONESIA IS LARGELY MADE UP of a great arc of volcanic islands that traces the line of the deep Sunda Trench, extending from the northern tip of Sumatra to near New Guinea.

ISLANDS OF FIRE
The islands of eastern Java are almost entirely made up of volcanoes. Many are active, including Krakatau—notorious for a cataclysmic eruption in 1883. At least 70 others in this volcanic arc have erupted since 1900.

EARTHQUAKE ZONE

The Sunda Trench marks where the Indian Ocean floor is pushing beneath the continent of Asia. This movement triggers many earthquakes, and it was an earthquake deep in the trench off northern Sumatra that caused the huge catastrophic waves of the 2004 Asian tsunami.

DRAGON'S DEN

Indonesian seas are notorious for highly venomous sea snakes like this, and huge saltwater crocodiles. The Sunda Arc is also home to the world's biggest lizard—the Komodo dragon—which inhabits a handful of the islands.

SPICE ISLANDS

The tiny Banda islands near New Guinea were once the only sources of nutmeg and mace. Until the early 16th century their location was kept secret, and the spices were literally worth more than their weight in gold.

SEA life... in mangrove swamps

SHELTERED SHORES in Indonesia, and throughout the tropics, are colonized by tidal forests of evergreen trees called mangroves. Thanks to their specialized root systems they can grow in salty, waterlogged mud, unlike most plants.

MANGROVE SWAMPS
Nearly all plants need air around their roots. The arching roots of these mangroves absorb air that they cannot get from the water-saturated, stagnant mud of this tidal shore. Other types of mangroves have spikelike roots that stick up out the water to act like snorkels.

LIFE ON THE MUD

The mud of the swamps is home to these colorful fiddler crabs, which process it to extract food. They dig their burrows in the mud and seal themselves in at high tide with a pocket of air, which they need to survive, despite having gills.

SHARPSHOOTER

At high tide the tangled mangrove roots offer a safe refuge for small fish. In Indonesia these include the extraordinary archer fish, which spits jets of water at insects to knock them off their perches and into the water for eating.

HUNGRY HUNTERS

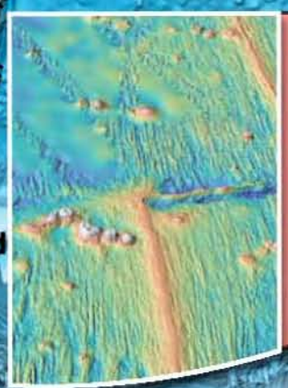
The mangrove trees provide nesting sites for birds such as herons, storks, and cormorants. These hunt for fish in the water but have to watch out for the powerful saltwater crocodiles—the largest crocodile species—that also live in the mangroves.

CLEARED AWAY

Throughout most of Indonesia, mangroves are under threat. Many have been cleared to make way for fish farms and prawn pools like these, or felled for their timber. This makes low-lying coasts far more vulnerable to storm waves and tsunamis.

1 RING OF FIRE

Ruapehu in New Zealand is one of more than 450 volcanoes that form a "ring of fire" around the Pacific. They have erupted near the ocean trenches where ocean floor is being destroyed.



2 EAST PACIFIC RISE

This sonar image shows part of the spreading rift in the eastern Pacific. The rift is spreading fast, but not fast enough to make up for the destruction at the ocean fringes.

ASIA
Sea of Okhotsk
Kuril Trench
Japan
Japan Trench
Northwest Pacific Basin
Emperor Seamount Chain
Izu-Ogasawara Trench
Philippine Basin
West Mariana Basin
Mariana Trench
East Mariana Basin
Mid-Pacific Mountains
Hawaiian Ridge
Hawaiian Islands
Murray Fracture Zone
Guadalupe
Molokai Fracture Zone
Revillagigedo Islands
Middle America Trench
Clarion Fracture Zone
Clipperton Island
Guatemala Basin
Clipperton Fracture Zone
Gallego Rise
Galápagos Fracture Zone
Marquesas Islands
Marquesas Fracture Zone
Penrhyn Basin
Tahiti
Tiki Basin
East Pacific Rise
Northeast Pacific Basin
Marshall Islands
Line Islands
Central Pacific Basin
West Caroline Basin
East Caroline Basin
Melanesian Basin
New Guinea
Solomon Islands
Coral Sea Basin
Great Barrier Reef
Coral Sea
Vanuatu
Fiji
Samoa
Samoa Basin
Niue
New Caledonia
Lord Howe Rise
South Fiji Basin
Kermadec Trench
Tonga Trench
AUSTRALIA
Tasman Sea
Tasman Basin
New Zealand
ANTARCTICA

Left: 3-D map of the Pacific Ocean • Above: The Great Barrier Reef, Australia

PACIFIC OCEAN

The vast Pacific Ocean covers one-third of the planet, but it used to be even bigger. While the Atlantic and Indian oceans are expanding, the Pacific is shrinking as its fringes are destroyed in deep trenches. The ocean is also peppered with coral-fringed volcanic islands and submerged seamounts.

NORTH PACIFIC

WINTER STORMS AND COLD CURRENTS bring vital nutrients to the sunlit surface of the north Pacific. The resulting plankton support masses of fish, whales, seals, and seabirds.

LUNGE-FEEDING WHALES
Humpback whales scoop up vast mouthfuls of fish in the cold waters off Alaska by lunging upward through the shoals with their mouths open.

FAST FACT
Most of the humpback whales that feed off the coast of Alaska in summer spend the winter near Hawaii, about 3,500 miles (5,600 km) away.

VOLCANIC CHAIN

The floor of the Pacific is pushing beneath Alaska, creating the deep Aleutian Trench and a chain of volcanic islands from Alaska to Siberia. One of these is the active Augustine Volcano in the Gulf of Alaska.

BEAR BAIT

Pacific salmon make mass migrations up the rivers of Alaska to spawn. They are so exhausted by the journey that they make easy prey for fishing grizzly bears, as well as hungry bald eagles.

GLACIER COAST

The coast of southern Alaska has some of the world's most spectacular scenery. It is famous for its rugged mountains and islands, and huge glaciers that grind their way right down to the sea.

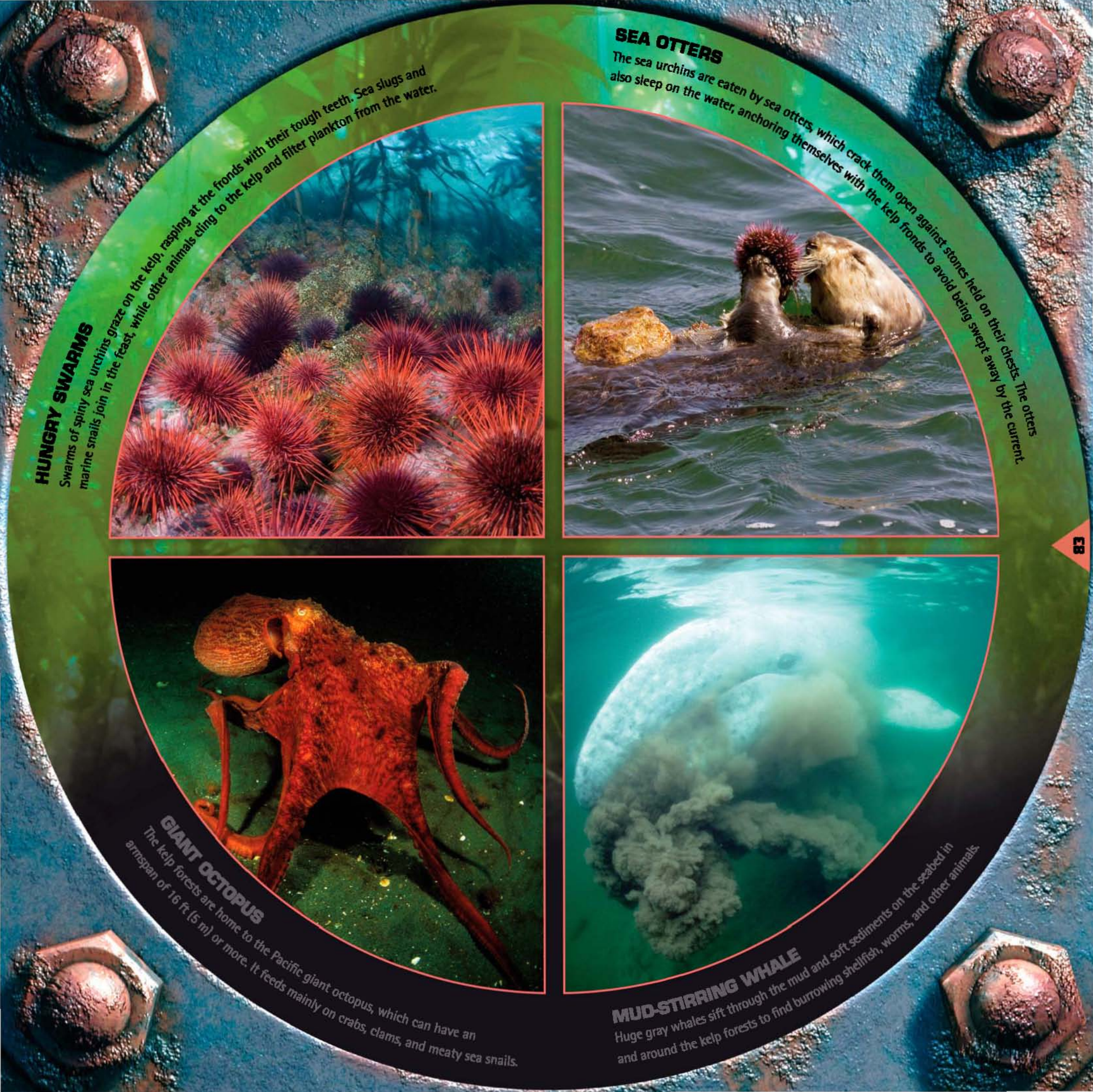
OIL SPILL

The Alaskan oil pipeline pumps oil from the Arctic to the Gulf of Alaska, where it can be shipped to the rest of the US. In 1989 a catastrophic oil spill from the tanker *Exxon Valdez* killed thousands of seabirds.

SEA life... in the kelp forests

ON THE PACIFIC SHORES of North America, submarine forests of giant kelp (a type of seaweed) support a thriving community of animals.

GIANT KELP
Leathery fronds of giant kelp can grow at rates of 2 ft (60 cm) a day to reach heights of 100 ft (30 m) or more.


HUNGRY SWARMS
Swarms of spiny sea urchins graze on the kelp, rasping at the fronds with their tough teeth. Sea slugs and marine snails join in the feast, while other animals cling to the kelp and filter plankton from the water.
SEA OTTERS
The sea urchins are eaten by sea otters, which crack them open against stones held on their chests. The otters also sleep on the water, anchoring themselves with the kelp fronds to avoid being swept away by the current.
GIANT OCTOPUS
The kelp forests are home to the Pacific giant octopus, which can have an armspan of 16 ft (5 m) or more. It feeds mainly on crabs, clams, and meaty sea snails.
MUD-STIRRING WHALE
Huge gray whales sift through the mud and soft sediments on the seabed in and around the kelp forests to find burrowing shellfish, worms, and other animals.

THE GALÁPAGOS

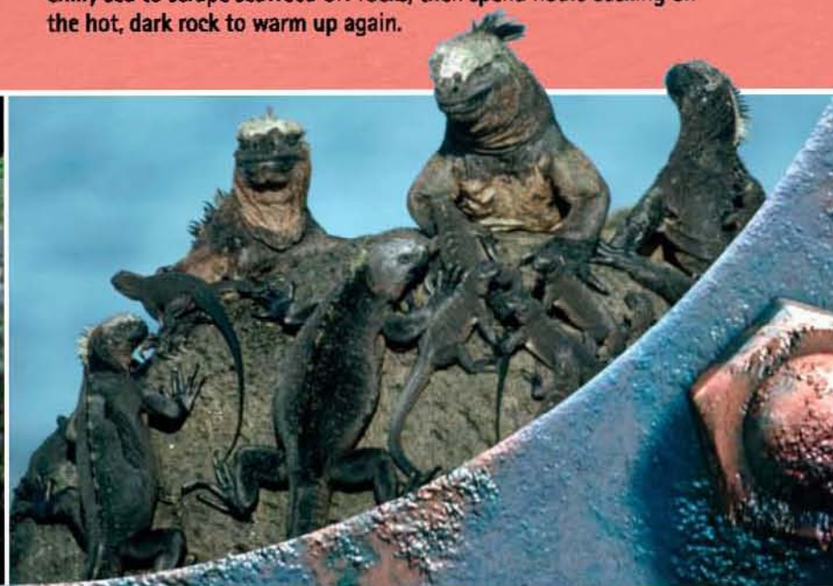
THE GALÁPAGOS ISLANDS in the eastern Pacific are famous for their wonderful wildlife. This owes its survival to the abundant food in the surrounding ocean, which is unusally fertile due to cold, mineral-rich currents swirling up from the ocean floor.

WEIRD AND WONDERFUL

Many unusual animals live on the Galápagos, including giant tortoises, flightless cormorants, and marine iguanas—the only lizards that feed at sea. Colorful Sally Lightfoot crabs scuttle over the rocks looking for edible scraps, and thousands of seabirds nest on the islands.

COLD WATER, HOT ROCK

Most of the islands' animals feed on fish from the plankton-rich waters of the cold Peru Current. These marine iguanas dive into the chilly sea to scrape seaweed off rocks, then spend hours basking on the hot, dark rock to warm up again.

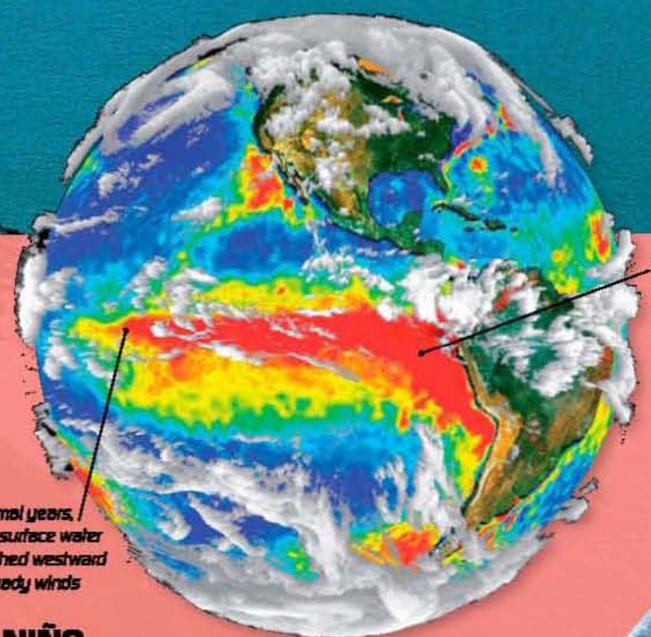


VOLCANIC WASTES

The Galápagos Islands are the cratered peaks of volcanoes that erupted from a hotspot beneath the ocean floor. The eastern islands are the oldest and greenest, while those in the west have barren wastes of dark volcanic rock.

MARINE RESERVE

The ecosystem of the Peru Current supports an amazingly productive fishery, especially in the waters off Peru. The seas around the Galápagos are now the second largest marine reserve in the world, where all fishing is banned, but preventing illegal fishing is very difficult.



EL NIÑO

Every few years the ecosystem is devastated by El Niño—a weakening of the prevailing winds in the tropical Pacific that allows warm surface water to flow east toward South America. This stops the colder, richer water of the Peru Current reaching the surface, preventing the growth of the plankton that feed the fish eaten by all the other animals.

DEEPWATER SUBMERSIBLES

USED FOR SCIENTIFIC RESEARCH into the nature of the oceans, these sophisticated submersibles explore far deeper than ordinary submarines.

JSL facts
Total crew: 4 (2 crew and 2 observers)
Length: 26 ft (8 m)
Power: 9 electric motors
Depth limit: 3,000 ft (900 m)
Maximum speed: 1.1 mph (1.8 km/h)

INSIDE JOHNSON-SEA-LINK
Many submersibles have poor visibility, but the 5-in- (12-cm-) thick clear plastic sphere of the Johnson-Sea-Link gives a panoramic view. The strong spherical shape resists the intense water pressure.

Powerful xenon arc lights provide illumination

Metal gantry supports lights and cameras

JOHNSON-SEA-LINK
The *Johnson-Sea-Link* prepares to descend to the wreck of the USS *Monitor*, sunk during the American Civil War. This submersible cannot dive to the deepest ocean floors, but its powerful lights and fantastic view make it ideal for working on the bottom of shallower seas.

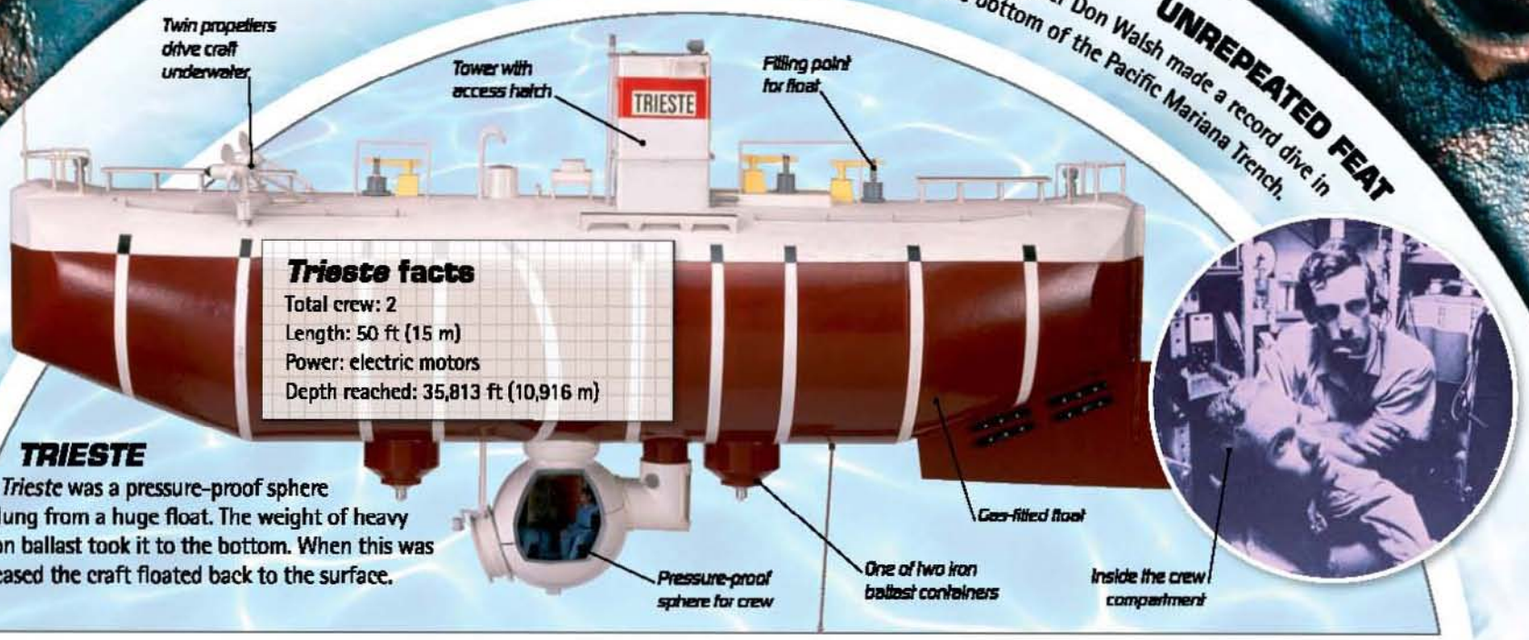
Strong transparent sphere gives excellent visibility

Video cameras relay view to mother ship

Side thruster provides maneuverability

UNREPEATED FEAT

In 1960 Swiss explorer Jacques Piccard and American oceanographer Don Walsh made a record dive in the *Trieste*, descending nearly 6.8 miles (11 km) to the bottom of the Pacific Mariana Trench.



Trieste facts

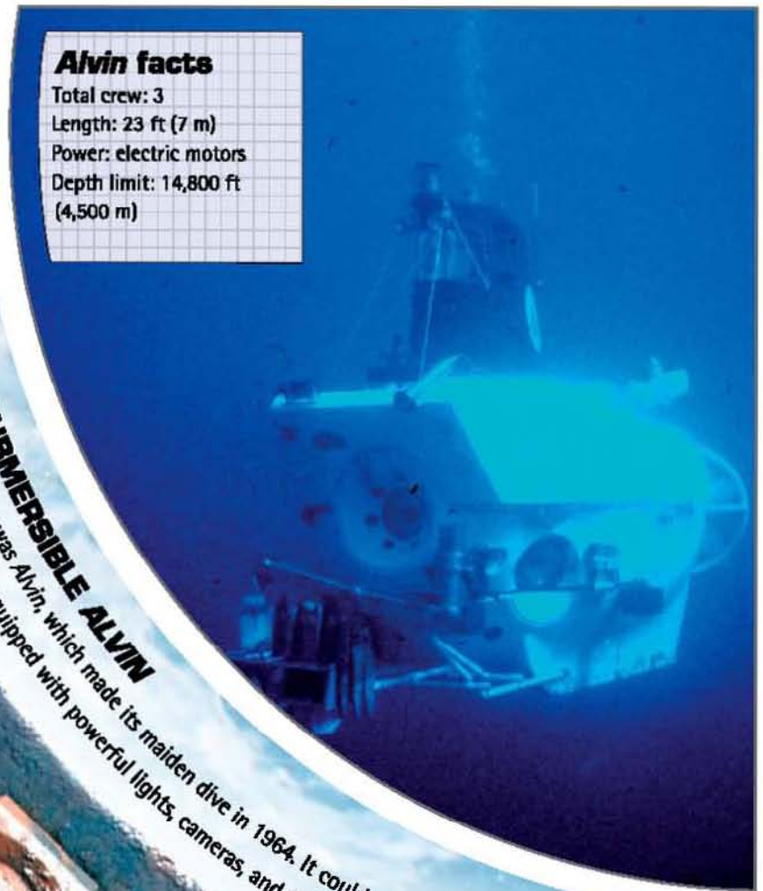
Total crew: 2
Length: 50 ft (15 m)
Power: electric motors
Depth reached: 35,813 ft (10,916 m)

TRIESTE

Trieste was a pressure-proof sphere slung from a huge float. The weight of heavy iron ballast took it to the bottom. When this was released the craft floated back to the surface.

MANNED SUBMERSIBLE ALVIN

The first modern submersible was *Alvin*, which made its maiden dive in 1964. It could maneuver precisely to explore the ocean floor, and was equipped with powerful lights, cameras, and sampling equipment.

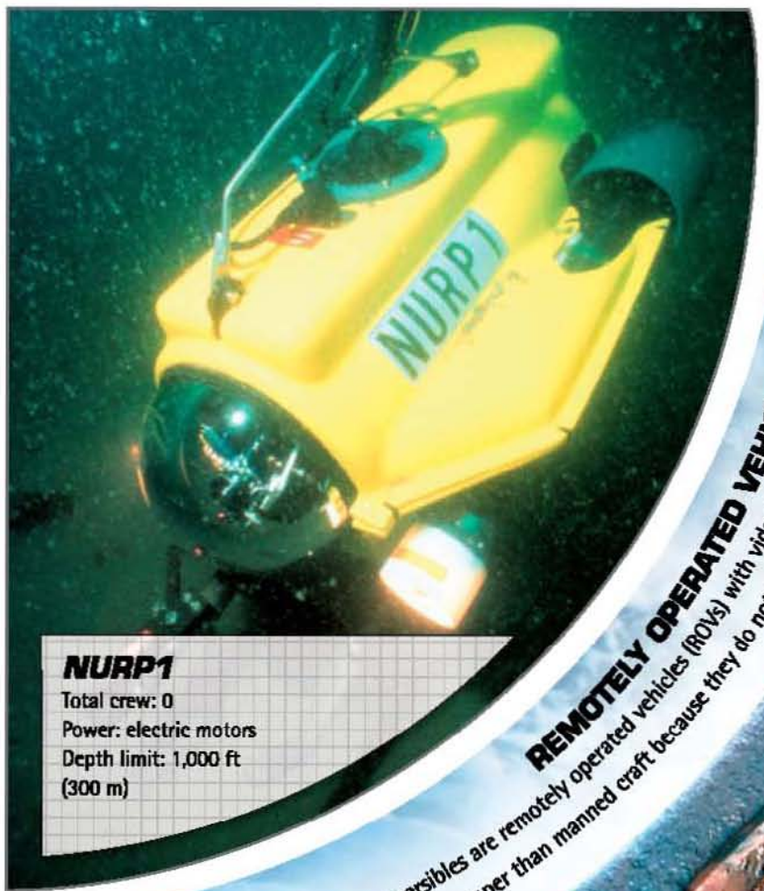


Alvin facts

Total crew: 3
Length: 23 ft (7 m)
Power: electric motors
Depth limit: 14,800 ft (4,500 m)

REMOTELY OPERATED VEHICLE *NURP1*

Many modern submersibles are remotely operated vehicles (ROVs) with video links to their mother ships. They are much cheaper than manned craft because they do not need to be equipped to carry a crew.



NURP1

Total crew: 0
Power: electric motors
Depth limit: 1,000 ft (300 m)

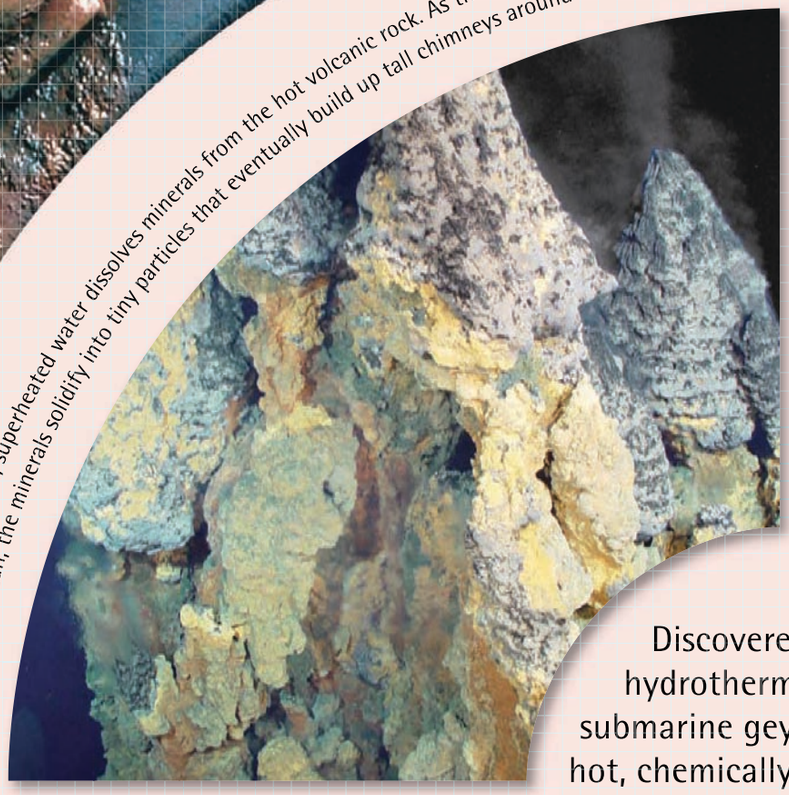
BLACK SMOKER
Volcanic activity superheats water in ocean-floor rock to more than 570°F (300°C), because the water pressure stops it from boiling. Minerals dissolved in the hot water turn into sooty clouds when it erupts.

FOCUS on... hydrothermal vents

Discovered in 1977, hydrothermal vents are submarine geysers that erupt hot, chemically enriched water from midocean ridges. The chemicals turn solid in the ocean, forming plumes called black smokers.

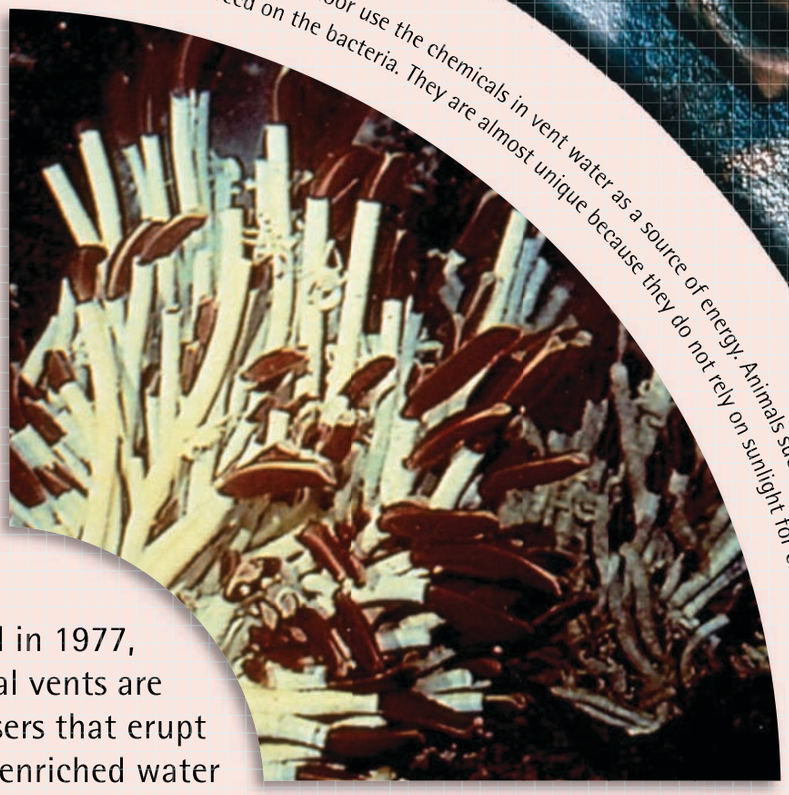
VENT CHIMNEYS

Deep in the ocean floor, superheated water dissolves minerals from the hot volcanic rock. As the hot water mixes with the cold ocean, the minerals solidify into tiny particles that eventually build up tall chimneys around the vents.



TEEMING LIFE

Bacteria on the ocean floor use the chemicals in vent water as a source of energy. Animals such as these giant worms then feed on the bacteria. They are almost unique because they do not rely on sunlight for energy.



HOT AND COLD

Pompeii worms live in colonies on vent chimneys, with their tails in water that may have a temperature of 158°F (70°C), and their heads in water at about 68°F (20°C). This would kill any other animal.

METHANE SEEPS

Animals have also been found living around seafloor seeps of natural gas (methane). The methane combines with cold water and freezes into a form of ice. Bacteria use this to make food, supporting communities of ice worms and other creatures.

HAWAII

HAWAII LIES AT THE END OF A CHAIN OF VOLCANIC ISLANDS and seamounts that have erupted from a hotspot beneath the moving floor of the Pacific. The most active volcano on Earth—Kilauea—is currently above the hotspot.

RECORD BREAKER

MAUNA KEA

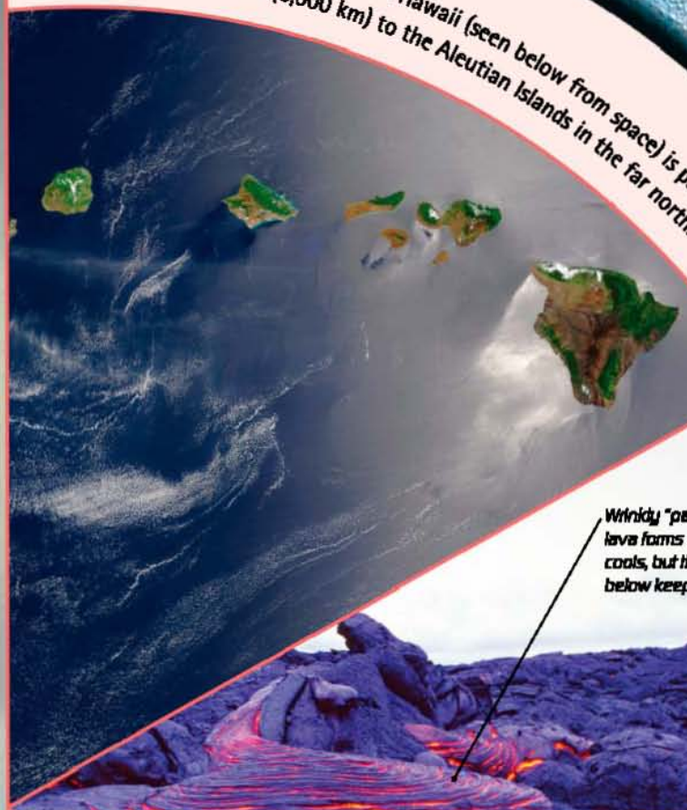
The highest volcano on Hawaii, Mauna Kea is also the biggest mountain on Earth. When measured from the ocean floor its peak is higher than Mount Everest's.

FIRE FOUNTAIN

Kilauea has been erupting continuously since 1983, ejecting vast amounts of incandescent molten rock in spectacular fire fountains. Rivers of lava spill down its flanks toward the sea.

ISLAND CHAIN

The chain of volcanoes of which Hawaii (seen below from space) is part extends almost 3,700 miles (6,000 km) to the Aleutian Islands in the far north.



LIQUID LAVA

The lava that erupts on Hawaii is molten basalt. It is very liquid and spills rapidly down the volcanic slopes where it cools to form strange, wrinkled masses of solid rock.

GIANT WAVES

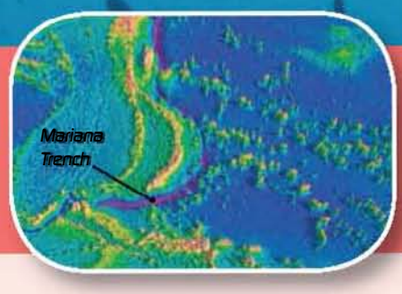
Hawaii is in the middle of the Pacific and lies in the path of huge ocean waves, which are famous for surfing. It is also vulnerable to tsunamis caused by earthquakes beneath the ocean.

CHINA SEAS

THE WESTERN PACIFIC IS FRINGED BY SHALLOW SEAS cut off from the main ocean by chains of islands dotted along the edges of ocean trenches. The islands are regularly rocked by earthquakes, and many have active volcanoes.

OCEANIC GIANTS
The giant manta ray feeds on the plankton that drifts in the warm, open seas.

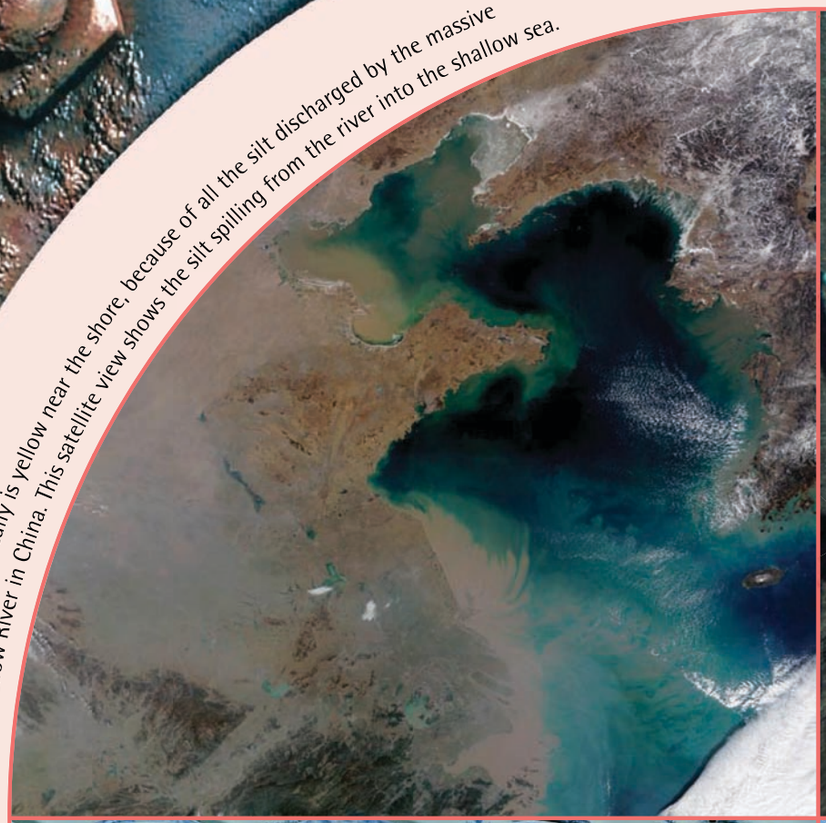
RECORD BREAKER



MARIANA TRENCH
This 3-D image built up from satellite data shows the Mariana Trench, the deepest chasm on Earth. Its deepest point lies 35,840 ft (10,924 m) below the waves.

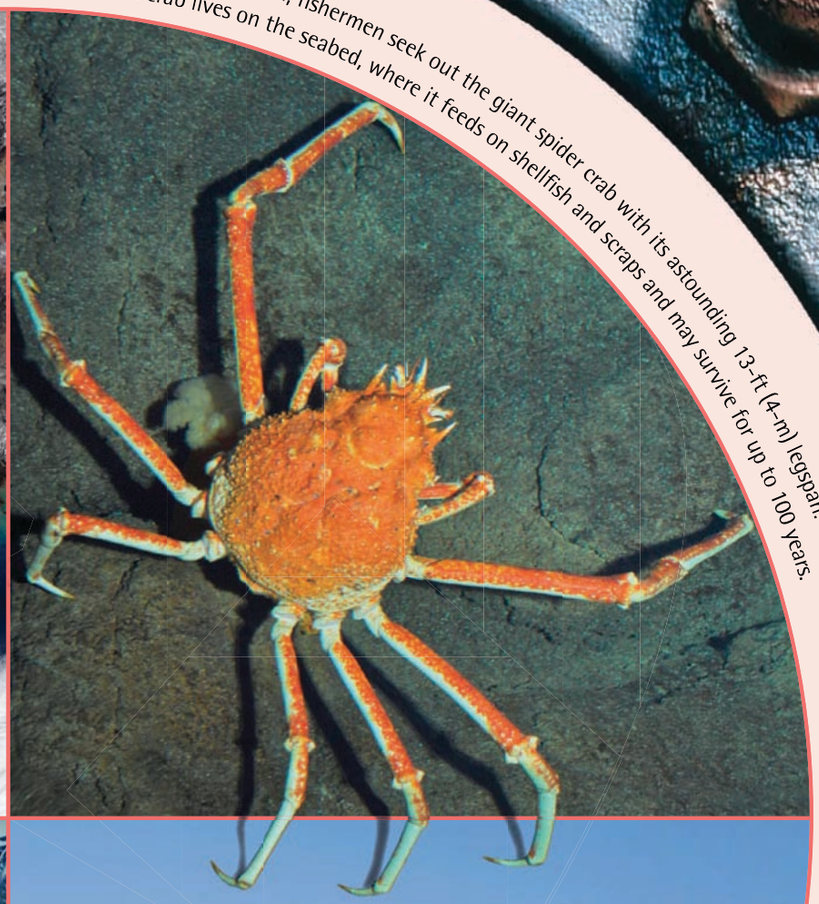
SILTY SEA

The Yellow Sea really is yellow near the shore, because of all the silt discharged by the massive Yellow River in China. This satellite view shows the silt spilling from the river into the shallow sea.



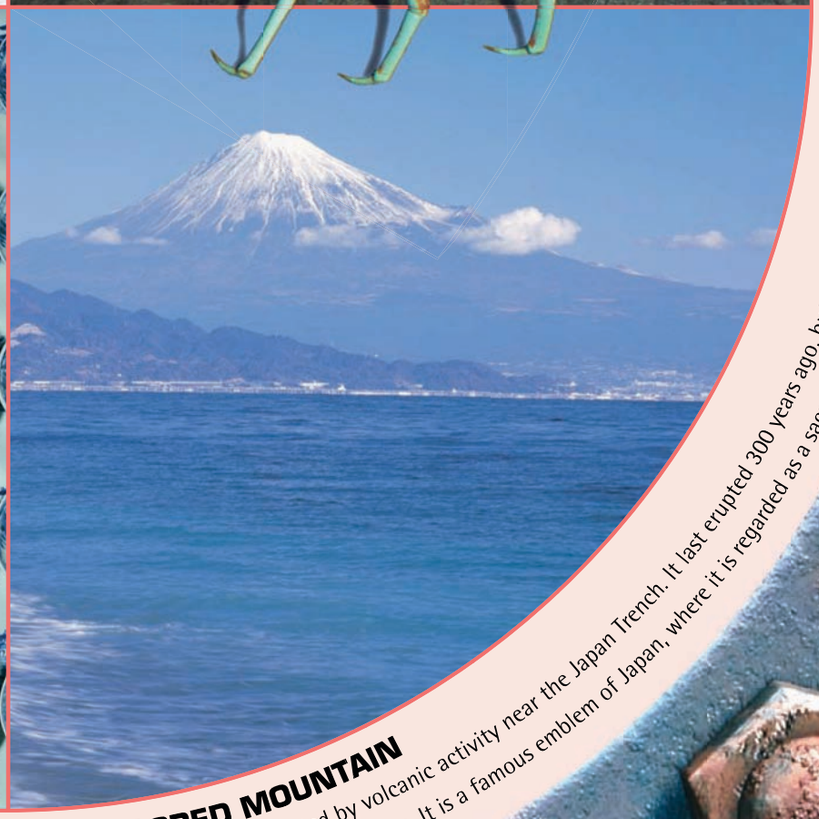
GIANT CRAB

In the Sea of Japan, fishermen seek out the giant spider crab with its astounding 13-ft (4-m) legspan. The crab lives on the seabed, where it feeds on shellfish and scraps and may survive for up to 100 years.



STORMY WATER

The China Seas are notorious for typhoons (hurricanes), resulting in many shipwrecks. The Chinese junk *Tek Sing* sank in 1822, and its cargo of valuable porcelain was located in 1999.



SACRED MOUNTAIN

Mount Fuji was created by volcanic activity near the Japan Trench. It last erupted 300 years ago, but is still classed as an active volcano. It is a famous emblem of Japan, where it is regarded as a sacred mountain.

OCEANIA

THE WESTERN PACIFIC is dotted with hundreds of volcanoes that have erupted from the ocean floor. Now nearly all extinct, they have been transformed into a magical realm of coral-fringed islands.

SINKING PEAKS

The extinct volcanoes that form many Pacific islands are slowly subsiding. Bora Bora, shown below, is halfway through the process. Once a high island with a coral fringe, it has been sinking for millions of years. Meanwhile, its coral fringe has grown upward, creating a barrier reef enclosing a sheltered lagoon.

CORAL ATOLLS

Many of the original volcanic islands have completely subsided and now all that survives is a barrier reef. Known as atolls, these ring-shaped reefs are topped with sandy coral islands and enclose shallow lagoons. Many populated atolls are at risk from rising sea levels, and some are already being abandoned.

PATTERN OF ISLANDS

An outrigger canoe sails across the crystal-clear lagoon of Tabiteuea, Kiribati—one of hundreds of coral islands that make up the oceanic regions of Polynesia, Melanesia, and Micronesia.

MUSHROOM ROCKS

In parts of Micronesia, coral islands have been uplifted by earthquakes beneath the ocean and carved into mushroom shapes by the waves. Crowned with dense trees, many are havens for wildlife, such as ocean birds, since they are safe from ground predators that cannot get to the islands.

SWIRLING CURRENTS

Some Pacific volcanoes never reached the surface, or have sunk entirely. They form submerged seamounts. Currents swirling up and around these peaks carry nutrients toward the surface, where they fuel the growth of plankton. This attracts fish, which are hunted in turn by predators like this hammerhead shark.

SEA life... on coral reefs

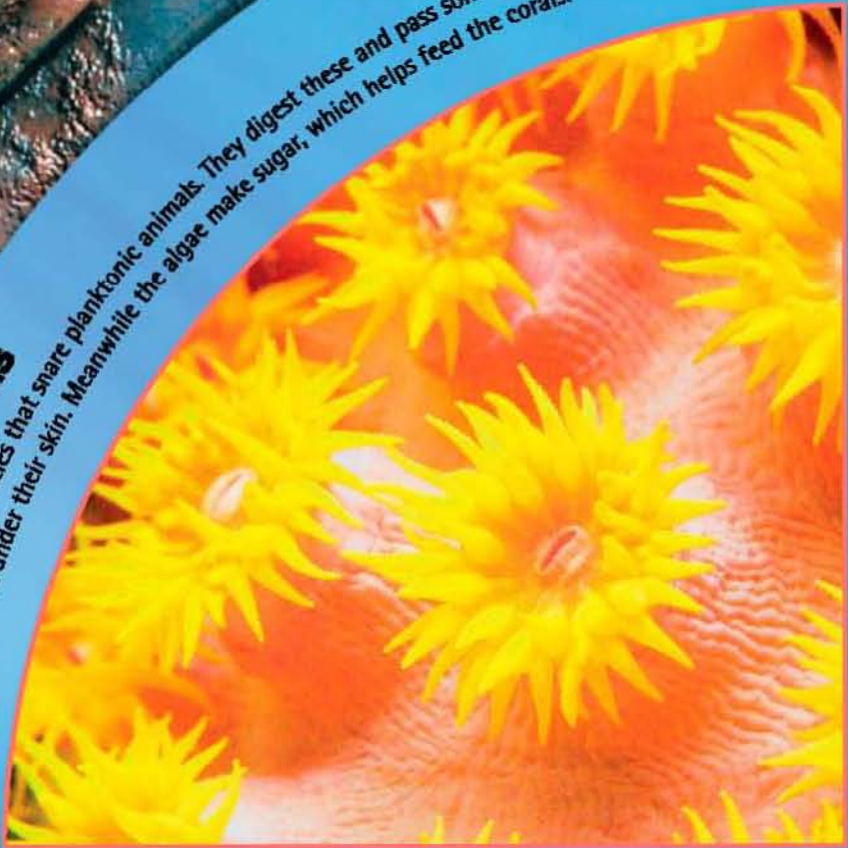
MAGICAL WORLDS OF COMPLEX LIFE, tropical coral reefs thrive in the clear sunlit water like underwater gardens.

DAZZLING DIVERSITY

Coral reefs are oases of life in barren tropical oceans. The corals—relatives of anemones—live in colonies in partnership with microscopic algae that use the energy of sunlight to make food. This enables the corals to build the reefs and support a dazzling diversity of marine life.

PRODUCTIVE PARTNERS

Corals have stinging tentacles that snare planktonic animals. They digest these and pass some of the nutrients to algae that live under their skin. Meanwhile the algae make sugar, which helps feed the corals.

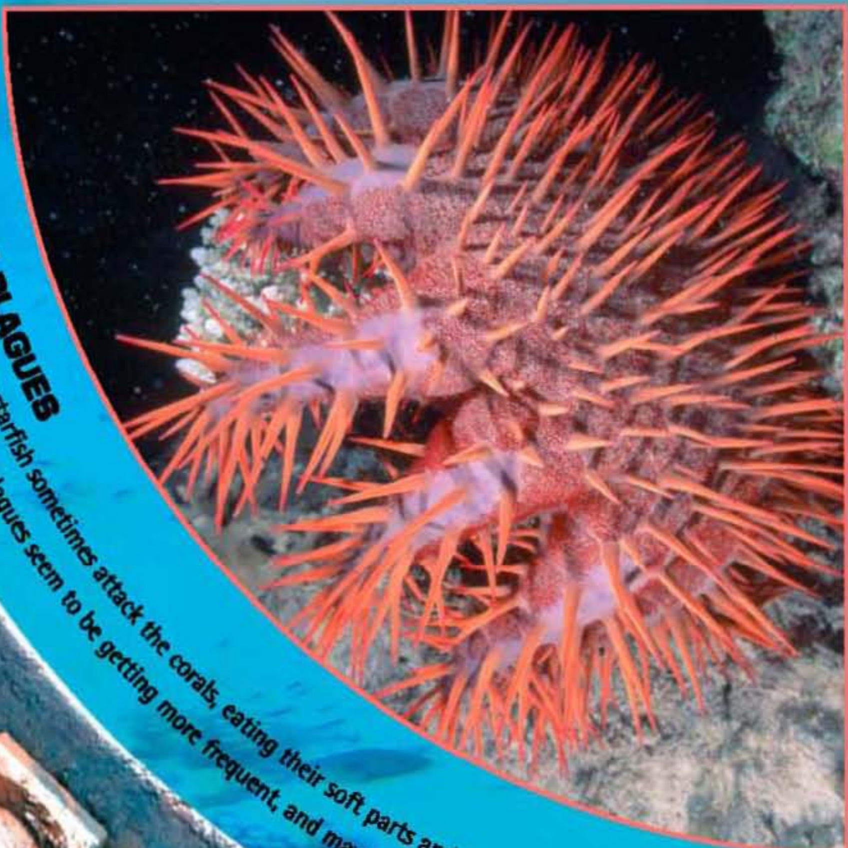


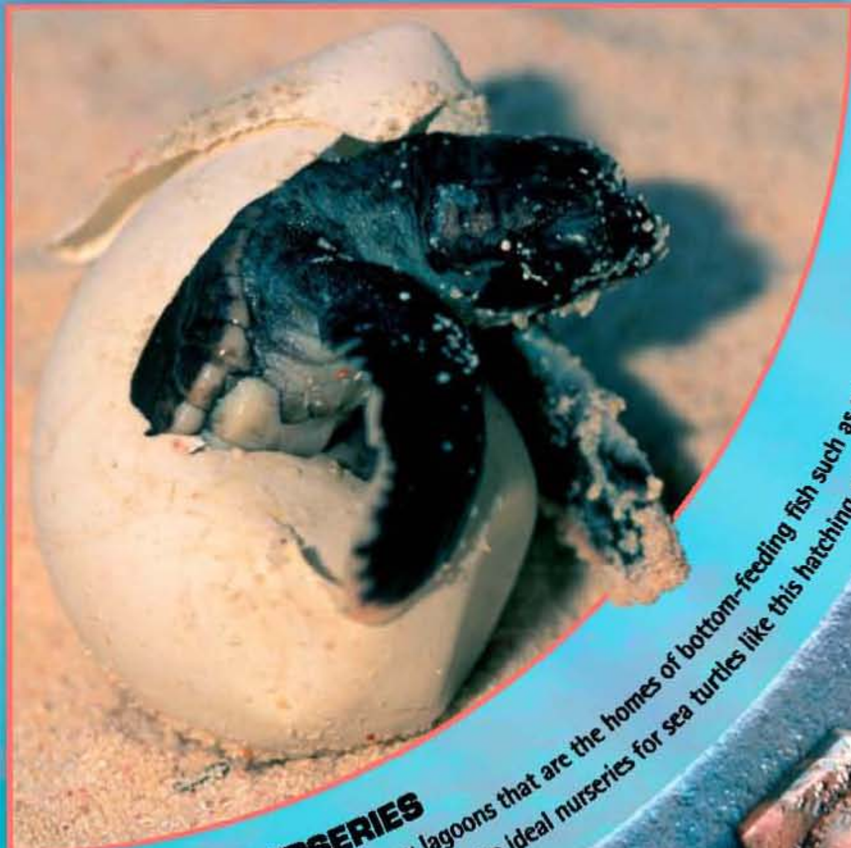
COLORFUL LIFE

The reefs harbor shoals of vividly colored small fish, big predators such as groupers and sharks, masses of crabs and shrimps, and mollusks such as colorful sea slugs, tritons, conches, and giant clams.

STARFISH PLAGUES

Swarms of crown-of-thorns starfish sometimes attack the corals, eating their soft parts and leaving only their stony skeletons. These starfish plagues seem to be getting more frequent, and may be very destructive.





TURTLE NURSERIES

The coral reefs enclose shallow lagoons that are the homes of bottom-feeding fish such as rays. Their beaches of white coral sand make ideal nurseries for sea turtles like this hatching green turtle.

SCUBA DIVING

THE INVENTION OF SCUBA—Self-Contained Underwater Breathing Apparatus—has revolutionized ocean exploration. Before SCUBA, much of the undersea world was a tantalizing mystery.

JACQUES COUSTEAU
The equipment was invented in 1943 by Jacques Cousteau, working with an engineer. He later made TV programs about diving.

SCUBA facts
Normal depth limit: 100 ft (30 m)
Maximum depth limit: 300 ft (90 m)
Normal dive duration: 40 minutes
Advanced dive duration: 2 hours
Usual gas: Compressed air

MAGICAL WORLD
Scuba diving is now a hugely popular pastime that supports a flourishing tourist industry in clear tropical waters.

SCUBA EQUIPMENT

Unlike the cumbersome diving equipment it has replaced, scuba gear enables divers to swim freely, since each carries his or her own breathing supply.

PRESSURE PROBLEMS

Intense water pressure at depth can cause problems for divers. They avoid these by making controlled "decompression" stops as they come up to the surface.

VALUABLE TOOL

Scuba has enabled many scientists to explore the oceans first hand, and discover, photograph, and describe an amazing variety of marine life.

HISTORY UNDER THE SEA

Marine archeology relies on the work of scuba divers, whose painstaking work has enabled many ancient wrecks and other sites to be properly excavated.

GREAT BARRIER REEF

THE BIGGEST OF ALL CORAL REEFS, the Great Barrier Reef covers 89,000 sq miles (230,000 sq km) of the continental shelf off the tropical northeast coast of Australia.

BIG BUILDUP

The organisms that build the reef are some 400 different species of colonial corals, which extract calcium from the seawater and use it to make limestone cups that support their soft bodies. When they die the limestone survives and new corals grow on top of it, building up a reef that attracts colorful fish like this spiny lionfish.

BLUE VOID

On the edge of the Australian continental shelf facing the open Pacific Ocean, just beyond the reef crest, the water depth may plunge from near zero to 3,300 ft (1,000 m) into a blue void. These deeper waters are patrolled by sharks like this silvertip reef shark, which preys on the smaller fish that live on the reef.

MEGAREEF

The reef is a vast complex of almost 3,000 reefs separated by deep channels like this one. But it is usually considered a single entity, up to 160 miles (260 km) wide and 1,400 miles (2,300 km) long—the largest structure on Earth built by living things.

DEADLY VENOM

The fantastically diverse marine life of the Great Barrier Reef includes many venomous species, such as the box jellyfish with its long stinging tentacles and the stonefish with its poisonous spines. The venomous bite of this pretty little blue-ringed octopus makes it one of the most deadly animals in the ocean.

WHITE DEATH

The biggest threat to the reef is a process called coral bleaching, caused by unusually high water temperatures. The heat makes the corals expel the colored algae that live under their skin, so they turn white. Since the algae provide most of the corals' food, this can prove fatal to the coral itself.

1 SCOTIA SEA

Defined by an arc of volcanic islands that have erupted from near the South Sandwich Trench, the Scotia Sea is a region of strong currents and big waves, dotted with icebergs that have drifted north from Antarctica.

2 ICE SHEET

Mountains on the fringes of Antarctica are half buried beneath the vast ice sheet that covers most of the continent. This ice sheet creates the deep chill that dominates the climate of the Southern Ocean.

SOUTHERN OCEAN

The icy ocean that surrounds Antarctica is defined by the Antarctic Convergence—where the south Pacific, south Atlantic, and southern Indian Ocean give way to colder, denser water. High winds sweep most of this water eastward around Antarctica, building up massive waves. In winter, sea ice covers an area bigger than Antarctica itself.

Left: 3-D map of the Southern Ocean Below: Research ship *James Clark Ross*, Antarctica

ANTARCTIC FRINGES

THE MOST VIOLENT OF THE OCEANS is also the richest in marine life, thanks to storms, sinking currents of cold water, and swirling eddies that stir up vital nutrients.

KRILL SWARMS
Immense swarms of shrimplike krill build up in the Southern Ocean. This mass of food supports huge numbers of fish, penguins, seals, and oceanic giants like this leaping humpback whale.

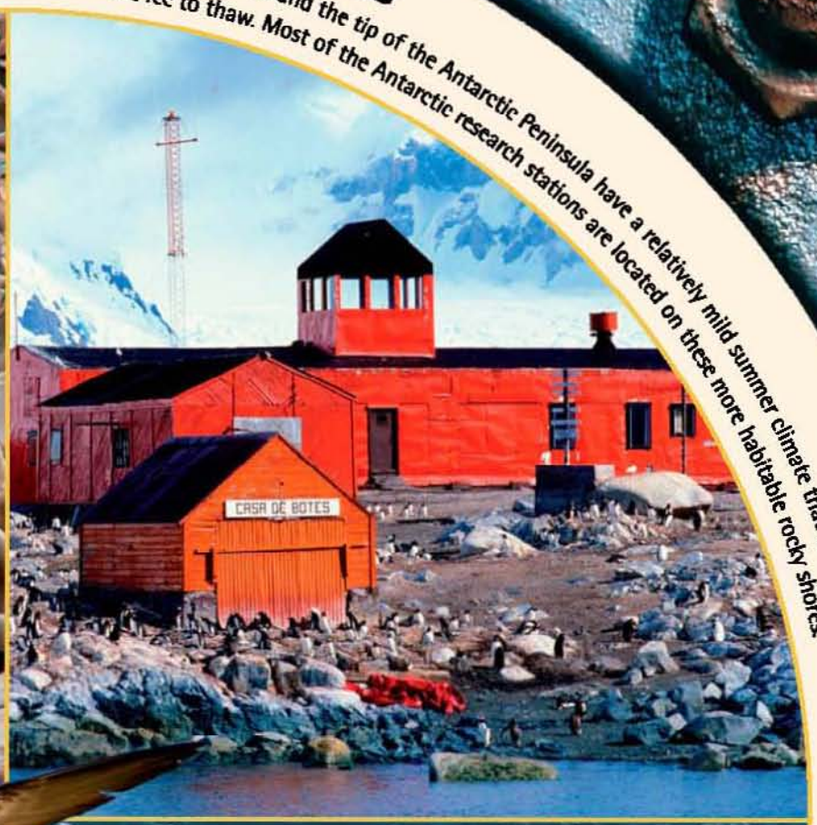
FAST FACT
Krill swarms can cover vast areas. One swarm seen in the Southern Ocean had an estimated area of more than 170 sq miles (450 sq km).

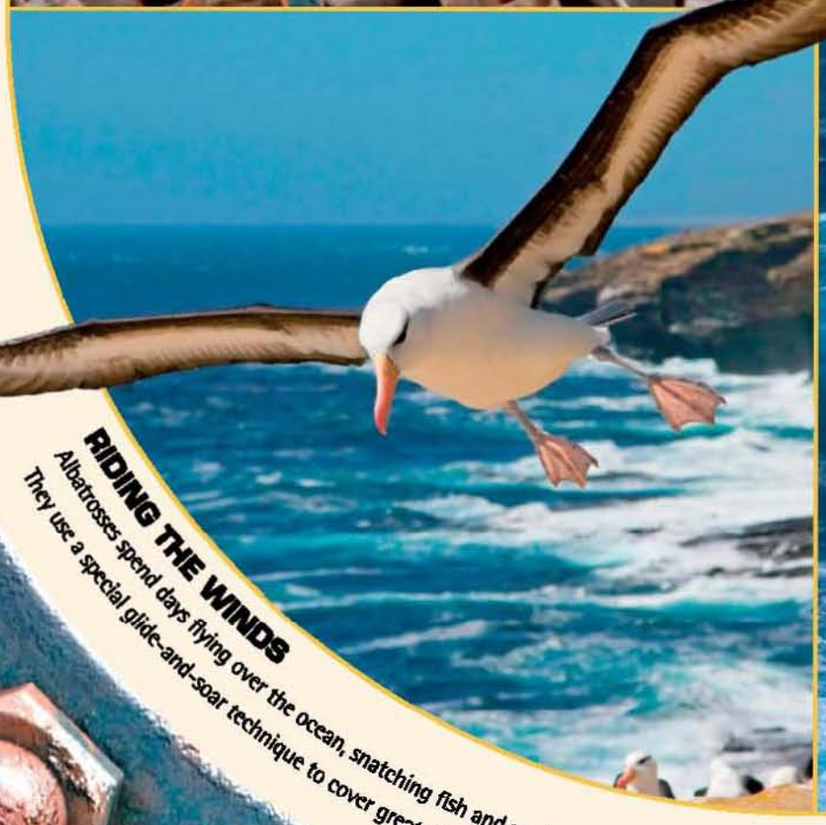
WINDSWEPT ISLANDS

The Southern Ocean is dotted with rocky, often volcanic islands. These provide nesting sites for seabirds such as albatrosses and penguins, as well as for fur seals like these, which gather in dense breeding colonies on the stony beaches.

SCIENTIFIC BASES

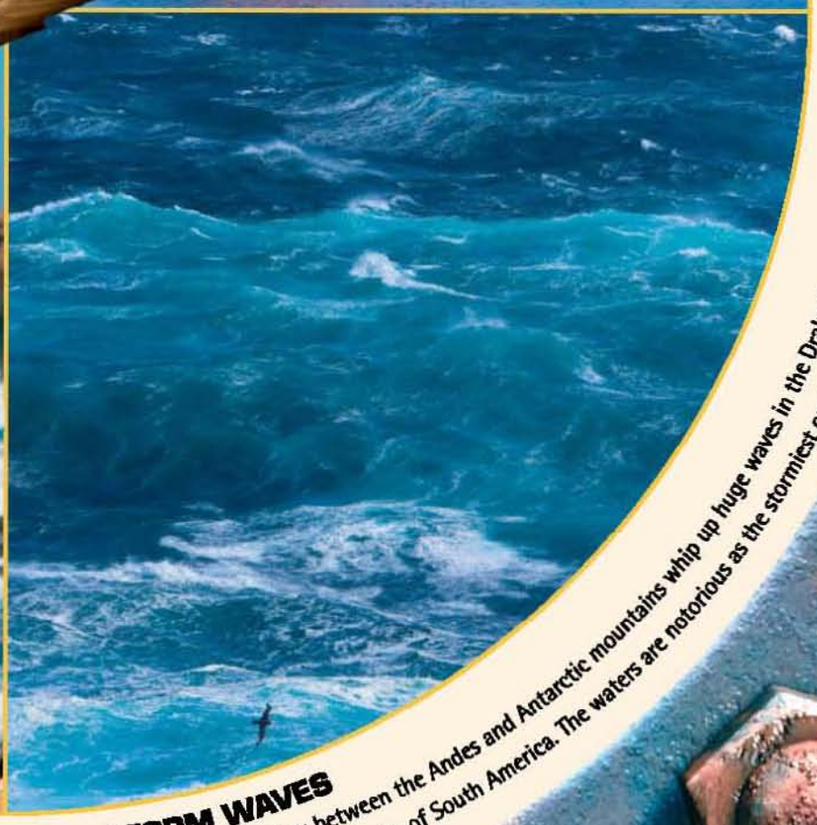
The rocky islands and the tip of the Antarctic Peninsula have a relatively mild summer climate that allows the ice to thaw. Most of the Antarctic research stations are located on these more habitable rocky shores.





RIDING THE WINDS

Albatrosses spend days flying over the ocean, snatching fish and squid from its surface. They use a special glide-and-soar technique to cover great distances without beating their wings.



STORM WAVES

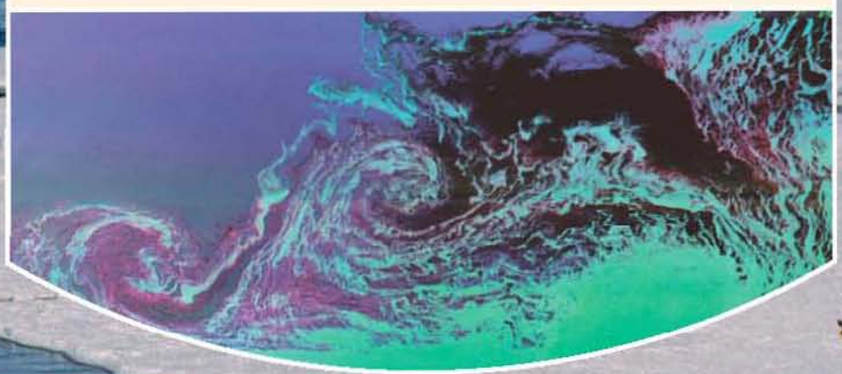
High winds funneling between the Andes and Antarctic mountains whip up huge waves in the Drake Passage between Antarctica and the southern tip of South America. The waters are notorious as the stormiest on the planet, with strong currents.

FROZEN SEAS

THE WEDDELL SEA AND ROSS SEA are great inlets in the Antarctic continent. They are the coldest parts of the Southern Ocean, largely covered by immensely broad and thick glacial ice shelves.

MIXING ZONE

The interaction of a westward-flowing coastal current with an eastward-flowing offshore current creates swirling eddies in the Weddell Sea, as shown in this radar satellite image. The eddies cause nutrient upwellings that nourish dense clouds of plankton, supporting a rich marine ecosystem.

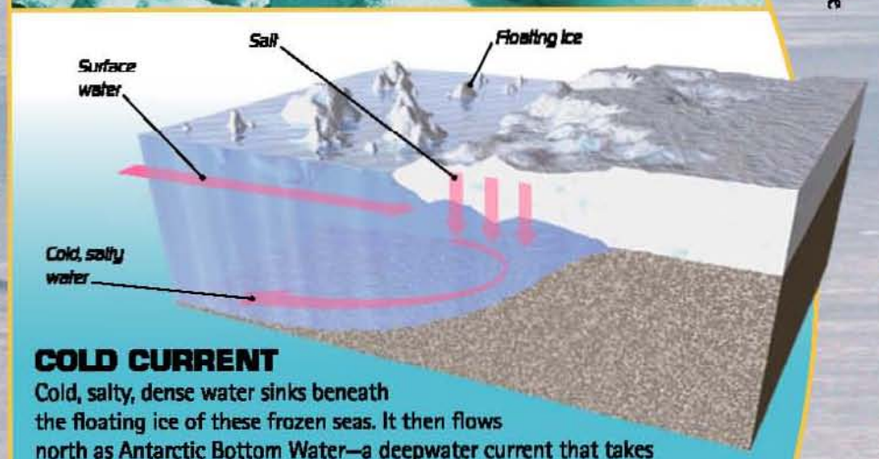


PACK ICE

For much of the year the Weddell Sea is covered with pack ice, here dominated by a colossal iceberg that has broken off the Ronne Ice Shelf. Long leads of clear water open up in summer.

TRAPPED

An expedition to the Weddell Sea led by Ernest Shackleton in 1914–16 failed because his ship *Endurance* became trapped in moving pack ice. They drifted for 10 months before the ice crushed the ship.



COLD CURRENT

Cold, salty, dense water sinks beneath the floating ice of these frozen seas. It then flows north as Antarctic Bottom Water—a deepwater current that takes the water halfway around the world before surfacing in the north Pacific.

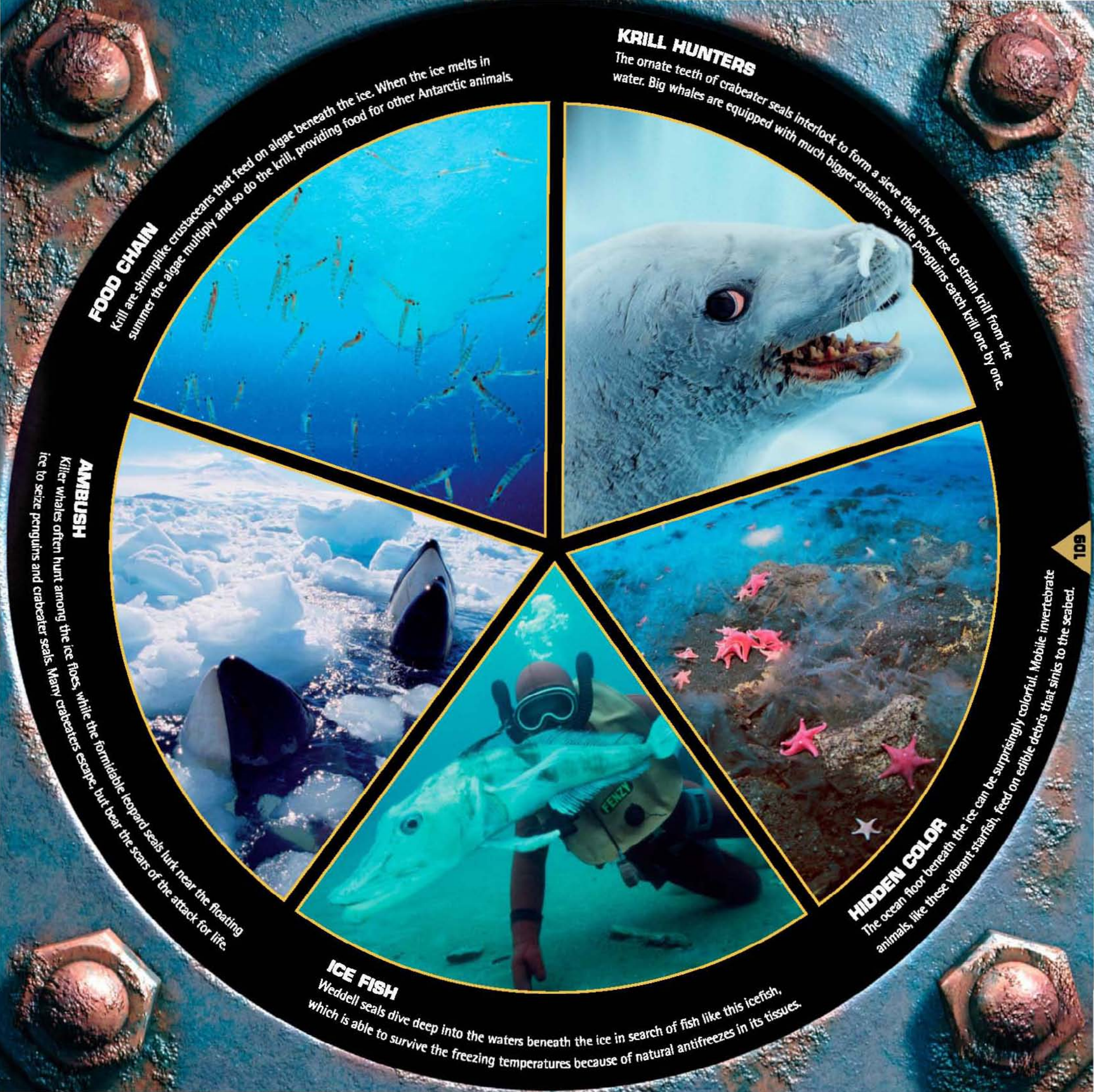
WINTER NURSERY

These Antarctic seas are the home of emperor penguins that breed in winter on the sea ice. The male penguins incubate the eggs on their feet while huddling together to keep out of the cold.

under the ice

ALL THE ANIMALS ON ANTARCTICA feed in the sea. They either hunt in open water or dive beneath the ice to catch krill, fish, and squid.

ICY WATERS
Many animals hunt off the ice edge, moving north as the ocean freezes in the fall and expands the ice sheet. Small penguins like these pursue krill in open water; other animals like seals hunt beneath the floating ice, seeking out holes where they can surface to breathe.


KRILL HUNTERS
The ornate teeth of crabeater seals interlock to form a sieve that they use to strain krill from the water. Big whales are equipped with much bigger strainers, while penguins catch krill one by one.
FOOD CHAIN
Krill are shrimplike crustaceans that feed on algae beneath the ice. When the ice melts in summer the algae multiply and so do the krill, providing food for other Antarctic animals.
AMBUSH
Killer whales often hunt among the ice floes, while the formidable leopard seals lurk near the floating ice to seize penguins and crabeater seals. Many crabeaters escape, but bear the scars of the attack for life.
HIDDEN COLOR
The ocean floor beneath the ice can be surprisingly colorful. Mobile invertebrate animals, like these vibrant starfish, feed on edible debris that sinks to the seabed.
ICE FISH
Weddell seals dive deep into the waters beneath the ice in search of fish like this icefish, which is able to survive the freezing temperatures because of natural antifreezes in its tissues.

FOCUS on... ice shelves

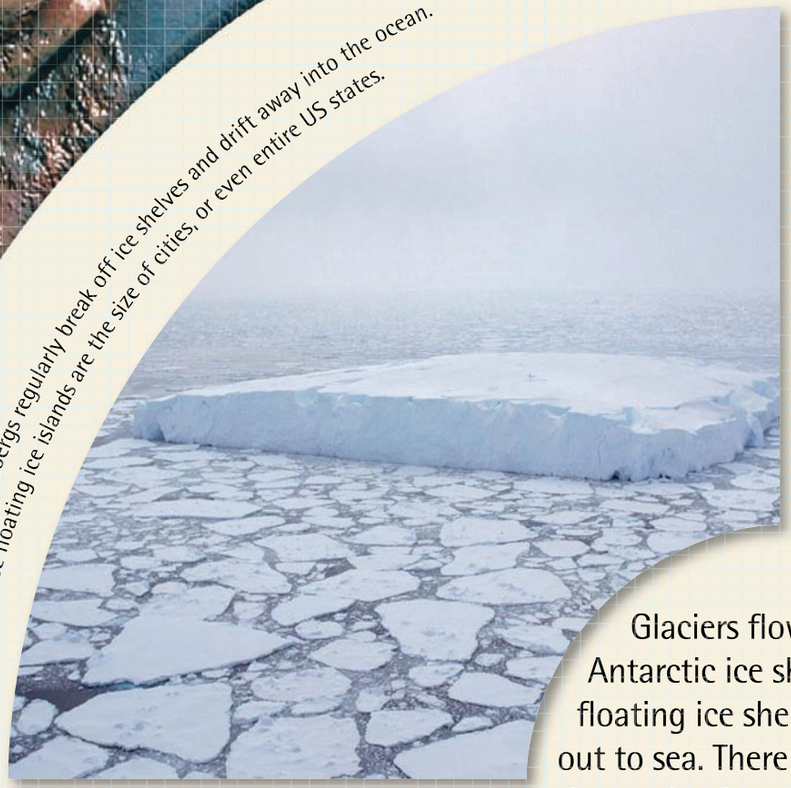
ICE BARRIERS
The ice cliffs of the Ross Ice Shelf extend for more than 370 miles (600 km) across the Ross Sea and are up to 160 ft (50 m) high in some places. The vast expanse of this ice shelf covers an area roughly the size of France.

BREAKUP

In 2002, roughly 1,250 sq miles (3,250 sq km) of the Larsen Ice Shelf on the Antarctic Peninsula broke up in just 35 days, probably because of climate change. This view from space shows the ice drifting away.

HUGE ICEBERGS

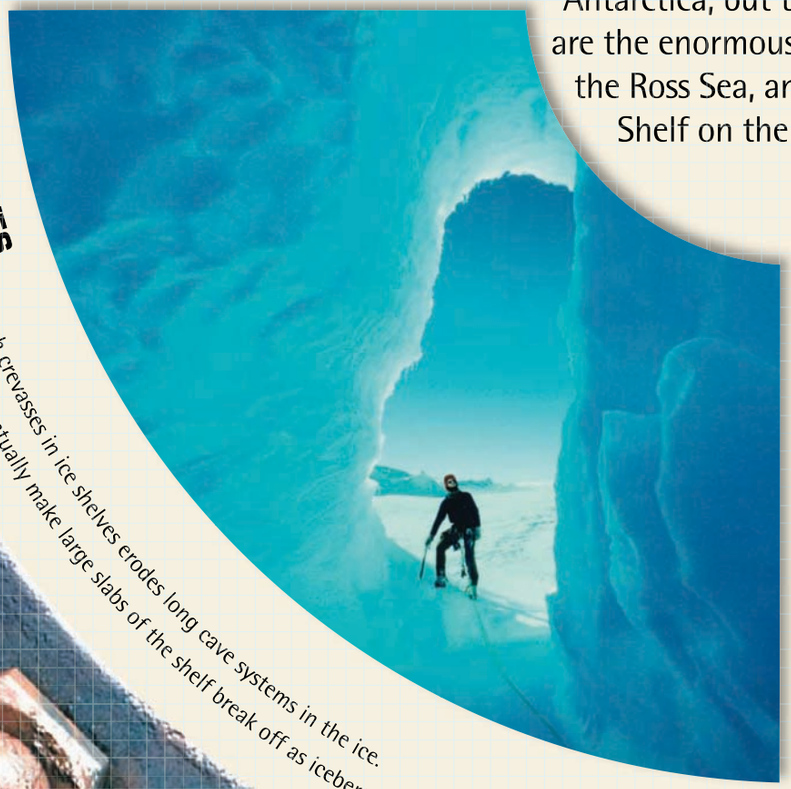
Colossal flat-topped icebergs regularly break off ice shelves and drift away into the ocean. Some of these floating ice islands are the size of cities, or even entire US states.



Glaciers flowing off the Antarctic ice sheet feed thick, floating ice shelves that extend out to sea. There are many around Antarctica, but the biggest by far are the enormous Ross Ice Shelf on the Ross Sea, and the Ronne Ice Shelf on the Weddell Sea.

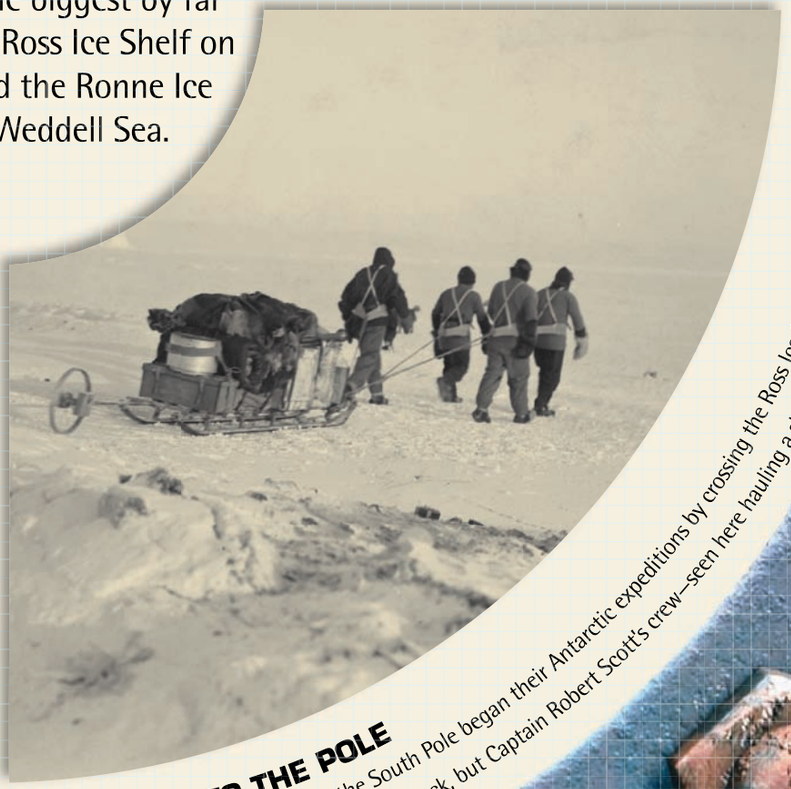
ICE CAVES

Meltwater flowing through crevasses in ice shelves erodes long cave systems in the ice. If these keep growing they can eventually make large slabs of the shelf break off as icebergs.



ROUTE TO THE POLE

The first explorers to reach the South Pole began their Antarctic expeditions by crossing the Ross Ice Shelf in 1911. Norwegian Roald Amundsen and his party got back, but Captain Robert Scott's crew—seen here hauling a sled—died on the return journey.



WATER POWER
Big turbines placed in the path of powerful ocean currents may soon be able to generate as much electricity as normal power plants, but without the pollution.

THAMES BARRIER
Built to protect London from extra-high tides and storm surges, the Thames Barrier has huge steel gates, slung between these towers, that swivel up from the riverbed to hold back the sea.

Left: Beneath a wave • Above: Crashing wave

OCEAN RESOURCES

The oceans have always offered both a challenge and an opportunity. Although difficult and dangerous to cross, they have provided a rich harvest of food and other resources. But the more we discover about them, the more we realize that their future may depend on us.

VOYAGES OF DISCOVERY

PEOPLE HAVE BEEN CROSSING OCEANS for thousands of years, yet we have known the true extent of the oceans only since the 1840s, when explorers finally mapped the entire globe.

OVER THE PACIFIC
The Polynesians started sailing across the ocean in large, but flimsy, double-hulled canoes some 3,500 years ago. Navigating by the stars they spread east until they reached Easter Island, famous for these huge statues, about 2,500 years later.

THE EARLIEST MARINERS

The first Australians must have crossed the Timor Sea from Indonesia at least 50,000 years ago, when Europe and North America were in the grip of the last ice age. How they did this is a mystery.

RAIDERS AND SETTLERS

From about 500 CE the Viking raiders and settlers were sailing out into the north Atlantic from Scandinavia. By 1000 CE they had discovered Iceland, Greenland, and even Newfoundland in North America.

ASIAN FLEETS

In the 15th century, Chinese admiral Zheng He explored the Indian Ocean with an enormous fleet of more than 300 ships. His flagship was a colossal Chinese junk, five times the size of contemporary European vessels.

AROUND THE WORLD

This is a close replica of the *Golden Hind*—the ship in which Francis Drake made the second voyage around the world in 1577–80. The first was completed 60 years before, by the survivors of an expedition commanded by Ferdinand Magellan.

OCEAN SCIENCE

UNTIL THE MID-18TH CENTURY most marine explorers were not interested in the ocean itself, beyond the problems it posed to navigation. But then scientists started to look more deeply and a whole new world opened up for investigation.

SCIENTIFIC PIONEERS

Oceanography began with Captain Cook's first voyage in HMS *Endeavour*, seen below in replica form, in the late 1700s. But the first truly oceanographic expedition was that of HMS *Challenger* in 1872–76. Packed with scientists taking measurements and samples, the ship zigzagged through the oceans for 69,000 miles (111,000 km).

RESEARCH SHIPS

Modern research vessels carry equipment to gather a wide range of data from different depths in the ocean. Some are equipped to map the seabed using sophisticated side-scan sonar, and a few highly specialized ships use drilling equipment to sample the rocks of the ocean floor.

LAST FRONTIER

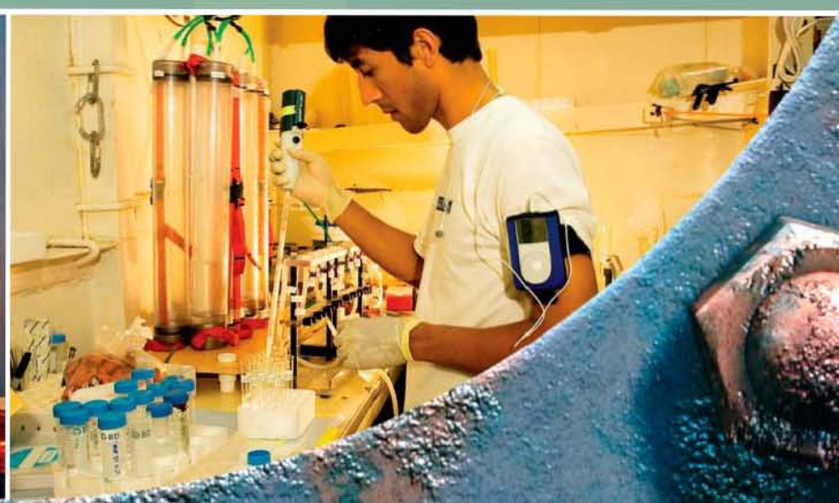
The oceans are the last frontier of Earth-based natural science, with much still unexplored and the focus of intensive research. Aided by amazing technology, scientists are able to produce vivid 3-D images of the ocean floors. They can also use satellite data to make maps of features like these ocean temperatures.

SATELLITE DATA

Oceanographic data is also gathered by satellites, often launched into space by NASA's Space Shuttle. Satellites can beam data back to Earth continuously, so they are especially useful for observing things that are always changing, such as the distribution of ocean life or sea ice, and for tracking oceanic storms.

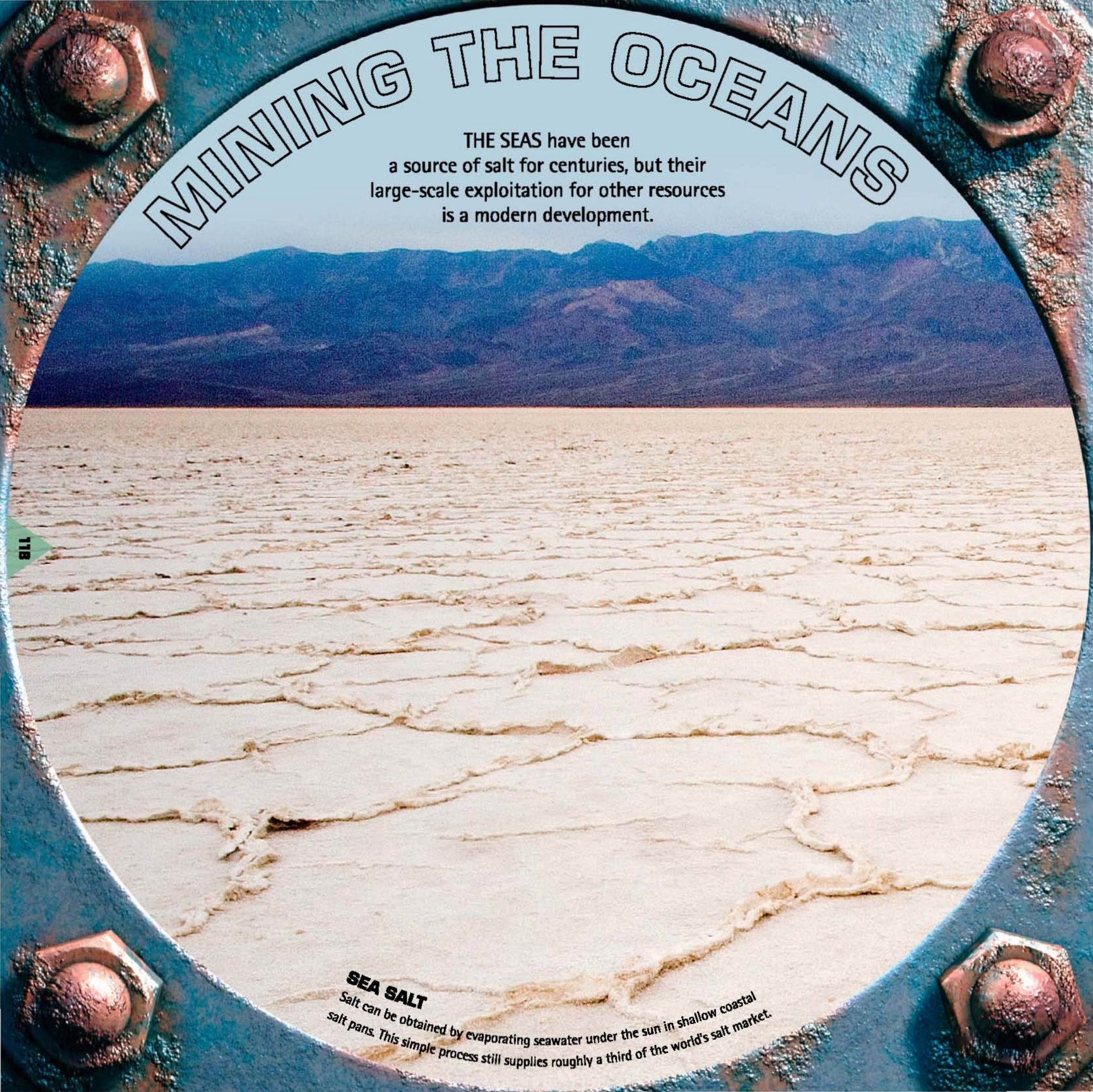
COMPLEX SCIENCE

The work of oceanographic research vessels and satellites is coordinated by institutions such as Woods Hole and Scripps in the US, and Southampton, England, and Naples, Italy, in Europe. These dedicated universities have experts in the many individual sciences, such as physics and geology, that make up the complex world of oceanography.



MINING THE OCEANS

THE SEAS have been a source of salt for centuries, but their large-scale exploitation for other resources is a modern development.



SEA SALT
Salt can be obtained by evaporating seawater under the sun in shallow coastal salt pans. This simple process still supplies roughly a third of the world's salt market.

FRESH WATER

Seawater can be turned into fresh water by forcing it through very fine filters to remove the salt. This desalination process uses a lot of energy, but in desert regions—where it is most vital—it can be achieved using solar power.

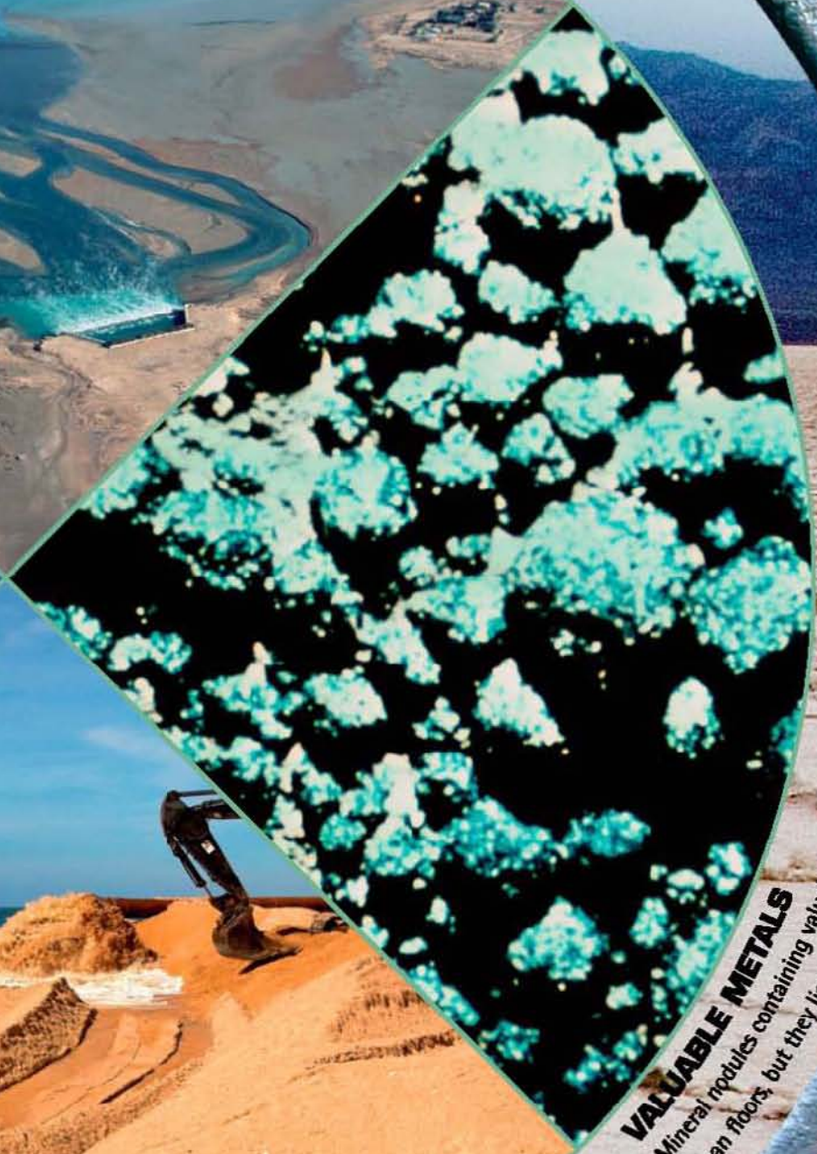
Waste salty water from a desalination plant flows back to the sea.

OFFSHORE OIL

Oil and gas reserves that may lie up to 16,500 ft (5,000 m) beneath the seabed are extracted using offshore drilling rigs.

VALUABLE METALS

Mineral nodules containing valuable metals, such as manganese, occur on some deep ocean floors, but they lie too deep to be harvested.



SAND AND GRAVEL

Vast amounts of sand and gravel are dredged from shallow waters for use in building and road construction projects. The purest quartz sand is also used for making glass.

OCEAN HARVEST

WE HAVE BEEN CATCHING or gathering fish and other seafoods since the Stone Age, but fishing techniques are now so efficient that we risk running out of fish to catch.

SUBSISTENCE FISHING
For many coastal communities, fishing is a way of life. Using simple methods like this hand-cast net in Thailand, they catch just enough for their needs. This has little impact on fish populations, which can breed fast enough to offset the losses.

GIANT NETS

The modern fishing industry relies on fleets of big ocean-going boats. Many of these use huge nets that can scoop entire shoals out of the water.

ON ICE

Using ice and refrigeration to chill down the catch keeps the fish fresh until the boat returns to unload at its home port.

OVERFISHING AND BYCATCH

Fishing is now so efficient that many seas have been overfished. Other species, like this turtle, also get trapped and killed by the nets and lines.

FISH FARMING

Fish farms like these in Thailand can supply a lot of the fish we eat, helping to reduce overfishing. But they can also cause problems by destroying natural coastal habitats such as tropical mangrove forests, or polluting the water with surplus fish food.

POLLUTION AND CLIMATE CHANGE

THE OCEANS have been used as dumping grounds for centuries. This did not matter when human populations were small, but now we pour vast amounts of pollution into the seas, poisoning the water and upsetting the balance of nature.

RED TIDE

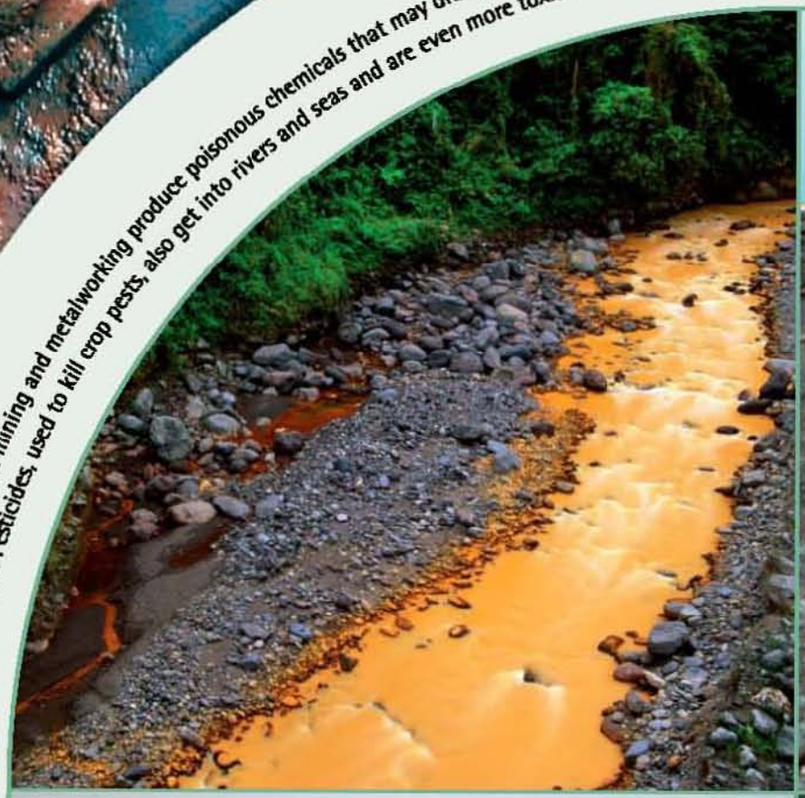
Organic pollution can cause dense plankton blooms like this "red tide," which may release deadly toxins. When the plankton dies and rots, it uses up all the oxygen in the water.

ORGANIC POLLUTION

Cities and towns generate a lot of organic waste. This can be made harmless by sewage treatment, but in many countries raw sewage is still dumped in the sea. Fertilizers also run off farmland into rivers that flow to the sea. Together they can overfertilize the water and destroy the natural ecology.

KILLER CHEMICALS

Many industries such as mining and metalworking produce poisonous chemicals that may drain into rivers and flow to the ocean. Pesticides, used to kill crop pests, also get into rivers and seas and are even more toxic.



OIL SPILLS

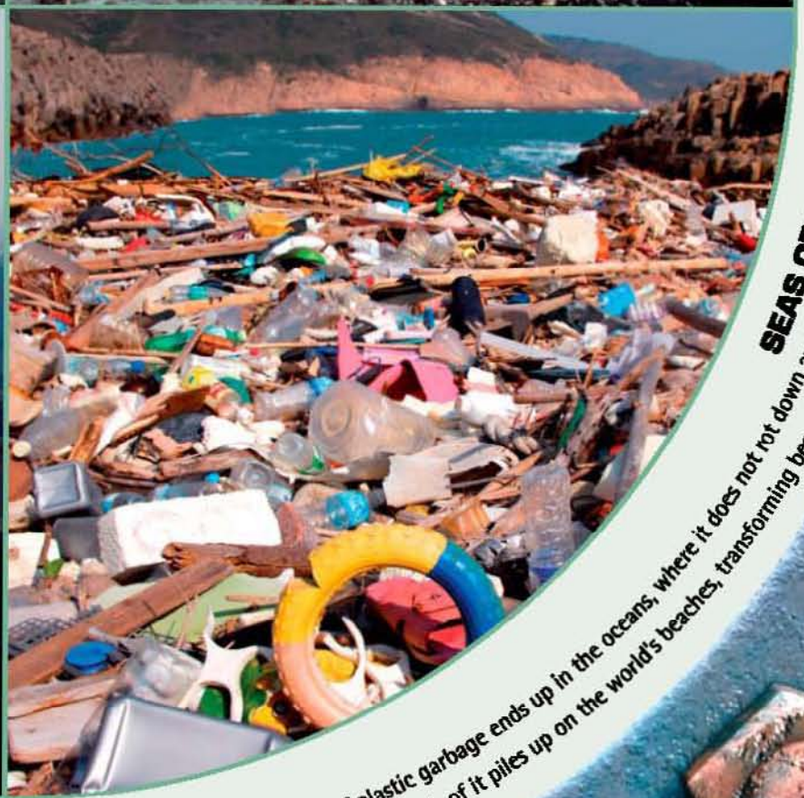
Shipwrecked oil tankers can spill vast amounts of thick oil into the sea. Since oil floats, it washes up on beaches like this one, destroying coastal habitats and killing marine life such as seabirds.

CLIMATE CHANGE

Industries and transportation pollute the air with gases like the carbon dioxide in coal smoke and vehicle exhaust. This is making the atmosphere warm up, raising ocean temperatures. Much of the carbon dioxide is absorbed by the oceans, making them more acidic, too.

SEAS OF PLASTIC

A lot of plastic garbage ends up in the oceans, where it does not rot down and becomes a deadly hazard to wildlife. Much of it piles up on the world's beaches, transforming beautiful shorelines into garbage dumps.



OCEAN CONSERVATION

WORKING FOR THE FUTURE

Oceans cover most of the globe, so if conservation helps keep them healthy it will help keep the whole planet healthy.

TROUBLED WATERS

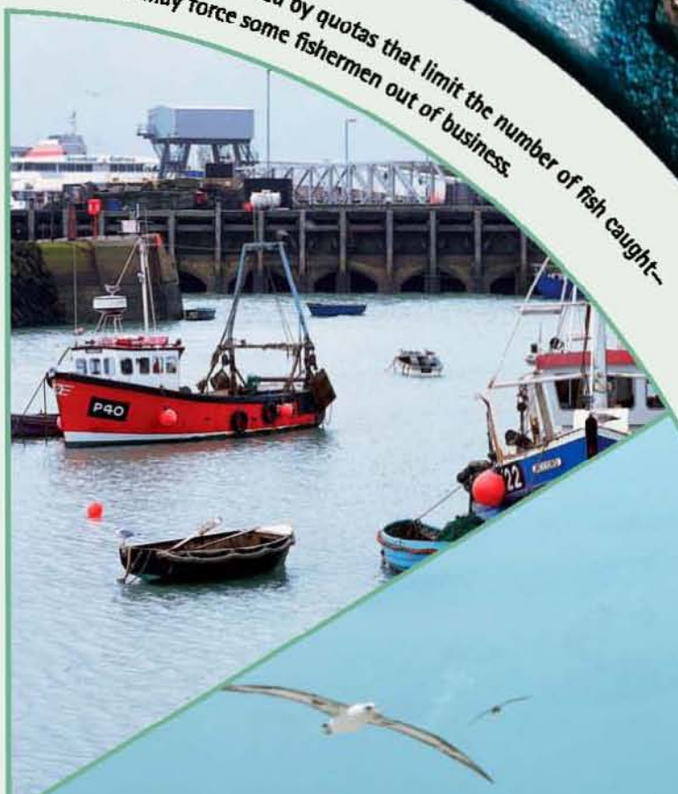
DYING CORAL REEFS

Warming oceans and increasing acidity are causing serious problems for tropical coral reefs. By the end of the century many of them may be dead or dying.

MARINE CONSERVATION is essential if we are to retain the beauty and diversity of ocean life.

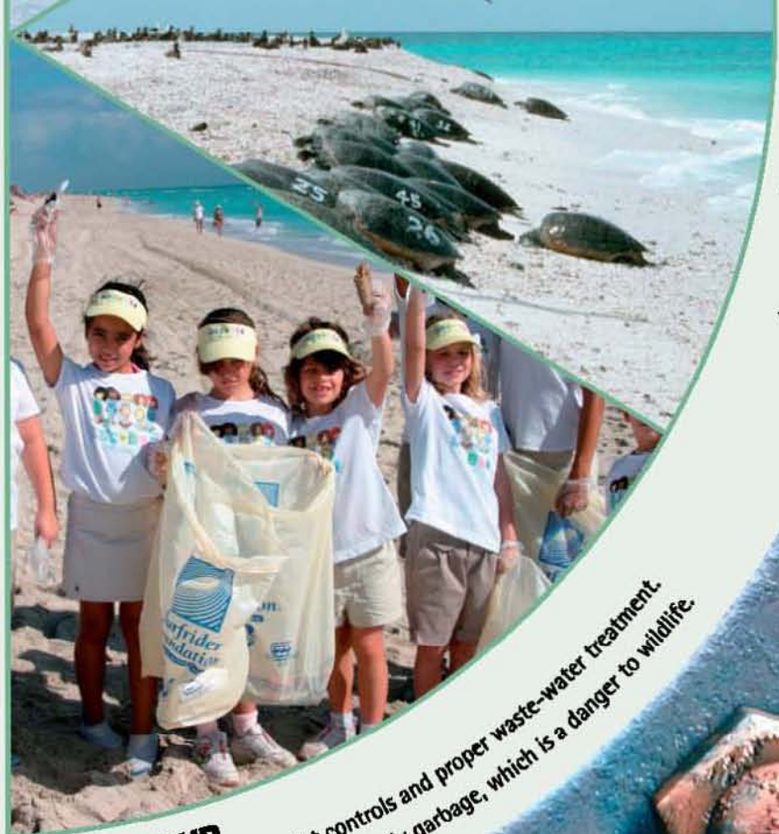
FISHING QUOTAS

Overfishing can be prevented by quotas that limit the number of fish caught – although this may force some fishermen out of business.



MARINE RESERVES

Protected seas and shores help animals like these breeding turtles, but they also act as nurseries for fish that may then restock fisheries.



BIG CLEAN-UP

Pollution can be reduced by strict controls and proper waste-water treatment. Everyone can help clear the beaches of ugly garbage, which is a danger to wildlife.

GLOSSARY

algae
plantlike organisms that can make food using the energy of sunlight

backwash
the movement of seawater down a beach after a wave has broken

ballast
heavy material used to weigh something down

barrier reef
a coral reef that protects a shallow lagoon from the deep ocean

basalt
a dark, heavy volcanic rock that forms the ocean floor and erupts as molten lava from midocean ridges and hotspot volcanoes

brackish
slightly salty water, but not as salty as the open sea

colony
a group of animals that live together, or come together to breed

continental shelf
the fringe of a continent submerged beneath a shallow coastal sea

corals
animals related to sea anemones that often build reefs

crustacean
an animal with a hard, shell-like external skeleton and jointed legs, such as a crab or shrimp

current
a flow of ocean water, driven by the wind or by differences in water density caused by temperature and/or salt content

cyclone
a weather system with clouds, rain, and strong winds caused by air swirling into a region of rising warm, moist air

downwelling zone
a sea area where water is sinking

ecosystem
an interacting community of living things in their environment

eddy
a swirling water current

erosion
wearing away, usually by natural forces such as waves on the shore

geyser
a jet of hot water that erupts from volcanically heated rocks

glacier
a mass of ice that is flowing very slowly downhill

granite
a hard rock with big crystals that occurs in continental mountains

gyre
a circular pattern of ocean currents

hotspot
a hot region beneath Earth's crust that makes volcanoes erupt above it

hurricane
a destructive oceanic storm that forms a huge rotating spiral of clouds and high winds

iceberg
part of a glacier or ice shelf that has broken off and floated out to sea

lagoon
an area of shallow water that has been cut off from the sea, often by a coral reef

landlocked
an area of water that is mostly surrounded by land

lava
molten rock that erupts from volcanoes

mass
a measure of the amount of material (matter) a body is made of

midocean ridge
a ridge of submarine mountains on the ocean floor created by a spreading rift between two plates of Earth's crust

minerals
natural materials that make up rocks; many dissolve in ocean water and are used by plants and algae to build their tissues

monsoon
a seasonal wind change that alters the weather pattern, especially in southern Asia

nutrients
substances that living things need to build their tissues

organism
a living thing

pack ice
thick floating ice that forms when the ocean surface freezes

phytoplankton
microscopic algae that drift near the ocean surface and make food using the energy of sunlight

plankton
living things that mainly drift in the water, rather than actively swim

polynya
a broad area of open water in a polar ocean that is surrounded by sea ice

predator
an animal that attacks and eats other live animals

rift
a break in Earth's crust caused by the rocks moving apart

seamount
an ocean-floor volcano that is not high enough to form an island

sediment
solid particles such as sand that have settled on the seabed or elsewhere. They may harden to form sedimentary rock

silt
like sand, but with much smaller particles

sonar
a system that uses pulses of sound waves to detect solid objects, used to find ocean depths and map the ocean floor

spherical
ball-shaped; a spherical object is a sphere

spit
a sand or shingle beach that projects from the land and has water on both sides

stagnant
water that has no oxygen in it

storm surge
a local, temporary rise in sea level caused by storm winds and low air pressure

submersible
a craft designed to dive to the ocean depths

superheat
to heat a liquid such as water under pressure, so it gets hotter than its normal boiling point

trawler
a fishing boat that drags a net over the seabed

trench
a deep chasm in the ocean floor created by one plate of Earth's crust being dragged beneath another

tropics
the regions that lie between the Tropic of Cancer and the Tropic of Capricorn, including the equatorial zone

tsunami
a wave generated by an earthquake on or near the ocean floor

turbine
a rotor driven by a flow of water or air, which can be used to turn an electricity generator

upwelling zone
a part of the ocean where deep water that is rich in nutrients is drawn to the surface

water vapor
the gas formed when liquid water is warmed and evaporates

zooplankton
the community of mostly small animals that drift in the ocean, mainly near the surface

INDEX

Bold page numbers are used to distinguish main sections on a subject

ACKNOWLEDGMENTS

DK would like to thank: Hitesh Patel for production support, Nic Dean for additional picture research, Hazel Beynon for proofreading, and Jackie Brind for the index.

Picture credits

The publisher would like to thank the following for their kind permission to reproduce their photographs: (Key: a-above, b-below/bottom, c-center, f-far, l-left, r-right, t-top)

2-3 Alamy Images: Wild Places Photography/Chris Howes. 4 DK Images: David Peart. 5 4Corners Images: Guido Cozzi (cra). Alamy Images: David Ball (cla). Corbis: Lee Cohen (clb). naturepl.com: Jurgen Freund (crb); Doug Perrine (tr). NHPA / Photoshot: Paal Hermansen (tl). Science Photo Library: British Antarctic Survey (b). 6 Getty Images: All Canada Photos/Darwin Wiggett (bl). Photolibrary: Alan Copson (br). Shutterstock: Terence Mendoza (cl). 6-7 Photolibrary: Radius Images. 7 Action Images: DPPI (fcr). Alamy Images: Andrej Creek (cla); Christopher Nicholson (tr); Florian Schulz (br); Martin Strmiska (bl); Wild Places Photography/Chris Howes (cb). Corbis: Bettmann (cr); Sygma/Jean Guichard (tl); zefa/Masumi Nakada (c). FLPA: Reinhard Dirscherl (crb). Getty Images: AFP/Marcel Mochet (fcrb). NHPA / Photoshot: A.N.T. Photo Library (cra); Oceans Image/Charles Hood (bc). Rex Features: (tc). 8 NASA: JPL/GSFC. PA Photos: AP/David Jordan (l). Shutterstock: Michael Svoboda (r). 9 Alamy Images: David Ball. 10 Science Photo Library: Dr Ken MacDonald (tr); NOAA (tl). 11 Science Photo Library: Dr Ken MacDonald (tl); Worldsat International (tr). 12 Shutterstock: Vaara. 13 Alamy Images: Robert Harding Picture Library Ltd (tr); ImageState (br). Corbis: Robert Harding World Imagery (tl); Ralph White (bl). 14 Corbis: David Pu'u (t); Steve Wilkings (b). 15 Corbis: Mark A. Johnson (br). DK Images: Michelle Grant (c) Rough Guides (t). Science Photo Library: Duncan Shaw (bl). 16 NASA: JacquesDescloitres/MODIS Land Rapid ResponseTeam/GSFC. 17 Getty Images: Stephen Frink (t). Shutterstock: Dmitry Goygel-Sokol (bl). 18 Getty Images: All Canada Photos/Darwin Wiggett (b). Shutterstock: Terence Mendoza (t). 19 Photolibrary: Alan Copson (b). 20 Alamy Images: Dennis Frates (b). FLPA: Minden Pictures/Konrad Wothe (t). 21 Corbis: Jason Hawkes (br). Getty Images: Photographer's Choice/Zap Art (tl). Photolibrary: Rodger Jackman (bl). Science Photo Library: Martin Dohrn (r). 22 Getty Images: The Image Bank/Daisy Gilardini (tl). naturepl.com: Eric Baccega (bl). 23 NHPA / Photoshot: Paal Hermansen. 24-25 FLPA: Minden Pictures/Tui De Roy. 25 Alamy Images: Bryan & Cherry Alexander Photography (br). Bryan and Cherry Alexander Photography: (tr). 26 Corbis: Baard Ness. 27 Alamy Images: Bryan & Cherry Alexander Photography (br). Corbis: Dan Guravich (tl). Getty Images: Discovery Channel Images/Jeff Foott (bl). Still Pictures: Fred Bruemmer (tr). 28 naturepl.com: Sue Flood. 29 Getty Images: Minden Pictures/Flip Nicklin (bl). naturepl.com: Martha Holmes (tl). Photolibrary: Doug Allan (tr); Louise Murray (br). 30 Getty Images: Stone/Hans Strand (b). 30-31 Getty Images: National Geographic Creative/David Littschwager. 31 Alamy Images: Bruce Coleman Inc. (tr). FLPA: Minden Pictures/Michio Hoshino (br). 32 Alamy Images: Robert Harding Picture Library Ltd (r). Photolibrary: Picture Press/Konrad Wothe. 32-33 Shutterstock: irabel8 (background). 33 Corbis: epa/ESA (br). DK Images: Courtesy of the National Maritime Museum, London/James Stevenson and Tina Chambers (t). naturepl.com: Ingo Arndt (bc). Rex Features: Lehtikuva Oy (bl). 34 NHPA / Photoshot: Bryan & Cherry Alexander Photography. 35 Alamy Images: Andre van Huizen (tr). Corbis: Ralph A. Clevenger (br). Getty Images: DeAgostini/G. Sioen (tl); Stone/Russell Kaye/Sandra-Lee Phipps (bl). 36 Corbis: Cordaiy Photo Library Ltd/John Farmar (cr). NASA: GSFC/JPL, MISR Team (cl). 37 naturepl.com: Doug Perrine (t). 38 Getty Images: National Geographic/Bill Curtsinger (b). 38-39 Rex Features: Leif-Goran Hjelm. 39 Photolibrary: OSF/Mark Hamblin (tr). Reuters: Str Old (br). 40 Corbis: Ralph White. 41 Getty Images: Liaison/John Chiasson (bl). NOAA: (br) (tr). Rex Features: ITV (tl). 42 Photolibrary: Hemisphere Images/Camille Moirenc. 43 Alamy Images: E. Champelovier (b). Photolibrary: F1 Online/Werner Dieterich (tr). Rex Features: Alex Segre (tl). 44 DK Images: Courtesy of the Natural History Museum, London/Dave King. 45 naturepl.com: Sue Daly (tl); OSF/Ben Osborne (br). Photolibrary: OSF/Chris Knights (bl); Robert Harding Travel/Thorsten Milse (tr). 46 Corbis: Sygma/Jean Guichard. 47 Alamy Images: Andrej Creek (bl); Christopher Nicholson (tr). NHPA / Photoshot: A.N.T. Photo Library (br). Rex Features: (tl). 48 Getty Images: National Geographic/Peter Carsten (bl). Reuters: (br). 48-49 Alamy Images: LOOK Die Bildagentur der Fotografen GmbH (t). 49 Alamy Images: ImagesEtStories (br). DK Images: Nigel Hicks (bl). Science Photo Library: M-Sat Ltd (c). 50 FLPA: imagebroker / J.W.Alker. 51 Alamy Images: K. Byrne (bc). Getty Images: Minden Pictures RM/Ingo Arndt (tc) (cla) (clb) (cra) (t); Visuals Unlimited/Ken Lucas (bl). Natural Visions: Heather Angel (tr); Norman T. Nicoll (tl). Photolibrary: Animals Animals/Bob Cranston (br). 52 Alamy Images: Mark Conlin. Getty Images: Stone/Erik Von Weber (b). 53 Alamy Images: WaterFrame (bl). FSA: (tl). FLPA: Silvestris Fotoservice (tr). Science Photo Library: Sinclair Stammers (br). 54 NOAA: (bl). Science Photo Library: NASA (br). 54-55 Corbis: Yann Arthus-Bertrand (t). 55 Alamy Images: Cameron Davidson (bl). National Geographic Image Collection: David Doubilet (br). 56 Getty Images: Gallo Images/Anthony Bannister (tr). Photolibrary: Reinhard Dirscherl (tl). 56-57 Photolibrary: Gerald Hoberman (b). 57 Alamy Images: Andy Lane (tr). TopFoto.co.uk: National Pictures (tl). 58 Corbis: zefa/Masumi Nakada. 59 Action Images: DPPI (br). Corbis: Bettmann (bl). Getty Images: AFP/Marcel Mochet (cr). 60 Getty Images: Aurora Creative/Dan Raffia (cr). USGS: Landsat (cl). 61 4Corners Images: Guido Cozzi. 62 Getty Images: Aurora Creative/Jonathan Kingston (br); Taxi/Peter Scoones (bl). 62-63 Photolibrary: Cusp/Sergio Pitamitz (t). 63 Corbis: Martin Harvey (cr). FLPA: Minden Pictures/Norbert Wu (br). Photolibrary: Pacific Stock/Vince Cavataio (bl). 64 FLPA: Minden Pictures/Flip Nicklin. 65 Alamy Images: WaterFrame (bl). Ardea: Ron & Valerie Taylor (br); M. Watson (tr) (cr). NHPA / Photoshot: Kevin Schafer (tl). 66 Alamy Images: mediacolors (b). Photolibrary: Nordic Photos/Chad Ehlers. 67 NHPA / Photoshot: Andrea Bonetti (b). Photolibrary: Pacific Stock/Ed Robinson (t). 68 NASA. 69 Corbis: Dallas Morning News/Smiley N. Pool (tr); Warren Faidley (tl). Getty Images: AFP (br). NASA: JPL (bl). 70 Natural Visions: Peter David. 71 FLPA: Minden Pictures/Flip Nicklin (br); Minden Pictures/Fred Bavendam (bl). Getty Images: Minden Pictures RM/Norbert Wu (tr). Natural Visions: Heather Angel (tl). 72 Corbis: Frans Lanting. 73 DeepSeaPhotography.Com: (tr). imagequestmarine.com: Peter Herring (bl). naturepl.com: David Shale (tl) (br). 74 4Corners Images: SIME/Morandi Bruno. 75 NHPA / Photoshot: Oceans Image/Zafer Kizilkaya (l). PA Photos: AP Photo/DigitalGlobe (t). Photolibrary: Fresh Food Images/Patrick Syder (br). Private Collection: (cr). 76 Photolibrary: JTB Photo. 77 Corbis: Gavriel Jecan (bl). Getty Images: AFP/Sebastien Blanc (br). naturepl.com: Georgette Douwma (tl). NHPA / Photoshot: Stephen Dalton (tr). 78 © 2008 by The Trustees of Columbia University in the City of New York, Lamont-Doherty Earth Observatory: Marine Geoscience Data System (b). Rex Features: Sipa Press (t). 79 naturepl.com: Jurgen Freund. 80 Alamy Images: Kevin Schafer. 81 Alamy Images: Ron Niebrugge (bl). Getty Images: AFP/Chris Wilkins (br). Photolibrary: Imagestate RM/Frank Lukassek (tr). USGS: AVO/Cyrus Read (tl). 82 Photolibrary: Animals Animals/Don Brown. 83 Alamy Images: Brandon Cole Marine Photography (bl). Getty Images: Minden Pictures/Flip Nicklin (br); National Geographic/Paul Nicklen (tl). Photolibrary: Animals Animals/Don Brown; OSF/David Courtenay (tr). 84 FLPA: Minden Pictures/Tui De Roy (br). Getty Images: National Geographic/Tim Laman (bl). 84-85 Photolibrary: De Agostini Editore/F. Galardi (t). 85 Getty Images: Minden Pictures/Chris Newbert (bl). NASA: R.B. Husar (br). 86 NOAA: (l). 87 NOAA: (tr) (bl) (br). 88 NOAA. 89 imagequestmarine.com: Peter Batson (bl). NOAA: (tl) (br). Science Photo Library: Dr Ken MacDonald (tr). 90 NASA: JacquesDescloitres/MODIS Land Rapid ResponseTeam/GSFC (b). 90-91 Alamy Images: Greg Vaughn. 91 4Corners Images: SIME/Kaos03 (cr). Alamy Images: Surfpix (br). NASA: MODIS (tr). 92 FLPA: Imagebroker / J.W.Alker (t). Science Photo Library: USGS (b). 93 Christie's Images Ltd.: (bl). Getty Images: Sebun Photo/R. Creation (br). Mary Evans Picture Library: (cl). NASA: JacquesDescloitres/MODIS Land Rapid ResponseTeam/GSFC (tl). Still Pictures: Visual and Written/Biosphoto / Calvo Kike (tr). 94 Corbis: George Steinmetz (br). Photolibrary: Nordic Photos/Chad Ehlers (bl). 94-95 Corbis: George Steinmetz. 95 Corbis: Bob Krist (bl). NHPA / Photoshot: Oceans Image/Douglas David Seifert (br). 96 Alamy Images: Martin Strmiska; Wild Places Photography/Chris Howes (tl). 97 Alamy Images: Florian Schulz (br). FLPA: Reinhard Dirscherl (tr). NHPA / Photoshot: Oceans Image/Charles Hood (bl). 98 Corbis: Stephen Frink. Getty Images: Hulton Archive/Archive France/RDA (bl). 99 Alamy Images: Chris A Crumley (bl) (bc). DK Images: Stephen Oliver (t). Science Photo Library: Alexis Rosenfeld (br). 100 Alamy Images: Reinhard Dirscherl (br). FLPA: Minden Pictures/Chris Newbert (bl). 100-101 Corbis: Theo Allofs. 101 Alamy Images: David Fleetham (bl). Ardea: Auscape/Dr David Wachenfeld (br). 102 Corbis: George D. Lepp (l). Getty Images: National Geographic/Gordon Wiltsie (r). 103 Science Photo Library: British Antarctic Survey. 104 FLPA: Foto Natura/Flip de Nooyer. 105 Alamy Images: Arco Images GmbH (tl); David Osborn (bl); WorldFoto (tr). Corbis: Momatiuk - Eastcott (br). 106 NASA: JPL (b). 106-107 NHPA / Photoshot: Bryan & Cherry Alexander Photography. 107 Corbis: Hulton Archive/Frank Hurley (tr). FLPA: Fritz Polking (br). 108 FLPA: Minden Pictures/Norbert Wu. 109 Ardea: Jean-Paul Ferrero (tl). Corbis: Rick Price (bc). FLPA: Minden Pictures/Norbert Wu (cl) (cr). NHPA / Photoshot: Haroldo Palo Jr. (tr). 110 FLPA: Imagebroker/Wolfgang Bechtold. 111 Alamy Images: Bryan & Cherry Alexander Photography (tl); John Digby (bl). Corbis: Hulton Archive/Herbert G. Ponting (br). NASA: (tr). 112 Alamy Images: G. P. Bowater (l). Marine Current Turbines Ltd: (r). Photolibrary: Pixland. 113 Corbis: Lee Cohen. 114 SuperStock: Hemis.fr. 115 Alamy Images: Rob Walls (bl). Corbis: Australian Picture Library/Ludo Kuipers (tl); Joel W. Rogers (br); Ted Spiegel (tr). 116 Alamy Images: Rob Walls (bl). Corbis: Paul A. Souders (br). 116-117 Science Photo Library: Los Alamos National Laboratory. 117 Alamy Images: ImagesEtStories (br). NASA: (bl). 118 DK Images: Paul Whitfield (c) Rough Guides. 119 Alamy Images: G. P. Bowater (cl); Chris Pancewicz (b). Corbis: Yann Arthus-Bertrand (t). Science Photo Library: Peter Ryan (cr). 120 Alamy Images: Pat Behnke. 121 Alamy Images: Jonathan Ball (tl). DK Images: Michael Spencer (b). FLPA: Minden Pictures/Norbert Wu (tr). Photolibrary: Fresh Food Images/Maximilian Stock Ltd (tc). 122 Science Photo Library: Bill Bachman (t); Simon Fraser (b). 123 Alamy Images: Lou Linwei (bl); Ron Yue (br). FLPA: Frans Lanting (tl); Panda Photo (tr). 124 DK Images: David Peart (b). 124-125 FLPA: Minden Pictures/Chris Newbert. 125 Alamy Images: Jeff Greenberg (br). Corbis: John Francis (cr). DK Images: Alex Wilson (tr). 126-127 DK Images: Zena Holloway. 128 DK Images: Zena Holloway

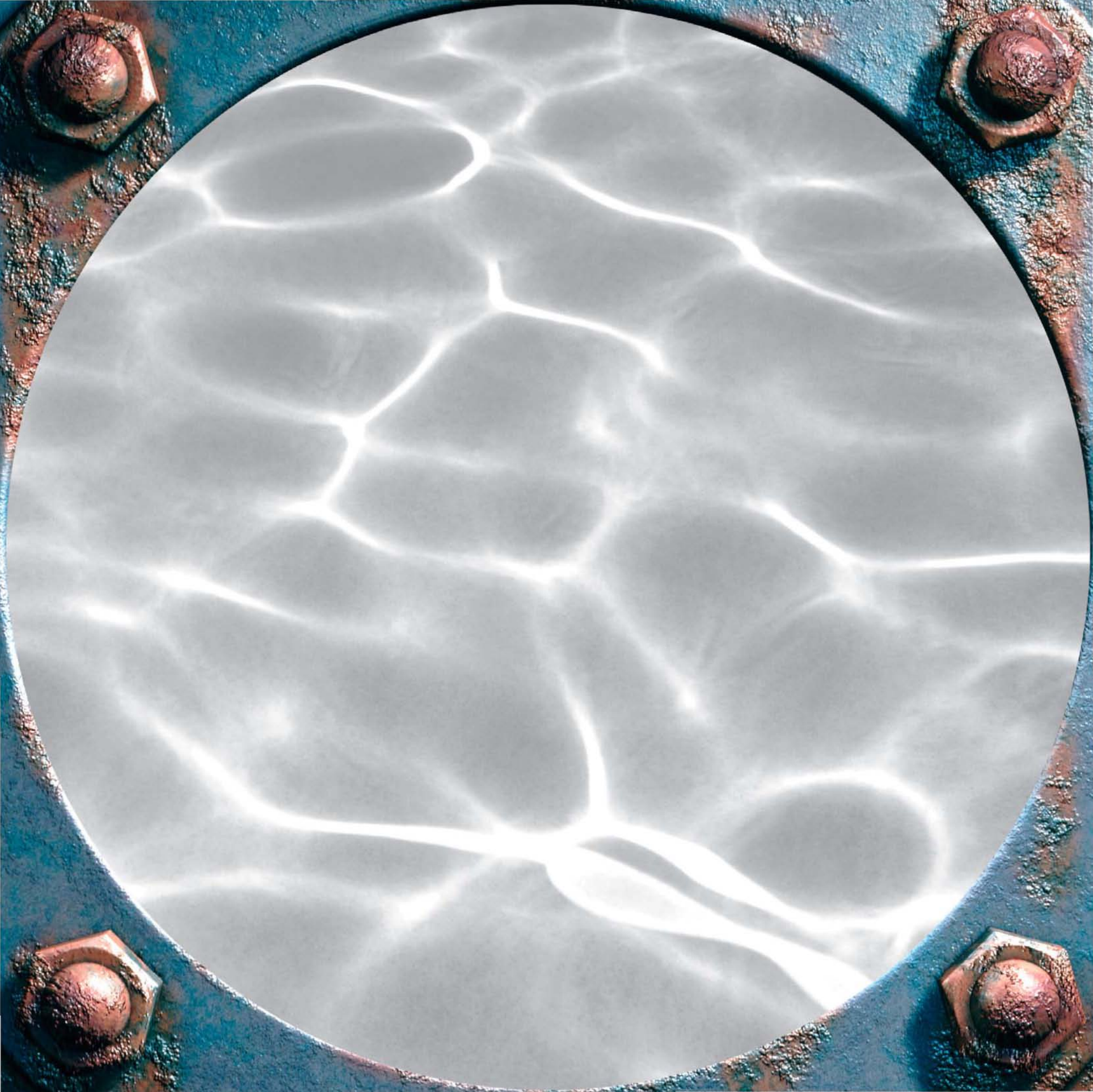
Fact cards: Flower hat jellyfish: Corbis/Frans Lanting; Seal: Corbis/Baard Ness; Hawaiian surf: Corbis/David Pu'u; Green Turtle: DK Images/David Peart; Angler fish: Natural Visions/Peter David.

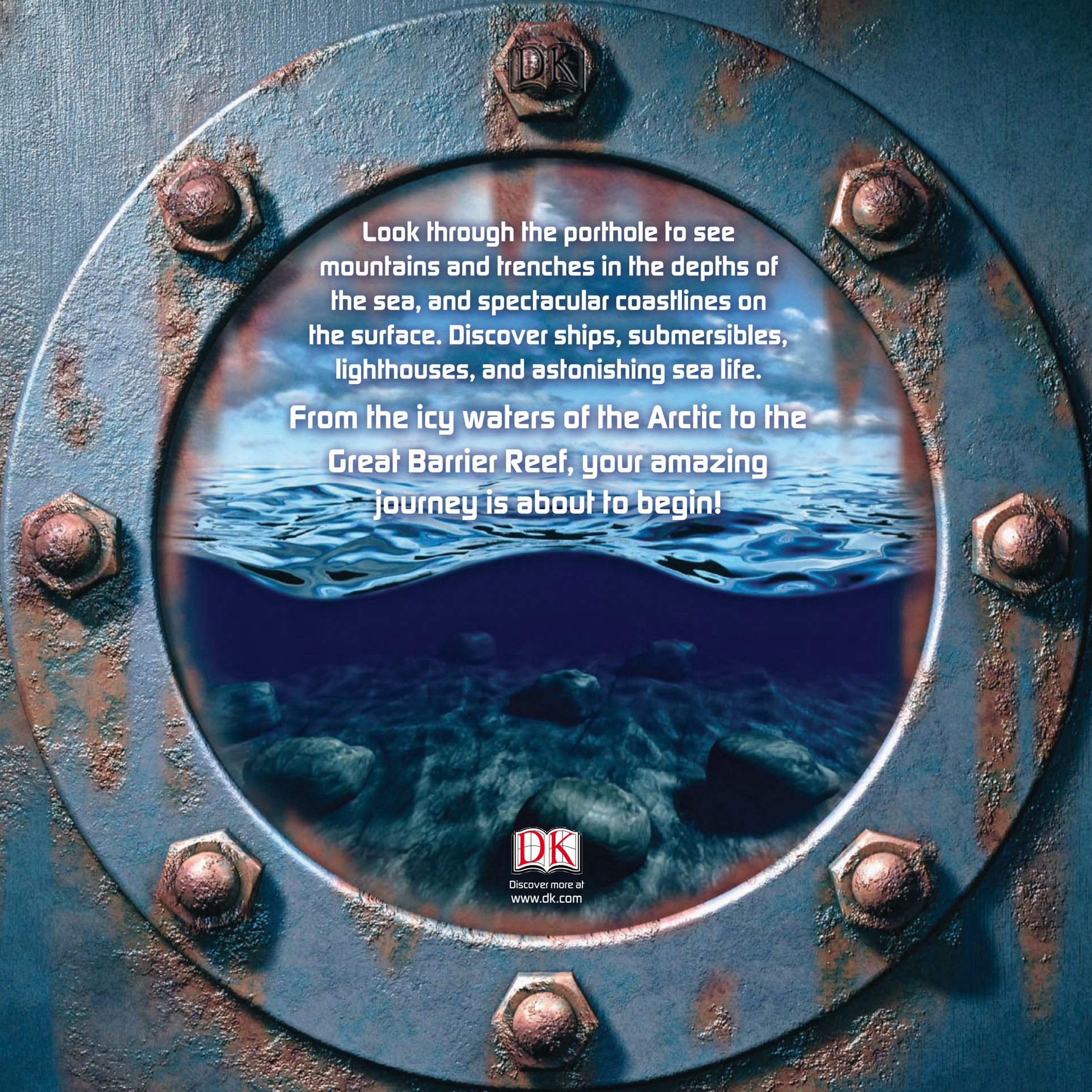
Stickers: crb DK Images/ Rough Guides; cra, clb DK Images/Rowan Greenwood; background, tc, cla DK Images/David Peart; fcra Naturepl.com/Georgette Douwma; tl NOAA: fcla NOAA/Matt Wilson/Jay Clark; tr Still Pictures/Fred Bruemmer

Poster: Diver: Corbis/amanaimages/Yusuke Yoshino; Oil spill: Corbis/Gallo Images/Martin Harvey; Shoal safety: Corbis/zefa/Gary Bell; Scallop: DK Images/Courtesy of the Natural History Museum, London; Coelacanth: DK Images/Courtesy of the Natural History Museum, London; Background: DK Images/David Peart; Plankton: Getty Images/National Geographic Creative/David Littschwager; Fishing: Getty Images/Science Faction/Karen Kasmauski

Jacket images: Front: Corbis: Australian Picture Library/Sean Davey c (O); zefa/Gregor Schuster (A); zefa/Guenter Russenbach (E); zefa/Matthias Kulka Getty Images: Stone/Michele Westmorland (N); Photolibrary: Image Source (C); SuperStock: age fotostock c. Back: Corbis: zefa/Matthias Kulka

All other images © Dorling Kindersley
For further information see: www.dkimages.com




Look through the porthole to see mountains and trenches in the depths of the sea, and spectacular coastlines on the surface. Discover ships, submersibles, lighthouses, and astonishing sea life.
From the icy waters of the Arctic to the Great Barrier Reef, your amazing journey is about to begin!
Discover more at
www.dk.com