Seashore

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The seashore, also called the coastline, shoreline, or beach, is the portion of a continent or island where the land and sea meet. The seashore includes the area covered by water during high tide and exposed to air during low tide, the area splashed by waves but never under water, and the area just beyond the shore that is always under water. (The tides are the rhythmic rising and falling of the sea.) Seashores vary greatly in appearance, from flat, sandy, and washed by gentle waves to storm-battered and rocky or bounded by tall cliffs.

How the Seashore is Formed

Seashores were first created when the continents and islands of Earth were formed. Since then, many changes have occurred. Some happened during prehistoric times and others are still taking place.

Movement of Earth's crust

The underlying structure of the shoreline depends upon the shape of the land where it meets the ocean and the type of rock of which it is a part. Earthquakes and volcanoes during prehistoric times may have helped form many shorelines. An earthquake, for example, caused part of the California shoreline to sink. The sunken area became what is now San Francisco Bay and a new shoreline was created. In regions like northern California, where earthquakes and volcanoes still occur, the shoreline may undergo many more changes in the future.

Glaciers

During prehistoric times, glaciers (giant, slow-moving rivers of ice) may have altered the shape of the seashore by cutting into it and leaving deep valleys behind when they retreated. Glaciers created the fjords (fee-OHRDS; long, narrow arms of the ocean stretching inland) of Scandinavia, Greenland, Alaska, British Columbia, and New Zealand. They also created the U-shaped valleys along the coastline of southern Chile. In polar regions, glaciers are still at work, carving deep channels as they inch toward the sea.

The presence of a glacier weighs the land down, causing it to sink. About 10,000 years ago when many glaciers receded, some coastlines rose up, and areas once under water were now above it. In some places, such as Scandinavia, the coastlines are rising as much as 0.4 inch (10 millimeters) a year even though the glaciers have been gone for thousands of years.

Changes in sea level

Sea level refers to the average height of the sea when it is halfway between high and low tides. Sea level changes over time. For example, when the Ice Ages ended and glaciers began to melt into the ocean, the level of the water rose. Some areas that were once exposed to the air were now covered permanently by water and new shorelines were created.

Sea level is still changing. For the past 100 years, it has risen about 0.08 inch (2 millimeters) per year. As the water creeps higher, more of the existing shoreline becomes submerged. Low-lying coastal areas in Texas and Louisiana have already been flooded.

Offshore barriers

The presence of a barrier island, reef (an underwater wall made of rocks, sand, or coral), or other offshore landmass running parallel to the shore may affect a seashore's formation. It does this by reducing the effects of wind and water. Deposits of sediment (particles of matter) are allowed to accumulate because the force of the waves is lessened.

Coral reefs are created in tropical regions by small, soft, jellylike animals called corals and algae that trap hard calcium carbonate. Corals attach themselves to hard surfaces and build a shell-like external skeleton. Many corals live together in colonies, the younger building their skeletons next to or on top of older skeletons. Gradually, over hundreds, thousands, or millions of years, a reef of these skeletons is formed. Because reefs slow the movement of the water, sediments sometimes lodge in the reef allowing plants to take root. As the plants die and decay, a layer of soil is created. Eventually, the shoreline may extend, and even trees may grow.

SEASHORE PARKS AND RESERVES OF THE WORLD (PARTIAL LIST)

Name	Location	Square miles (square kilometers)	Features
Aldabra Islands Nature Reserve	Seychelles (Africa)	60 (156)	Protects giant tortoise and other animals
Bako National Park	Sarawak	10 (26)	Bays and caves; forest; wild pigs, deer, monkeys, birds
Cape Le Grand National Park	Australia	124 (321)	Beach; coastal plants
Easter Island National Park (Rapa Nui)	Chile	63 (163)	Protects vegetation and animals
Elat Gulf Coral Reef Reserve	Israel	0.5 (1.3)	Coral reefs with tropical fish
Eldey Nature Reserve	Iceland	0.006 (0.015)	Gannet breeding area
Franklin D. Roosevelt National Park	Uruguay	58 (150.8)	Sand dunes, pines
Ise-Shima	Japan	201 (522.6)	Forested coastline; pearl farms
Kong Karls Land Reserve	Norway	200 (520)	Arctic islands, polar bears
Kranji Reserve	Singapore	0.08 (0.21)	Mangrove marsh
Kyzylagach	Azerbaijan	363 (943.8)	Coastal reed and salt marshes; flamingos, bustards
Pembrokeshire Coast	Great Britain	225 (585)	Rocky coast; island birds
Prince Edward Island	Canada (Gulf of St. Lawrence)	7 (18.2)	Forested coastline; many small mammals
Rikuchu Kaigan	Japan	45 (117)	Cliffs, islands, and beaches; forests; birds
Skallingen	Denmark	12 (31.2)	Dunes, marshes
St. Lucia	Natal (Africa)	190 (494)	Estuary on False Bay; hippopatoami and birds
Westhoek Nature Reserve	Belgium	1.3 (3.4)	Sand dunes, marine plants
Yala National Park	Sri Lanka	91 (236.6)	Lagoons, rocky hills

The Bordering Sea

The oceans are constantly, restlessly moving. This movement takes place in the water column (the water in the ocean exclusive of the sea bed or other landforms) in the form of tides, waves, and currents; all of which affect the shoreline.

Tides

Tides are rhythmic movements of the oceans that cause a change in the surface level of the water. When the water level rises, it is called high tide. When it falls, it is called low tide. Along some shorelines, the tides are barely measurable. In other areas the difference between high and low tide may be several feet (meters). High and low tides occur in a particular place at least once during each period of 24 hours and 51 minutes.

Tides are caused by a combination of the gravitational pull of the sun and moon and Earth's rotation. The sun or moon pulls on the water, causing it to bulge outward. At the same time, the centrifugal force (movement from the center) created by Earth's rotation causes another bulge on the opposite side of Earth. Both of these areas experience high tides. At the same time, water is pulled from the areas in between, and those areas experience low tides.

When the Earth, sun, and moon are lined up, the gravitational pull is strongest. At these times, high tides are higher and low tides are lower than normal. These are called spring tides. When the Earth, sun, and moon form a right angle and the gravitational pull is weakest, high tides are lower and low tides are higher than normal. These are called neap tides.

Tidal bores are surges of tidal waters caused when ridges of sand block the flow of ocean water and direct it into a narrow channel, sometimes as a single wave. Most tidal bores are harmless, but the bore that enters the Tsientang River in China sometimes reaches 15 feet (4.5 meters) in height and travels 25 feet (7.5 meters) per second.

Waves

Waves are rhythmic rising and falling movements in the water. Most surface waves are caused by wind. Their size is due to the speed of the wind, the length of time it has been blowing, and the distance over which it has traveled. A breaker is a wave that collapses on a shoreline in a mass of foam. As it rolls in from the ocean, the bottom of the wave is slowed by friction as it drags along the sea floor. The top then outruns it and topples over, landing on the shore.

Waves can be extremely powerful. Storm waves can even hurl large rocks high into the air. So many rocks have broken the beacon at the lighthouse at Tillamook Rock, Oregon, that the beacon--133 feet (40.5 meters) above the water--is now enclosed in a steel grating.

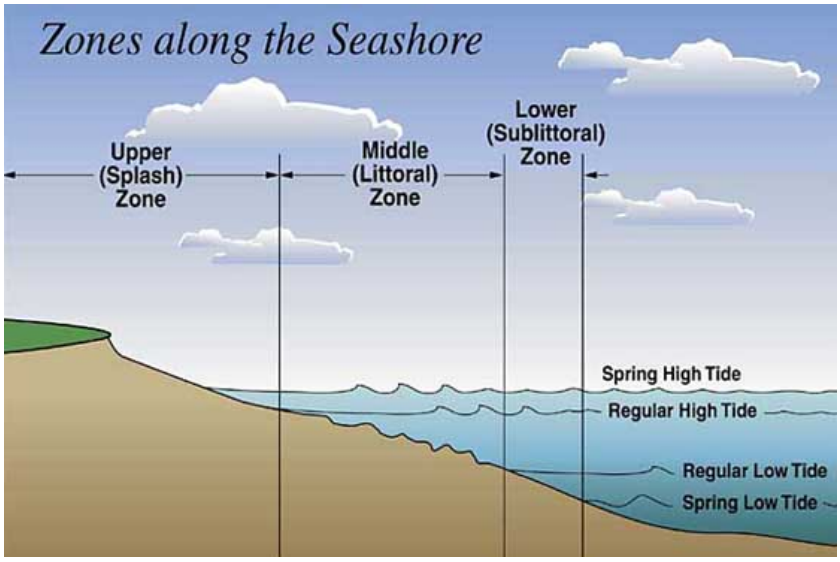
One dangerous type of wave, called a tsunami (soo-NAH-mee), is caused mainly by undersea earthquakes. When the ocean floor moves during the quake, its vibrations create a powerful wave that travels to the surface. When tsunamis strike coastal areas, they can destroy entire towns and kill many people.

Currents

Currents are the flow of the water in a certain direction. Most currents are caused by the wind, the rotation of Earth, and the position of continental landmasses. A longshore current is one that runs along a shoreline. Rip currents, or riptides, are strong, dangerous currents that occur when currents moving toward shore are deflected away from it through a narrow channel.

Upward and downward movement also occurs in the ocean. Vertical currents are primarily the result of differences in the temperature and salinity (level of salts) of the water. In some coastal areas, strong wind-driven currents carry warm surface water away. Then an upwelling (rising) of cold water from the deep ocean occurs to fill the space. This is more common along the western sides of continents. These upwellings bring many nutrients from the ocean floor to the surface, encouraging a wide variety of marine (ocean) life.

Zones in the Seashore



The seashore can be divided into zones based on relationships to the ocean, particularly the tides.

The seashore's lowest zone is underwater at all times, even during low tide. This lower zone is called the sublittoral zone. It is a marine environment.

The intertidal zone (called the middle, or littoral, zone) is covered during high tide and exposed during low tide. This is the harshest of

all seashore environments, since any animal or plant that lives here must be able to tolerate being submerged for part of the day and exposed to the air and sun for the rest.

The upper zone is never underwater and may be frequently sprayed by breaking waves. It is often referred to as the splash or supralittoral zone. Conditions here are similar to other dry-land areas.

Climate

The climate of a particular seashore depends upon its location. In general, if the shoreline is part of a desert country, such as Saudi Arabia, the climate will be hot and dry. If it is part of a country in the frozen north, such as Siberia, the climate will be cold. The presence of the ocean can create some climatic differences.

The ocean absorbs and retains some of the sun's heat. In the winter, the warmer water releases heat into the colder atmosphere, helping to keep temperatures warmer inland. In summer, when the water temperature is cooler than the air temperature, winds off the ocean help cool coastal areas.

Other effects of the ocean on climate result primarily from moderating ocean currents and storms at sea.

Moderating currents

Ocean currents may be warm or cold, depending upon where they started. The presence of a current can moderate the weather along a particular coastline. For example, the North Atlantic Drift is a warm current that originates in regions farther south. As it flows around the coast of Scotland, it warms the air temperature enough that palm trees will grow there. As it travels farther north along the coast of Norway, it keeps the water above freezing so that Norway's ports are open all winter, even though they are above the Arctic Circle.

Storms at sea

Seashores are vulnerable to storms that originate at sea and produce strong winds and high waves. Hurricanes and typhoons are violent tropical storms that form over the oceans. Their wind speeds can reach 75 to 200 miles (120 to 322 kilometers) per hour. Their forceful, rotating winds cause much damage when they reach land, as do the waves that batter the shoreline.

The worst coastal weather in the world is in the North Atlantic where the climate is cooler and the force of the waves has been measured at 6,000 pounds per square foot (13,200 kilograms per square meter). Driven by gale-force winds, waves along these coastlines have been known to be very destructive.

Geography of the Seashore

The geography of the seashore is affected by the process of erosion (wearing away) and deposition (dep-oh-ZIH-shun; setting down), which helps determine the different types of surface and landforms found at the seashore.

Erosion and deposition

As waves crash against a shoreline, they compress (squeeze) the air trapped in cracks in rocks. As the waves retreat, the pressure is

suddenly released. This process of pressure and release widens the cracks and weakens the rock, causing it to eventually break apart. Some waves, especially those created by storms, are very high and forceful. In places where wave action is strong, the waves pick up particles of rock and sand and throw them against the shoreline with a crashing motion. This produces a cutting action.

Some of the chunks and particles eroded from a shoreline may then be carried out to sea by waves. The particles sink and become deposited on the ocean floor. Other particles may be carried by longshore currents farther along the coast and deposited where there is shelter from the wind, and the wave action is not as severe. Even boulders may be carried by this means.

Shoreline surfaces

Seashore surfaces are classified as rocky, sandy, or muddy, depending upon their composition (makeup).

Rocky shores may consist of vertical cliffs, sloping shores, platforms, and boulder-covered areas. Vertical cliffs have no protection from the waves. On shores covered by boulders, spaces among the stones are protected, and pools of water, called tide pools, may form in them.

Beaches along rocky shorelines usually consist of pebbles and larger stones. The waves carry away the finer particles.

Sandy shores make up about 75 percent of the world's seashores that are not ice-covered. They are constantly changing, depending upon the movement of the wind, the water, and the sand.

Some sandy shores form a steep slope down to the sea. On this type of shoreline, the waves break directly on the beach. Cycles of erosion and deposition are more extreme and have a greater effect on the shape of the shoreline. The greater the force of the waves, the steeper the slope, and the larger the sand particles.

Sandy shores that slope gently down to the sea are usually protected in some way from the full force of the water. A reef, for example, may have formed some distance from shore. As a result, the waves that reach the beach are gentle, erosion is slow, and sand particles are finer.

The texture of the sand helps determine what the beach will be like. Fine sand packs down and produces a smooth, gentle slope. Coarse sand allows the waves to sink in and move the particles around, producing a steep surface.

An estuary is where a river, traveling through lowlands, meets the ocean in a semi-enclosed channel or bay. In these gently sloping areas, river sediments (soil and silt) collect, and muddy shores form. Water in an estuary is brackish, a mixture of fresh and saltwater.

Estuaries are semi-enclosed by land, which usually protects them from the full force of ocean waves. High tide may bring in a new supply of seawater and the water becomes more salty. During low tide, fresh water from the river dominates. After a rain washes soil into the river, the water carried into the estuary may be cloudy from the added sediments.

Landforms

Landforms found at the seashore include cliffs and rock formations; beaches and dunes; deltas; spits and bars; and certain types of saltwater wetlands.

Cliffs and rock formations

High cliffs usually occur when highlands meet the sea. Pounding waves may gradually eat into the base of the cliffs, eroding the rock and creating a hollowed-out notch. Eventually, the overhang collapses and falls onto the beach, creating a platform of rock and soil.

Many coastlines consist of both hard and soft rock. Wave action erodes the soft rock first, sometimes sculpting strange and beautiful shapes, such as arches. Caves may be carved into the sides of cliffs, or headlands may be created. A headland is a large arm of land made of hard rock that juts out from the beach into the ocean after softer rock has been cut away.

Beaches and dunes

Beaches are almost-level stretches of land along the water's edge. They may be covered by sand or stones. Sand is small particles of rock less than 0.08 inch (2 millimeters) in diameter. It may be white, golden, brown, or black, depending upon the color of the original rock. Yellow sand usually comes from quartz and black sand from volcanic rock. White or pink sand may have been formed from limestone, seashells, or coral particles.

Sand is carried not only by water but also by wind. When enough sand has been heaped up to create a ridge or hill, it is called a dune. Dunes range from 15 to 40 feet (4.6 to 12.2 meters) in height, and a few may become 75 feet (23 meters) tall. Individual dunes often travel, as the wind changes their position and shape. They tend to shift less if grasses take root in them and help hold them in place.

Deltas

In estuaries, where rivers meet the sea, huge amounts of silt (very small particles of soil) carried from far inland by the river are deposited in the ocean along the shoreline. Large rivers can dump so much silt that islands of mud build up, forming a fan-shaped area called a delta. In regions where Earth's crust is thin, the weight of these sediments may cause the shoreline to sink. Huge deltas have formed at the mouths (where a river empties into a larger river or ocean) of the Mississippi River in the United States and the Nile River in Egypt.

Spits and bars

A spit is a long, narrow point of deposited sand, mud, or gravel that extends into the ocean. In an estuary, a spit may reach up into the river's mouth.

A bar is an underwater ridge of sand or gravel formed by tides or currents that extends across the mouth of a bay (an area of the ocean partly enclosed by land). If the bar closes off the bay completely, the water trapped behind the bar is called a lagoon. A tombolo is a bar that forms between the beach and an island, linking them together.

Saltwater wetlands

Saltwater wetlands are portions of land covered or soaked by ocean water often and long enough to support plants adapted for life under those conditions.

A swamp is a type of wetland dominated by trees. A saltwater swamp is formed by the movement of the ocean tides. When the tide is low, flat places in the swamp are not under water.

Marshes are wetlands dominated by nonwoody plants such as grasses, reeds, rushes, and sedges. Saltwater marshes are found in low, flat, poorly drained coastal areas. They are especially common in deltas, along low-lying seacoasts, and in estuaries. Saltwater marshes are greatly affected by the tides, which raise or lower the water level on a daily basis. A saltwater marsh may have tidal creeks, tidal pools, and mud flats.

Plant Life

Seashore plants include many kinds of seagrasses and some species of trees. The types of plants that grow in a particular region are determined by climate and the kind of shoreline surface--rocky, sandy, or muddy. Some sandy or muddy shores do not support plants because the soil is frequently disturbed.

Plants that live in the lower (sublittoral) zone along the seashore are always surrounded by water. Most have not developed the special tissues and organs for conserving water that are needed by plants on land. The surrounding water offers support to these plants, helping to hold them upright. Their stems are soft and flexible, allowing them to move with the currents without breaking.

Plants that live in the intertidal (littoral) zone are very hardy because they are exposed to the air for part of the day and are underwater for part of the day. Plants in the upper (supralittoral), or splash, zone have adapted to life on land. However, they must be tolerant of salty conditions.

Algae, fungi, and lichens

Most marine plants are algae, and many algae are green plants. However, it is generally recognized that algae do not fit neatly into the plant category. Most algae have the ability to make their own food by means of photosynthesis (foh-toh-SIHN-thih-sihs), the process by which plants use the energy from sunlight to change water and carbon dioxide into the sugars and starches they use for

food. Algae require other nutrients they obtain from the water. In certain regions, upwelling of deep ocean waters during different seasons brings more of these nutrients to the surface. This results in sudden increases in the numbers of algae. Increases also occur when nutrients are added to a body of water by sewage, or by runoffs from fertilized farmland.

Some forms of algae, called phytoplankton (fy-toh-PLANK-tuhn), are so tiny they cannot be seen without the help of a microscope. They float freely in the water, allowing it to carry them from place to place. Other larger species, often referred to as seaweeds, may be anchored to the seafloor.

Fungi (FUHN-ji) cannot make their own food by means of photosynthesis. Some, like molds, obtain nutrients from dead or decaying organic matter. They assist in the decomposition (breaking down) of this matter and release many nutrients needed by other plants. Others are parasites and attach themselves to, and feed on, other living organisms.

Lichens are combinations of algae and fungi that live in cooperation; the fungi surround the algal cells, and the algae obtain food for themselves and the fungi by means of photosynthesis. Lichens prefer the upper zones of the seashore, surviving dryness by soaking up water during high tide.

Common algae

Two types of algae commonly found along the seashore include phytoplankton and seaweeds. Diatoms and dinoflagellates (DI-noh-FLAJ-uh-lates) are the most common types of phytoplankton.

Seaweeds are forms of green, brown, and red algae that grow primarily along rocky seashores. Green algae prefer the upper zone where they are exposed to sunlight and fresh water from rain. Brown algae prefer the middle zone and shallow water. They absorb sunlight readily and are tough enough to endure the action of waves and tides. Red algae live in tide pools or offshore waters, as do the large forms of brown algae, called kelps.

Seaweeds are different from land plants in that they do not produce flowers, seeds, or fruits. They lack root systems because they do not need roots to draw water from the soil. Instead, they have rootlike holdfasts that anchor them to rocks. They are seldom found on sandy shorelines because there are no rocks for anchorage.

The type of shoreline determines the species of seaweeds that will grow there. Different species prefer different zones along the same shoreline. Some are better adapted to dry conditions than others. Some species, for example, have a thick layer of slime that prevents water loss, while others have a layer of tissue that retains water.

Growing season

Algae contain chlorophyll, a green pigment used to turn energy from the Sun into food. As long as light is available, algae can grow. In some species, the green color of the chlorophyll is masked by orange-colored compounds, giving the algae a red or brown color.

The growth of ocean plants is often seasonal. In northern regions, the most growth occurs during the summer. In temperate (moderate) zones, growth peaks in the spring but continues throughout the summer. In regions near the equator, growth is steady throughout the year.

Reproduction

Algae may reproduce in one of three ways. Some split into two or more parts; each part becoming a new, separate plant. Others form spores (single cells that have the ability to grow into a new organism). A few reproduce sexually, during which cells from two different plants unite to form a new plant.

Fungi and lichens usually reproduce by means of spores. Lichens can reproduce when soredia (algal cells surrounded by a few strands of fungus) break off and form new lichens wherever they land.

Green plants

Green plants have roots, stems, leaves, and often flowers. Most green plants need several basic things to grow: light, air, water, warmth, and nutrients. Like algae, green plants depend upon photosynthesis for food. The nutrients, primarily nitrogen, phosphorus, and potassium, are obtained from the soil. These minerals may not be in large supply. In some seashores along dry, desert coasts, plants have evolved that can absorb mist from the nearby ocean through their leaves. The mist provides enough water for them to survive.

Green plants grow in all seashore zones. Those that grow in the lower zone are sea plants, and those that grow in the upper zone are land plants.

Common green plants

Green plants found along the seashore include seagrasses, such as eelgrass, turtlegrass, and paddleweed. These plants live in the lower zone but are similar to land grasses. They have roots, and they bloom underwater. Beds of seagrass occur in sandy or muddy shores in calm areas protected from currents, such as in lagoons or behind reefs. They attract a wide variety of grazing marine animals. These grasses help slow the movement of the water and prevent erosion of the shoreline.

The high salt content of the seawater in the intertidal zone makes it hard for land plants to adapt. Grasses such as marsh grass, cord grass, and salt hay grass thrive here. In salt marshes, glasswort and sea lavender are found.

Sand dunes are too dry to support much plant life, but there are many species of plants that grow on dunes. These include sandwort, beach pea, marram grass, yellow horn poppy, beach morning glory, and sea oats. Sea oats grow a long taproot (main root) that may extend more than 6 feet (1.8 meters) into the sand to reach water. Dunes may support trees, such as pine and fir, if the soil is stable and freshwater is available.

Mangrove trees grow in estuaries in tropical zones where the shoreline is muddy. Some are small, shrublike plants; others are tall and produce large forests. Mangroves have two root systems. One is used to anchor them in the muddy bottom. The other is exposed to the air from which it pulls oxygen because the soil in mangrove swamps is usually low in oxygen.

Growing season

The growing season depends upon where the seashore is located. Near the equator, growth continues throughout the year. In northern regions, there is a spurt of growth during the summer. In moderate climates, growth begins in the spring and continues throughout the summer.

Reproduction

Green plants often depend upon the wind and insects to carry pollen from the male part of a flower, called a stamen, to the female part of a flower, called a pistil, for reproduction. This process is called pollination. Others send out stems from which new plants sprout.

Endangered species

Coastlines are popular places for people to live, but plants can suffer when their natural habitat is disturbed. Algae and seagrasses can be destroyed by polluted water. Dune grasses are easily trampled by beachgoers or destroyed by dune buggies and other off-road vehicles. When visitors pick flowering plants, they limit the plants' ability to reproduce. Many mangrove forests are being reduced due to erosion of the deltas.

Animal Life

The kinds of animals that live along a particular shoreline are determined by zone (upper, intertidal, or lower) and the type of surface (rocky, sandy, or muddy). This is true of different species of the same animal. Hermit crabs, for example, live comfortably in the lower and intertidal zones of rocky shores, whereas mudcrabs prefer muddy estuaries.

Lower zone animals, including sea anemones, shrimp, and small fish, are underwater almost all of the time. Upper zone animals, such as ghost crabs, prefer dry conditions and live on land. The middle, or intertidal, zone along rocky shores supports the most life-forms, in spite of its being the harshest zone of all. Cockles, barnacles, clams, sea urchins, and fish are all found in this zone. Some, such as clams, survive during low tide when they are exposed to air by closing their shells to keep from drying out. Their shells also help them survive battering by the waves. Others find shelter in small pools where water collects in depressions and among rocks when the tide goes out, remaining there until high tide returns.

On depositional (sandy or muddy) shores, animals are constantly shifted around by the motion of water because there is nothing on which to anchor themselves. Many burrowing animals, such as clams and lungworms, survive by digging into the sand. They often have siphons (tubes) through which they can draw in oxygenated water and food.

Life on eroding shores is even harder; animals must attach themselves firmly to rocks or be washed away by the battering waves. The crevices of the rocks are homes to soft-bodied animals such as sea anemones. Dark caves found on many rocky shorelines provide a place where many sea creatures may take shelter.

Microorganisms

Seashores are home to many kinds of microscopic animals. Most microorganisms are zooplankton (tiny animals that drift with the current) that live on the surface of the sea. They include protozoa, nematodes (worms), and the larvae or hatchlings of animals that will grow much larger in their adult form. Some zooplankton eat phytoplankton and, in turn, are preyed upon by other carnivorous (meat-eating) zooplankton.

Bacteria

Bacteria are found in every zone along the shore and provide food for microscopic animal forms. They also help decay the dead bodies of larger organisms.

Much of the water that washes up on a beach sinks downward again and the sand or gravel acts as a filter. Particles of matter suspended in the water become trapped between the grains of sand. These particles become food for the bacteria that consume them and then release other nutrients into the water.

Invertebrates

Animals without backbones are called invertebrates. Many species are found along the seashore. Crustaceans and mollusks, invertebrates that usually have hard outer shells, are well adapted to the intertidal zone because their shells help prevent them from drying out during low tide. Soft-bodied animals, such as sea anemones and small octopi, prefer rocky shores where they can hide in rock crevices and survive low tide in rock pools.

Sand dunes are home to many insects, such as wasps, ants, grasshoppers, and beetles. Some insects and spiders burrow into the sand during the heat of the day and hunt for food at night.

Common seashore invertebrates

Tiny crustaceans called sand hoppers, or beach fleas, live on sandy beaches where they can hop several feet (1 meter) in one jump even though they are only 0.6 inch (1.5 centimeters) long. They are not real fleas and do not bite humans or other animals but live on seaweed and dead matter.

On rocky shores, many species of periwinkles are common. Periwinkles are snails that come in several colors, including brown, yellow, and blue. They eat algae and can live many days without water. A periwinkle has a hinged door in its shell that it can shut, keeping moisture locked inside.

On muddy shores, mangrove forests are often homes for oysters and barnacles, which attach themselves to the trunks and roots of

trees. Snails and crabs are common in saltwater marshes.

Food

Invertebrates may eat phytoplankton, zooplankton, or both. Mollusks draw seawater in through their siphons and filter out the tiny creatures, which they then consume. Some invertebrates eat plants or larger animals. Starfish, for example, dine on mollusks.

Reproduction

Most invertebrates are insects, which have a four-part life cycle. The first stage is spent as an egg. The second stage is the larva. It may be divided into several stages between which there is a shedding of the outer skin casing. A caterpillar is an example of an invertebrate in the larval stage. The third stage is the pupal stage, during which the insect lives in yet another protective casing, like a cocoon. Finally, the adult breaks through the casing and emerges. In most cases, the young are not cared for by the parents. Survival often depends on the absence of predators.

Reptiles

Reptiles, such as lizards and snakes, are cold-blooded vertebrates. Only one species of lizard, the marine iguana, lives both in the sea and on the seashore. Pine lizards may be found in dry areas on sandy beaches where pitch pines grow. Some species of snakes, such as the hognose snake, live among sand dunes on sandy shorelines, preferring the dry conditions found there. Fowler's toads can be found on upper beaches. A saltwater crocodile makes its home in the waters of Southeast Asia, where it lives along muddy seashores near the mouths of rivers. A notable reptile at the seashore is the sea turtle.

Common seashore reptiles

Sea turtles can be distinguished from land turtles by their flippers, which enable them to swim, and by their tolerance for salt water. Green sea turtles are migrators, traveling as far as 1,300 miles (2,094 kilometers) to return to a particular breeding area where they lay their eggs.

The saltwater, or estuarine, crocodile lives in northern Australia and in the region stretching from the east coast of India to the Philippines. It is one of the largest species of crocodiles; average males grow 17 feet (5 meters) long. Most crocodiles float on the surface of the water close to the shoreline where they wait for prey to wander past. The saltwater crocodile is also known to swim out to sea.

Food

Turtles eat soft plants, as well as small invertebrates such as snails and worms. Turtles have no teeth. Instead, they use the sharp, horny edges of their jaws to shred the food enough so they can swallow it.

Sand dune snakes are carnivorous and catch mice and other small prey. They also eat the eggs of nesting shorebirds. Saltwater crocodiles are carnivorous and feed primarily on fish and turtles. They have been known to attack and eat humans.

Reproduction

Both snakes and turtles lay eggs. Turtles lay theirs in holes on a sandy shore, which they then cover over with sand. After the nest is

finished, the female abandons it, taking no interest in her offspring. Six weeks later the eggs hatch and the young turtles make a run for the ocean and swim away.

Fish

Fish are primarily cold-blooded vertebrates (dependent on the environment for warmth) having gills and fins. Gills are used to draw in water from which oxygen is extracted. Fins are used to help propel the fish through the water.

Most fish found along the seashore are smaller varieties that can live in shallow water or in tide pools. They are dull in color to match the sand or gravel background. Some have suckers (suction cups) on their undersides that allow them to cling to rocks so they will not be washed away. The exception is the flounder, which can grow to be quite large and spends its entire life in the shallow pools of water on the beach.

Common seashore fish

Flatfish live in shallow water on sandy shorelines. They begin life looking like other fish; however, as they mature, they lie on one side and become flattened. The eye on the bottom side migrates to the top until both eyes are looking upward.

Mudskippers are small amphibious (am-FIB-ee-yuhs) fish that live along muddy shores, especially near mangrove forests. Amphibious means that they can live either on land or in water. When the tide is in, mudskippers swim and breathe underwater. When the tide is out, they breathe air and use their fins to hop among the tree roots.

Other shoreline fish include spiny dogfish, which are a species of shark, common anchovies, killifish, northern pipefish, bluefish, northern barracuda, striped bass, cowfish, four-eyed butterfly fish, northern sea robins, barred sea perch, and kelp greenlings.

Food

Some fish, such as the clingfish of Chile, attach themselves with suckers to rocks and scrape off any animals or plants on which they feed before letting the waves carry them back out to sea. Predatory fish, such as some sculpin species, may lie in wait in rock pools until the tide brings in their prey. Most shoreline fish are slow swimmers that feed on other slow-moving creatures, such as shrimp.

Reproduction

Fish reproduce by laying eggs. Some build nests and care for the new offspring, while others carry the eggs with them until they hatch, usually in a special body cavity or in their mouths. For example, female seahorses lay their eggs in a pouch on the underside of the male, who then carries the eggs until they hatch.

Some fish, such as the Atlantic menhaden, live in deep waters for most of the year. During breeding season, they appear in large numbers in shallower shoreline waters where they lay their eggs.

Birds

Birds are vertebrates. Most seabirds remain near land where they can nest during breeding season. Many have adapted to marine environments by means of webbed feet for swimming and special glands for removing excess salt from their blood.

Shorebirds, such as oystercatchers and gulls, feed or nest along the coast and prefer hunting in shallow water. Their feet are usually webbed and most migrate. Lesser golden plovers, for example, spend their winters in South America and their summers in the Arctic. During their travels, they may stop to rest on the eastern coast of the United States.

Wading birds, such as the American avocet, are often found along muddy shores. They have long legs, wide feet, long necks, and long bills that are useful for nabbing fish and other food.

Waterfowl are birds that spend most of their time on water, such as ducks. Their legs are positioned closer to the rear of their bodies, which is good for swimming, but awkward for walking. As a result, they waddle as they walk. Their bills are designed for grabbing vegetation, such as grasses, on which they feed.

Farther inland, common land birds, such as red-winged blackbirds, may live among dune grasses where they hunt for insects.

Food

All birds that live along the seashore are carnivorous. Most eat fish, squid, or zooplankton, and they live where food is plentiful. Several species, such as eiders, dive to the bottom of shallow water where they feed on shrimp, worms, or crabs. Other species, such as sanderlings, dash into the water as waves retreat in order to grab prey before it has a chance to get away. Some, like gulls, are scavengers that eat dead matter other creatures have discarded.

Reproduction

Sea and shorebirds usually nest on land. Some nest in huge colonies on the ground, others dig burrows, and still others, like the kittiwakes, prefer ledges on a cliff. Like ordinary land birds, they lay eggs and remain with the nest until the young are able to survive on their own. Some live and feed in one area and migrate to another for breeding. Birds that nest on sandy shores tend to lay speckled or blotchy eggs in beige and brown colors that blend in with the sand and pebbles in order to protect the eggs from predators.

Common seashore birds

Birds that live along the seashore include gulls, plovers, pelicans, boobies, puffins, ruddy turnstones, sandpipers, sanderlings, and penguins. There are only a few true sea ducks, including the eider and the scoters.

Mammals

Mammals are warm-blooded vertebrates that have at least some hair and bear live young nursed with the mother's milk. Few mammals live permanently along the seashore. Those that do, such as mice, are small and prefer dry areas out of reach of the tide. Many land mammals, such as skunks, rats, foxes and raccoons, may visit the shoreline at night in search of food. They prefer low tide, when mussels, oysters, worms, and tide pool animals are exposed and easy to find.

Food

Many mammals are carnivorous. Raccoons, for example, hunt crabs, shrimp, and turtle eggs. Sea otters eat mussels and other invertebrates, using rocks and other "tools" to break the shells. Some mammals, such as mice, are omnivorous, which means they eat both plants and animals, such as insects. Herbivores, like rabbits, eat only plants.

Reproduction

Mammals bear live young. Most have only one offspring at a time, but rodents, such as mice, have large families. The young are nursed with milk produced by the mother until they are able to find food on their own. This is true whether the mammal spends some of its time in the water or all of its time on shore.

Common seashore mammals

Sandy beaches are home to cottontail rabbits, voles, and mice. Rocky shores in some regions provide breeding and socializing areas for seals and walruses. Sea otters are found along rocky coastlines. Muskrats are common along muddy shores that have marshy areas.

Endangered species

All species of sea turtles are endangered. Sea turtles lay their eggs on beaches which make the eggs easily hunted and/or destroyed. The eggs are a popular food in many parts of the world, as are the turtles themselves. Turtles are also threatened by pollution, which can destroy their food supply.

In certain areas, other animals are endangered, including the starlet sea anemone, the osprey, the Eskimo curlew, the Dalmatian

pelican, and the West Indian manatee.

Human Life

In times past, the oceans were the only transportation route between the eastern and western hemispheres. The oceans have always been important for fish and other food resources. For these reasons, people have usually lived within an easy distance of the seashore. More than one third of the world's population still lives in or around cities located on the coast. By 2025, it is expected that two out of three people will live within 62 miles (100 kilometers) of a seashore.

Impact of the seashore on human life

People have always lived along the seashore, so it has had an important effect on human life.

Food

Various species of seaweed are used by people as food and in food preparations. Humans eat many of the animals found along shorelines, including crabs, mussels, clams, oysters, shrimp, fish, turtles, and turtle eggs. Anchovies, tiny fish that live in shallow coastal waters, are one of the most important commercial fishes.

Fish farming, the raising of fish for commercial purposes, is an important industry of the coastlines.

Harbors

Many of the world's great cities, such as New York, San Francisco, Hong Kong, Tokyo, and London, are harbor cities. From these harbors, millions of tons of goods are shipped around the world, which has an important effect on the world economy. Many factories are built near harbors in order to keep transportation costs low. Passenger ships and ferries use these harbors to carry people from place to place.

Energy

The ocean is a source of energy. The energy in the tides, for example, can be harnessed to produce electrical power. The first tidal power station was developed in an estuary in France in 1966. Turbines (engines with fanlike blades) are built into a dam that spans the estuary. As the tides flow in and out of the estuary, they turn the turbine blades. Plans have been made to build a similar station on the estuary of the Severn River in England.

Other types of power stations may be located by the sea because seawater is used to cool the machinery.

Minerals and metals

Minerals and metals are other important resources of coastlines. Rocks, sand, and gravel dredged from the sea bottom, especially off the coasts of England and Japan, are used in the construction of roads and buildings. Along the Namibian coast of southwest Africa, diamonds are mined.

Recreation

Beaches, sandy beaches in particular, attract millions of visitors each year. Huge hotels, resorts, and amusement parks have been built along coastlines where people can enjoy sailing, swimming, fishing, walking, camping, and lying in the sun.

Impact of Human Life on the Seashore

While the benefits that coastlines have brought to human life are many, human life has brought many impacts to the seashores.

Use of plants and animals

After World War II (1939-45), the technology of commercial fishing improved and a growing population increased the demand for fish as a food source. By the 1970s, major food species, including anchovies and certain shellfish, had been greatly reduced.

Fish farms have helped maintain certain species of commercially popular fish. Shellfish, such as oysters, mussels, scallops, and clams, are the most commonly farmed. Crabs, lobsters, shrimp, salmon, trout, and tilapia are farm raised, but to a lesser extent. The output of fish farms (aquaculture) from 1990 to 2002 increased at a rate of 10 percent per year, producing 38,000,000 tons (34,473,020 metric tons) in 2002.

Other sea plants and animals have been taken as souvenirs or art objects, reducing their numbers. When seashells are taken from dead animals, no harm is usually done. However, many shells available commercially are taken from living animals and the animals are left to die.

Preventing natural changes

Homes and other structures built along coastlines are threatened when storms, erosion, and other natural processes change the

seashore. Sometimes, people try to work against nature by building walls and other barriers to protect these structures. Often, these efforts make the problems worse. As the natural shape of a shoreline is changed, waves may become stronger and do even more damage.

Changes made by humans to protect one shoreline may cause unexpected, undesirable changes in another. Walls built to prevent the sand from being washed away from beaches at Ocean City, Maryland, for example, kept that sand from naturally rebuilding the beaches on Assateague Island to the south. The erosion rate averages 10 feet (3 meters) per year since the walls were built. So far about 9 miles (15 kilometers) of the inlet have been affected.

Overdevelopment

Use of the land for harbors, recreation, and housing has changed the appearance of many shorelines. The popularity of beaches has caused many to become crowded with so many people and buildings that wildlife has either been destroyed or frightened away. In many places, the coastline has lost its natural beauty and has become just another part of a big city.

Dune buggies, dirt bikes, and other recreational vehicles destroy plants and scare animals. Hikers can destroy vegetation, and even well-meaning people who wish only to observe nature can frighten animals or upset the natural rhythms of their lives.

Quality of the environment

In 2006, there were 25,643 occasions when beaches were closed and swim advisories were in effect in the United States because the water was polluted. Most ocean pollution caused by humans is concentrated along the seashore. Sewage and industrial wastes are dumped from coastal cities, adding metals and chemicals to the water. Discarded items, such as plastic bags and food wrappers, pose health hazards for both animals and people.

Insecticides (insect poisons) and herbicides (weed poisons) reach the oceans when the rain washes them from fields and they are carried by rivers to the sea. These poisons often enter the food chain and become concentrated in the bodies of some organisms. Fertilizers and human sewage are also a problem. They cause phytoplankton to reproduce rapidly. When the plants die, their decaying bodies feed bacteria. The bacteria reproduce and use up the oxygen in the water, and other organisms, such as fish, soon die.

Industrial accidents and waste are other problems. It is estimated that 1,435 people died and thousands were paralyzed when they ate fish contaminated with mercury, a metallic element used at a nearby factory at Minamata Bay in Kyushu, Japan in 1953. Oil spills from tanker ships are another danger, as is oil from oil refineries, pipelines, and offshore oil wells. Power plants and some industries often dump warm water into the oceans, causing thermal (heat) pollution. Organisms that require cooler water are killed by the increase in the water temperature.

Agriculture, construction, and the removal of trees digs up the soil. The rain then washes the soil into streams and rivers. Eventually, it enters the ocean to collect as sediment in coastal areas. Some organisms that cannot survive in heavy sediment, such as clams, die. Organisms that inhabited preagricultural, preconstruction, and forested areas also die.

Pollution can travel, so that problems caused by one country may damage the shoreline environment in another.

Native peoples

In most parts of the world, people often settled near coastlines where fish were plentiful and the ocean offered a means of transportation. Since the mid-twentieth century, desirable seashore locations have been taken over by tourists and non-native residents. Few native peoples have continued to live traditional lifestyles. Many have gone to live in cities or adopted more contemporary ways of life. Among those that have tried to maintain important elements of their traditional cultures are the Samoans and Native American tribes of the northwest coast.

Samoans

The Samoa Islands lie in the Pacific Ocean southwest of Hawaii. The largest island, Savai'i, has an area of only 659 square miles (1,707 square kilometers), so the seashore is easily accessible and an important part of everyone's life.

The people of Samoa are Polynesian and closely related to the native people of Hawaii and New Zealand. Although the islands have felt the influence of Europe and then America since 1722, traditional Samoan culture has remained very important.

The Samoan economy is based on agriculture. Crops include corn, beans, watermelons, bananas, and pineapples. Fish have always been an important food source for local families, but fishing was not commercially important until 1953 when a tuna cannery was built in the town of Pago Pago.

Native Americans of the Northwest Coast

The Columbia and Fraser Rivers in North America open into the Pacific Ocean, and each year millions of Pacific salmon return to those rivers to breed. This ample supply of fish led many native peoples to settle there, including the Tlingit, Haida, Tsimshian, Kwakiutl, Nootka, and Salish. The area proved rich in other wildlife as well. Mussels, clams, oysters, candlefish, herring, halibut, and sea lions were available from the sea. The land provided food, such as moose, mountain sheep and goats, deer, and many small animals, as well as roots and berries.

Products of the seashore, such as shells, dried fish, fish oil, and the dugout canoes built for transportation were considered a source of wealth. Religious beliefs were based on mythical ancestors whose images were carved on totem poles, boats, masks, and houses.

By 1900, traditional ways of life were disappearing, but the people remained on or near their ancient lands. Many now work in forestry. Some groups are restoring native customs, and there is interest in a return to arts-and-crafts production.

The Food Web

The transfer of energy from organism to organism forms a series called a food chain. All the possible feeding relationships that exist in a biome make up its food web. Along the seashore, as elsewhere, the food web consists of producers, consumers, and decomposers. These three types of organisms transfer energy within the seashore environment.

Phytoplankton are among the primary producers along the lower zone of the seashore. They produce organic (derived from living organisms) materials from inorganic chemicals and outside sources of energy, primarily the Sun. Other primary producers include seagrasses and plants that live in the upper zone.

Zooplankton and other animals are consumers. Animals that eat only plants are primary consumers. Secondary consumers eat the plant-eaters. They include zooplankton that eat other zooplankton. Tertiary consumers are the predators, like starfish and mice that eat the second-order consumers. Some, such as mice and humans, are omnivores, organisms that eat both plants and animals.

Decomposers feed on dead organic matter and include some insects and species of crabs. Bacteria also help in decomposition.

A serious threat to the seashore food web is the concentration of pollutants and dangerous organisms that become trapped in sediments where organisms lower on the food chain feed. These life-forms become food for consumers higher on the food chain, and at each step in the food chain the pollutant becomes more concentrated. Finally, when humans eat contaminated sea animals, they are in danger of serious illness. The same process is true of diseases such as cholera, hepatitis, and typhoid, which can survive and accumulate in certain sea animals, and are then passed on to people who eat those animals.

Spotlight on Seashores

Point Reyes National Seashore

Point Reyes National Seashore is part of a large peninsula (arm of land) extending off California into the Pacific Ocean. Its broad beaches are backed by tall cliffs and forested hills and valleys.

Point Reyes National Seashore

Location: Pacific coast of California, north of San Francisco

Area: 64,546 acres (25,818 hectares)

The shoreline along the California coast was carved by volcanoes and earthquakes, and earthquakes are still common. During the 1906 earthquake that struck San Francisco, the Point Reyes peninsula moved more than 16 feet (5 meters) to the northwest. Shifting sands, islands, and steep underwater cliffs are all found in the region.

Wave action is strong and has carved the offshore rocks into rugged shapes. Rip currents and a pounding surf make swimming dangerous in some places. In sheltered areas, quiet bays and lagoons have formed, which are enclosed by sand dunes and grass-covered lowlands.

Sea stars, horseshoe crabs, and other invertebrates live along the shore, and Point Reyes is popular with seabirds, sea otters, and sea lions. Migrating gray whales can often be seen passing in the distance.

Padre Island National Seashore

Padre Island National Seashore is located on a barrier island that stretches about 110 miles (177 kilometers) along the coast of Texas in the Gulf of Mexico. Padre Island borders the Laguna Madre, a shallow lagoon. The park consists of sandy beaches and dunes as high as 40 feet (12 meters).

Padre Island National Seashore

Location: Coast of Texas, along the Gulf of Mexico

Area: 133,918 acres (53,567 hectares)

Many waterfowl winter on the island. Other birds include herons, terns, egrets, brown pelicans, and white pelicans. Since the mid-1980s, scientists have been bringing eggs from endangered sea turtles here to help rebuild the population.

The island is uninhabited by people and is the largest undeveloped beach remaining in the United States (exclusive of Alaska and Hawaii).

Virgin Islands National Park

Virgin Islands National Park occupies about over 7,000 acres (2,833 hectares) of St. John, the smallest of the three main Virgin Islands, and takes in many tiny islands offshore. Many caves and grottoes are found along the shoreline.

Virgin Islands National Park

Location: Caribbean Sea, east of Puerto Rico

Area: 7,000 acres (2,833 hectares)

The park's white sandy beaches are backed by steep mountains and valleys covered with tropical forests. The highest point of land is Bordeaux Peak at 1,277 feet (389 meters). Mangrove forests grow along the shore, while a number of coral reefs support tropical fish and other marine creatures such as sea urchins offshore. The only native mammals living within the park are bats.

Pre-Columbian Indians once lived here, and relics of their culture can be found. For two centuries, the islands were a base for pirates, and some people believe that buried treasure may still be hidden in the region.

Acadia National Park

Acadia National Park in Maine includes parts of Mt. Desert Island, Isle au Haut, Schoodic Peninsula, and several smaller islands. It is a rugged, rocky shoreline backed by mountains. Coniferous forests grow close to the water. Mt. Desert Island features Cadillac Mountain, which is 1,530 feet (466 meters) high.

Acadia National Park

Location: Atlantic coast of Maine

Area: 41,634 acres (16,653 hectares)

More than 10,000 years ago, the shoreline was much further out than it is now. For that reason, the region is often called the drowned coast. Its cliffs were once inland mountains, and the park includes a fjord called Somes Sound. Some areas show the rubble left by glaciers.

Wave action of the North Atlantic is strong here, and huge blocks of granite have been dislodged from the cliffs and lie along the shore. Anemone Cave, a large cavern 89 feet (27 meters) deep, has been carved into the solid rock by wave action. In sheltered areas, small bays and coves have formed.

The intertidal zone has many tide pools and is home to a host of creatures, including sea stars, periwinkles, anemones, sea urchins, and crabs. Seabirds, such as gulls, guillemots, and ducks are common.

Cape Hatteras National Seashore

Cape Hatteras National Seashore in North Carolina is a chain of low, narrow, barrier islands, including Bodie, Hatteras, and Ocracoke. At some points the islands are as much as 30 miles (48 kilometers) off the North Carolina coast. The seashore area has 70 miles (110 kilometers) of beaches, dunes, and salt marshes and is a wildlife refuge.

Cape Hatteras National Seashore

Location: Atlantic coast of North Carolina

Area: 30,350 acres (12,282 hectares)

Cape Hatteras National Seashore is known for severe storms. Off the Cape, which is a promontory (arm of land) on Hatteras Island, cold northern currents meet the warmer Gulf Stream as it moves through the Atlantic. Their collision breeds stormy conditions. Diamond Shoals, a region of shallow water, has been called the "graveyard of the Atlantic" because so many ships have been wrecked there. Their remains are still visible from the shore.

The Cape has had a lighthouse since 1803. The present lighthouse, which is the tallest in the continental United States at 191 feet

(58 meters), has been in operation since 1870. Years of severe weather, including hurricanes, threatened to destroy it and it was finally moved inland.

Rhine River Delta

The Rhine River Delta in the Netherlands is a vast area connecting the Rhine River with the North Sea. Centuries ago, it was marshy and dotted with small islands. Storms often swept in from the North Sea, and the land was frequently flooded.

Rhine River Delta

Location: North Atlantic coast of the Netherlands

Area: Approximately 900 square miles (2,340 square kilometers)

Drawn by the plentiful supply of fish, the Dutch began living on the islands in the Rhine River Delta around 450 BC. They built hills of earth on which to live during flood times. In the twelfth century, special walls called dikes were constructed to keep out the sea. Later, Dutch soldiers fighting in Middle Eastern lands learned a trick from the Arabs who used windmills to pump water for growing crops. The Dutch figured the same process could be used in reverse to drain the land. Soon, the Dutch had built dikes around the marshy areas and used windmills to pump the water out into the ocean. By the 1700s, the Netherlands had 10,000 windmills. In later years, steam-driven pumps replaced the windmills, which have become a symbol of the Netherlands and are popular among tourists.

In 1919, work began to reclaim a freshwater lake, called the Zuider Zee, that had been invaded by the sea. A dam was completed in 1932 that allowed the seawater to drain, reclaiming 407,724 acres (165,000 hectares) of land. By 1937, the lake was fresh again and was renamed Ijsselmeer.

A winter storm in 1953 hit and destroyed many dikes along the coast, killing hundreds of people when the land was flooded. The Dutch built more dams across the delta to prevent such an accident from repeating. The project was finished in 1986, closing all the estuaries in the area except two that are used for shipping. Protected by dikes, dams, and pumps, the Rhine Delta's fertile soil is now valuable farmland. About 25 percent of the Netherlands is below sea level during high tide. The lowest spot, 22 feet (6.7 meters) below sea level, lies to the northeast of Rotterdam.

Fjords of Western Norway

Usually found in northern regions along mountainous coasts, fjords are valleys eroded by glaciers. When the glaciers retreated or melted, the ocean poured in, creating long, narrow, deep arms of water that project inland. The fjords of western Norway have high, steep walls; often rising to 3,280 feet (1,000 meters). The crowns of these surrounding cliffs may be heavily forested. Cascading waterfalls sometimes drop from great heights, adding to the spectacular scenery.

Fjords of Western Norway

Location: North Atlantic coast of Norway

Individual Length: As much as 114 miles (182 kilometers)

The depth of the fjords depends upon how much erosion took place below sea level. The deepest along western Norway is the Sognefjord at 4,291 feet (1,304 meters). Inland, some fjords end in glaciers, from which huge chunks of ice break off creating icebergs.

Fjords are not always penetrated by cold ocean water and are usually ice free in the winter, except along the coast where the water may be more shallow and freezes more rapidly. Gales (high winds) are frequent on the western coast.

Inland fjord valleys are rich in vegetation, especially coniferous trees, lowland birches, and aspens. The coast attracts large numbers of food fishes, such as cod, herring, mackerel, and sprat. Woodcocks and migratory birds, as well as lemmings, hares, red foxes, and reindeer, are common.

Words to Know

Estuary
: The place where a river traveling through lowlands meets the ocean in a semi-enclosed area.

Intertidal zone
: The seashore zone covered with water during high tide and dry during low tide; also called the mitermle, or the littoral, zone.

Littoral zone
: The area along the shoreline that is exposed to the air during low tide; also called intertidal zone.

Longshore currents
: Currents that move along a shoreline.

Neap tides
: High tides that are lower and low tides that are higher than normal when the Earth, sun, and moon form a right angle.

Rip currents
: Strong, dangerous currents caused when normal currents moving toward shore are deflected away from it through a narrow

channel; also called riptides.

Spring tides
High tides that are higher and low tides that are lower than normal because the Earth, sun, and moon are in line with one another.

Sublittoral zone
The seashore's lower zone, which is underwater at all times, even during low tide.

Submergent plant
A plant that grows entirely beneath the water.

Supralittoral zone
The seashore's upper zone, which is never underwater, although it may be frequently sprayed by breaking waves; also called the splash zone.

Tidal bore
A surge of ocean water caused when ridges of sand direct the ocean's flow into a narrow river channel, sometimes as a single wave.

Tsunami
A huge wave or upwelling of water caused by undersea earthquakes that grows to great heights as it approaches shore.

Locked in the Ice

Exploration of remote areas, such as Antarctica, demanded people with courage and endurance. Ernest Shackleton (1874-1922), a British explorer, had those characteristics and made several expeditions to Antarctica in the early 1900s. His most remarkable, and almost fatal, journey was made in 1914 with twenty-seven other men on board a small ship called *The Endurance*, a name that would prove prophetic.

The Endurance became trapped in drifting ice in the Weddell Sea (part of the Antarctic Ocean) during one of the coldest winters in memory. The explorers had come prepared to spend the winter, if necessary, but the weather did not get warm enough the following spring to free the ship. The ice crushed its forward section, and the ship sank in November 1915. By then the men had begun to kill penguins and their own sled dogs for food.

They managed to save three small boats and, for seven days, used them to travel to an uninhabited island. All were starved and exhausted, but taking no time to rest on the island, Shackleton and five of the strongest men set out again in one of the boats to seek aid. They finally found it on South Georgia Island farther north. Shackleton turned around and went back to rescue the others. The first three tries were unsuccessful, but he succeeded on the fourth attempt. Everyone survived because of Shackleton's courage and endurance.

The Beaches at Normandy

Beaches have often been used by invading armies to conquer the neighboring region. During World War II (1939-45), the beaches of the province of Normandy, France, were the site of an important strike against Nazi Germany. Germany had conquered France earlier in the war and much of their power in that country was concentrated in Normandy, which bordered the English channel and was only a short distance from England, which the Nazis hoped to conquer.

On D-Day, June 6, 1944, in an effort to recapture France, the Allies (Britain, Canada, Poland, France, and the United States) struck the beaches at Normandy. The beaches, named Utah, Omaha, Gold, Sword, and Juno, stretch about 50 miles (80 kilometers) along the coast between Cherbourg and LeHavre. The slope of the beaches is gentle and a wide expanse of shore is exposed at low tide. The date for the invasion was selected based on the tides, the weather, the presence of moonlight, and other conditions.

The Germans, who expected trouble, were unaware of the exact invasion point and had fifty infantry and ten tank divisions spread out over France and neighboring countries. To distract the Germans, British-based aircraft bombed rail lines, bridges and airfields on French soil for two months before D-Day. The night before, paratroops were dropped inland to interfere with enemy communications. Naval guns pounded German gun nests on shore.

In the early daylight at low tide on June 6, in rough seas, about 5,000 Allied ships approached the Normandy coastline. The British and Canadians moved in efficiently at Gold, Juno, and Sword beaches and the Americans at Utah Beach. But at Omaha Beach, the central point of the landings, American troops encountered heavy German gunfire, and many men were killed. Within five days, sixteen Allied divisions had landed in Normandy. By August, Paris had been freed, and it was the beginning of the end of Nazi rule in Europe.

A realistic account of the Normandy invasion can be viewed in Stephen Spielberg's 1998 Academy-Award-winning film *Saving Private Ryan.*

The Silver Dragon

High tides arrive at most shorelines gradually. In locations where tapering coastlines face a large ocean, however, the volume of the tide is focused very narrowly and its force increases. When such a tide meets a river flowing into the sea, a steep wave forms, forcing itself up the river and far inland. This wave is called a tidal bore.

The world's largest tidal bore is called the Silver Dragon, and it occurs once a month where the South China Sea invades the Quiantang River of China. Reaching heights of 20 feet (6 meters) or more, the Silver Dragon rushes over an area 5 miles (8

kilometers) wide.

Other large bores occur on the Amazon River in South America, on the Petitcodiac where it meets the Bay of Fundy in Canada, on the Hooghly in India where it flows into the Bay of Bengal, and on the Severn in England.

In the Path of the Great Waves

Over 2.8 million people have been killed by tsunamis (giant waves) during the past twenty years. One in every three tsunamis occurs off the coast of Chile, and that country experiences 40 percent of all the damage caused worldwide.

In 1964, an earthquake struck Alaska, causing great damage and breaking a pipeline carrying oil. The oil caught fire. Then a tsunami three stories tall followed the quake and, picking up the burning oil, carried it overland in a tide of fire. The fires reached the railroad yards, where the steel tracks soon glowed red from the heat. When more tsunamis followed and flowed over the tracks, the sudden cooling made the tracks rise up and curl like snakes.

The Legendary Lusca

Along the shores of the Bahama Islands, in the depths of the beautiful blue waters of the Caribbean Sea, lives the legendary Lusca, a creature that is supposedly half shark and half octopus. The Lusca draws people and even boats into its lair and, afterwards, like a rather rude dinner companion, it signals its satisfaction with a sudden upwelling "burp" of water.

Although not really a sea monster, the Lusca can be a bit tricky to get to know. A Lusca is not a creature at all, but an underwater cave carved out of the limestone that lies under the Bahama Islands. As sea levels rise and fall, these caves fill with water. When rainwater mixes with the seawater, their different densities (weights) cause whirlpools. These whirlpools account for people being drawn down into the caves and for the sudden burps of water. These extreme conditions often churn up sediments, making the caves dangerous for divers who, in the resulting dimness, may not be able to find their way out again.

The Web of Life: Seashore Succession

Life exists everywhere on our planet, even in the most remote, unfriendly places. Often, one life form leads the way for others because its presence in the habitat causes changes. Soon, other life forms move in, some to eat the first inhabitants, others because the habitat is now more comfortable for them. This process of succession occurs regularly along the seashore in some surprising ways.

Suppose a new boat is tied to the end of a pier. Within minutes, life forms will have begun to build colonies on its hull. Within an hour, bacteria will attach themselves to any surface below the water line. Phytoplankton and zooplankton come next, usually within the first day. By the second or third day, hydroids and bryozoa, tiny but more complex animals, move in too. If the boat is not moved, barnacles and larger algae will have attached themselves to its hull by the end of the week and the other animals will have been greatly reduced in number. Eventually, mussels will move in, crowding everybody else out.

Bursting at the Seams

Crabs, like other crustaceans, have a hard outer shell. This shell does not grow as the crab grows. Any crab that outgrows its current shell has to get rid of it fast or feel the pinch. This shedding of the shell is called molting.

Molting is caused by hormones, chemical messengers in the crab's body that help split the shell so the crab can climb out. While it runs around shell-less, the crab is in greater danger from predators. Eventually, its skin hardens and soon it has a new, ready-made suit of armor.

Plastic is not a Nutrient

Sea turtles love to snack on jellyfish. Unfortunately, plastic bags puffed with air resemble jellyfish and a sea turtle that can not distinguish between the two, can die. Plastic bags cannot be digested and moved through the animal's body; the bags and other plastic garbage block an animal's digestive tract. Dolphins, seals, whales, and other animals are also in danger from plastics. A gallon-sized plastic milk bottle, a plastic float, a garbage bag, and other items were found wedged in the digestive tract of a dead sperm whale.

Surf's Up!

Next to swimming and sunbathing, surfing is probably the best-known beach activity. Surfing involves being carried on the sloping portion of a wave as it moves toward shore. It is especially popular along the coasts of Hawaii, California, New Zealand, Australia, South Africa, Puerto Rico, Peru, Great Britain, and Brazil, where wave conditions are the most favorable.

For body surfing, a person swims toward shore, matching the speed of a particular wave. The swimmer then stiffens the body in order to provide a flat surface that will glide on the front of the wave and carry him or her to shore. To surf using a board, the person lies on the board and paddles until the board is going as fast as the chosen wave. The person then stands up and rides the wave toward shore.

Surfboards weigh between 24 and 40 pounds (11 and 18 kilograms) and are 6 to 12 feet (1.8 to 3.7 meters) long. Surfing requires

good balance, timing, and coordination because boards can reach speeds of 35 miles (56 kilometers) per hour.

Surfing originated in Hawaii, where it was used by nobility as part of a religious ceremony. In 1920, Duke Kahanamoku of Hawaii, the Olympic swimming champion, formed the first surfing club and almost single-handedly made the sport popular.

World's Worst Oil Spill

Oil spills are especially hazardous to coastlines. The oil is carried ashore by ocean waves and tides, but when the water retreats back to the sea, the oil remains. Thick deposits stick to the shoreline and coat the plants and animals that live there. Oil mats the feathers of birds and the fur of swimming animals leaving the creatures unable to keep warm, and causing many to die of the cold.

The world's worst oil spill took place in 1989 when the ship *Exxon Valdez* was wrecked in Prince William Sound, Alaska. Eleven million gallons (42 million liters) of oil were spilled. Over time, the oil spread out, covering 10,000 square miles (25,900 square kilometers) of ocean and 1,200 miles (1,940 kilometers) of coastline. It is estimated that as many as 6,000 otters, whales, dolphins, and seals, and 645,000 birds died. Three nearby national parks and three national wildlife refuges were also affected.

Kon-Tiki

Norwegian explorer Thor Heyerdahl (1914-2002) was convinced that ancient peoples once sailed across 4,300 miles (6,900 kilometers) of the Pacific Ocean from Peru and colonized Polynesia. To test his theory, he set out with a crew of six people to duplicate the feat in 1947. The expedition lasted 101 days and was carried out on a large raft called the *Kon-Tiki*.

Named for a legendary Inca Sun-god, the *Kon-Tiki* was patterned after sailing rafts used by the ancient Incas, native peoples who lived in what is now Peru. The raft measured 45 feet (13.7 meters) long in the center and tapered to 30 feet (9.1 meters) at the sides. No metal was used. Instead, the nine thick balsa logs were tied together with hemp rope. Two masts supported a large rectangular sail, and a bamboo cabin was built in the center for shelter.

On April 28, 1947, the raft was set adrift 50 miles (80 kilometers) off the coast of Peru. Ninety-three days later, the *Kon-Tiki* sailed past the island of Puka Puka, which lies east of Tahiti. On August 7, 1947, after the *Kon-Tiki* crashed into a reef in the Tuamoto Archipelago, the voyage was finished, but Heyerdahl had proved his point. The *Kon-Tiki* is now in a museum in Oslo, Norway. Heyerdahl wrote about the voyage in his book, *Kon-Tiki*.

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- American Oceans Campaign, 2501 M Street, NW Suite 300, Washington D.C. 20037-1311, Phone: 202-833-3900, Fax: 202-833-2070, Internet: http://www.oceana.org.
- Center for Marine Conservation, 1725 De Sales St. NW, Suite 600, Washington, DC 20036, Phone: 202-429-5609 Internet: http://www.cmc-ocean.org.
- Coast Alliance, P.O. Box 505, Sandy Hook, Highlands, NJ 07732, Phone: 732-291-0055, Internet: http://www.coastalliance.org.
- Environmental Defense Fund, 257 Park Ave. South, New York, NY 10010, Phone: 212-505-2100; Fax: 212-505-2375; Internet: http://www.edf.org.
- Envirolink, P.O. Box 8102, Pittsburgh, PA 15217; Internet: http://www.envirolink.org.
- Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, Phone: 202-260-2090; Internet: http://www.epa.gov.
- Friends of the Earth, 1717 Massachusetts Ave. NW, 300, Washington, DC 20036-2002, Phone: 877-843-8687; Fax: 202-783-0444; Internet: http://www.foe.org.
- Greenpeace USA, 702 H Street NW, Washington D.C. 20001, Phone: 202-462-1177; Internet: http://www.greenpeace.org.
- Olympic Coast Alliance, P.O. Box 573 Olympia, WA 98501, Phone: 360-705-1549, Internet: http://www.olympiccoast.org.
- Sierra Club, 85 2nd Street, 2nd fl., San Francisco, CA 94105, Phone: 415-977-5500; Fax: 415-977-5799, Internet: http://www.sierraclub.org.
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