ESTUARIES AND LAGOONS

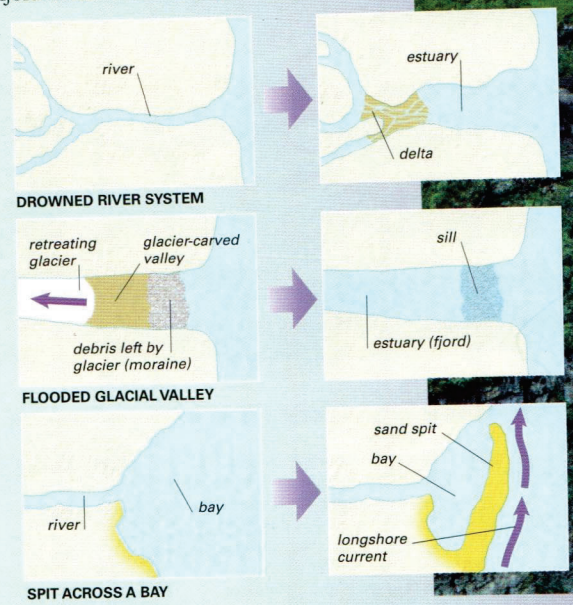
ESTUARIES AND COASTAL LAGOONS ARE BOTH semi-enclosed, coastal bodies of water. An estuary typically connects to the open sea, is quite narrow, and receives a significant input of fresh water from one or more rivers. This fresh water mixes with the salt water to a varying degree, depending on river input and tides. Many estuaries are simply the seaward, tidally affected ends of large rivers. Coastal lagoons are usually linked to the sea only by one or more narrow channels, through which water flows in and out; sometimes these channels open only at high tide.

ESTUARY FORMATION

Estuaries form in four main ways. For example, the sea level may rise and flood an existing river valley on a coastal plain, such as in Chesapeake Bay in the US. Alternatively, the sea level can rise to flood a glacier-carved valley, forming a fjord. Estuaries formed in this way are deeper than other types, but have shallow sills at their mouths that partially block inflowing seawater. Coastal wave action can also create an estuary, by building a sand spit or bar across the open end of a bay fed by a stream or river (see p.93). Other estuaries result from movement at tectonic faults (lines of weakness) in Earth's crust, where downward slippage can result in a surface depression. This becomes an estuary if seawater later floods in.

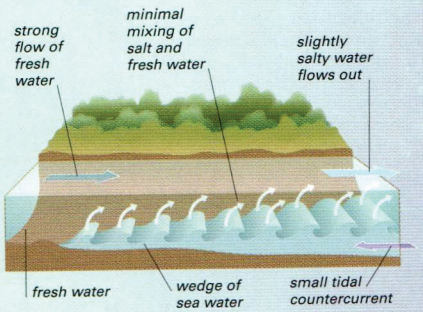
CONGO RIVER ESTUARY
Formed by flooding of a river valley, this estuary is the world's second largest (after the Amazon) in terms of discharge rate.

FORMATION PROCESSES
An estuary can form when sea-level rise causes the seaward end of a river valley to flood (top) or inundates a glacier-carved valley to create a fjord (middle), or when a spit extends across a bay (bottom).



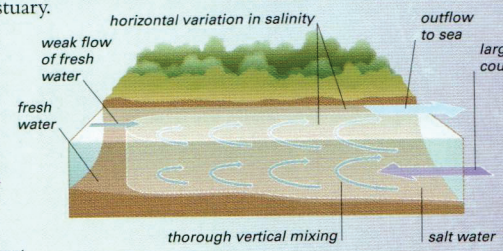
TYPES OF ESTUARIES

The way in which fresh and salt water mixes in an estuary determines its classification. A strong river inflow usually means minimal mixing—the less-dense fresh water flows over the denser salt water, which forms a wedge-shaped intrusion into the bottom of the estuary. This is a salt-wedge (river-dominated) estuary. In partially mixed and fully mixed (tide-dominated) estuaries, there is considerable mixing, producing turbulence and increased salinity in the fresh water. In each case, this is balanced by a strong, tidally influenced influx of salt water from the sea: this influx brings sediments from offshore, which are deposited as mud in the estuary.



SALT-WEDGE ESTUARY
In a salt-wedge estuary (left), there is a strong flow of fresh river water over a wedge of salt water, with little mixing between the two layers.

PARTIALLY MIXED ESTUARY
In this type of estuary, there is considerable mixing between fresh and salt water. The saltiness of the water increases with depth in all parts of the lower estuary.



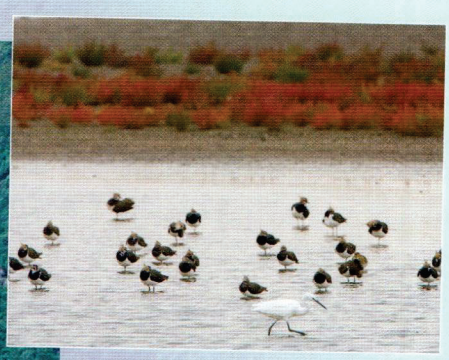
FULLY MIXED ESTUARY
In a fully mixed (or tide-dominated) estuary, the fresh and salt water are well-mixed vertically, but there is some horizontal variation in saltiness.

CARVED BY GLACIERS
A fjord is an estuary formed when the sea floods a deep valley originally carved out by a glacier. Norway's Geiranger Fjord is 12 miles (20 km) long, and reaches a depth of 660 ft (200 m).

ESTUARINE ENVIRONMENTS

Estuaries are unique coastal environments. They are typically long and funnel-shaped, so tides don't just rise here—they rush in, creating strong currents and, sometimes, wall-like waves called tidal bores. The high rate of sedimentation means that mud accumulates, so tidal mudflats and salt marshes (see pp.124–25) or in the tropics, mangrove swamps (see pp.130–31), develop. Despite the effects of tides and currents, the high turbidity that reduces plant photosynthesis, and fluctuations in salinity and temperature, most estuaries are biologically highly productive. This is partly due to the high concentration of nutrients in river water, and because estuaries are well oxygenated. Although only a limited range of organisms, such as mussels, cope with living in estuaries, populations are often huge.

COMMON EUROPEAN OYSTER



RICH FOOD SOURCE
Estuaries attract waders and other shorebirds because of the high concentrations of small animals (such as worms and shrimp) that live in the mud deposits. These lapwings and an egret are congregating to feed in the Thames estuary, UK.

ESTUARY DWELLER
Various species of starfish tolerate the estuarine environment, where they feed on mussels, crustaceans, and worms. This common starfish is in an estuary in Brittany, France.

COASTAL LAGOONS

Coastal lagoons occur worldwide, and are different from the lagoons found at the centers of coral atolls (see p.152). Calmer and usually shallower than estuaries, most lagoons are connected to the sea by tidal channels. Although fresh water does not usually flow into coastal lagoons, some do receive a significant river inflow. So, as well as saltwater lagoons, there are also some partly, or predominantly, freshwater lagoons.

In hot climates, some lagoons are hypersaline (saltier than ocean water), due to high evaporative losses. Although some coastal lagoons are severely polluted, the cleaner ones are often well stocked with fish, crustaceans, and other marine life, and frequently attract large numbers of shorebirds. Some provide feeding or breeding areas for sea turtles and whales.

LAGOON AND CHANNELS
Matagorda Bay is a lagoon on the coast of Texas, separated from the Gulf of Mexico by a long, narrow peninsula. Two channels, located near the southwest corner of the lagoon, connect it to the gulf.

ATLANTIC OCEAN NORTHWEST

St. Lawrence Estuary

TYPE Salt-wedge (river-dominated) estuary

AREA Approximately 10,000 square miles (25,000 square km)

LOCATION Quebec, eastern Canada

The St. Lawrence Estuary is one of the world's largest estuaries. Some 500 miles (800 km) long, it discharges about 3 million gallons (12 million liters) of water into the Gulf of St. Lawrence each second. The estuary is rich in marine life. In its wide middle and lower reaches, the icy Labrador Current flows 1,000 ft (300 m) below the surface in the opposite direction of the main estuarine flow. In one section, near the mouth of a fjord that branches off the estuary, the current's nutrient-rich waters rise abruptly and mix with warmer waters above. This upwelling of nutrients encourages plankton growth, providing the base of a food chain that involves many species of fish and birds, and a small population of beluga whales.

WINTER SCENE
In winter, much of the estuary becomes iced over. A stretch of the estuary is seen here at low tide, shortly after sunrise.

ATLANTIC OCEAN NORTHWEST

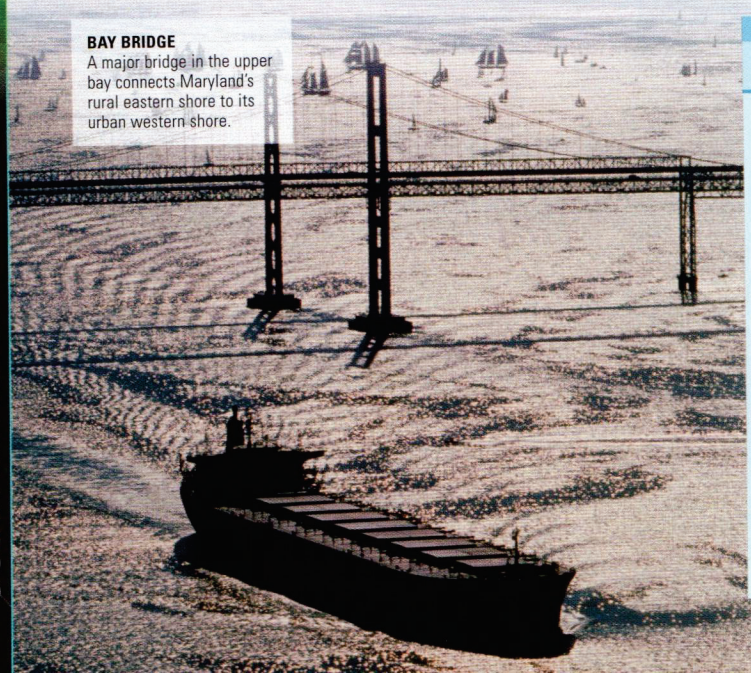
Chesapeake Bay

TYPE Partially mixed estuary

AREA 3,200 square miles (8,200 square km)

LOCATION Surrounded by Maryland and parts of eastern Virginia, US

Chesapeake Bay is the largest estuary in the US. Its main course, fed by the Susquehanna River, is over 185 miles (300 km) in length. It has numerous sub-estuaries, and more than 150 rivers and streams drain into it. This body of water was created by sea-level rise drowning the valley of the Susquehanna and its tributaries over the last 15,000 years. Once famous for its seafood, such as oysters, clams, and crabs, the bay is now far less productive, though it still yields more fish and shellfish than any other estuary in the US. Industrial and farm waste running into the bay causes frequent algal blooms, which block sunlight from parts of its bed. The resulting loss of vegetation has lowered oxygen levels in some areas, severely affecting animal life. The depletion of oysters, which naturally filter water, has had a particularly harmful effect on the bay's water quality.

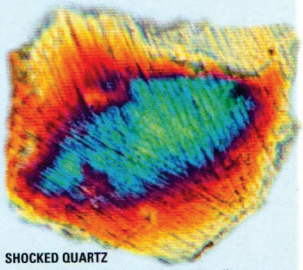


BAY BRIDGE
A major bridge in the upper bay connects Maryland's rural eastern shore to its urban western shore.

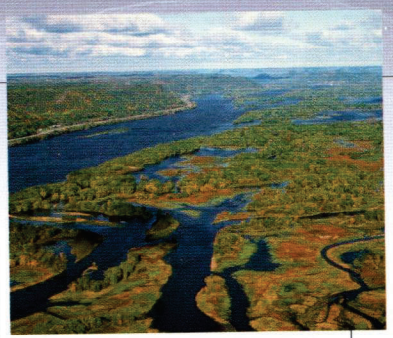
DISCOVERY

IMPACT CRATER

In the 1990s, drilling of the seabed at Chesapeake Bay led to the discovery of a meteorite impact crater 53 miles (85 km) wide under its southern region. The 35-million-year-old crater helped shape today's estuary.



SHOCKED QUARTZ
Evidence for the crater included the discovery of grains of shocked quartz, which forms when intense pressure alters its crystalline structure.



MAIN CHANNEL FLOWING THROUGH DELTA

ATLANTIC OCEAN WEST

Mississippi Estuary

TYPE Salt-wedge (river-dominated) estuary

AREA 25 square miles (60 square km)

LOCATION Southeastern Mississippi Delta, southeastern Louisiana, US

The Mississippi Estuary is about 30 miles (50 km) long and lies at the seaward end of the Mississippi River, where the river flows through its own delta. The estuary consists of a main channel and several subchannels. Together, these discharge an average of some 4.75 million gallons (18 million liters) of water per second into the Gulf of Mexico. The main channel is a classic example of a salt-wedge estuary—its surface waters contain little salt, but they flow over a wedge of salt water, which extends deep down for several miles up the estuary.