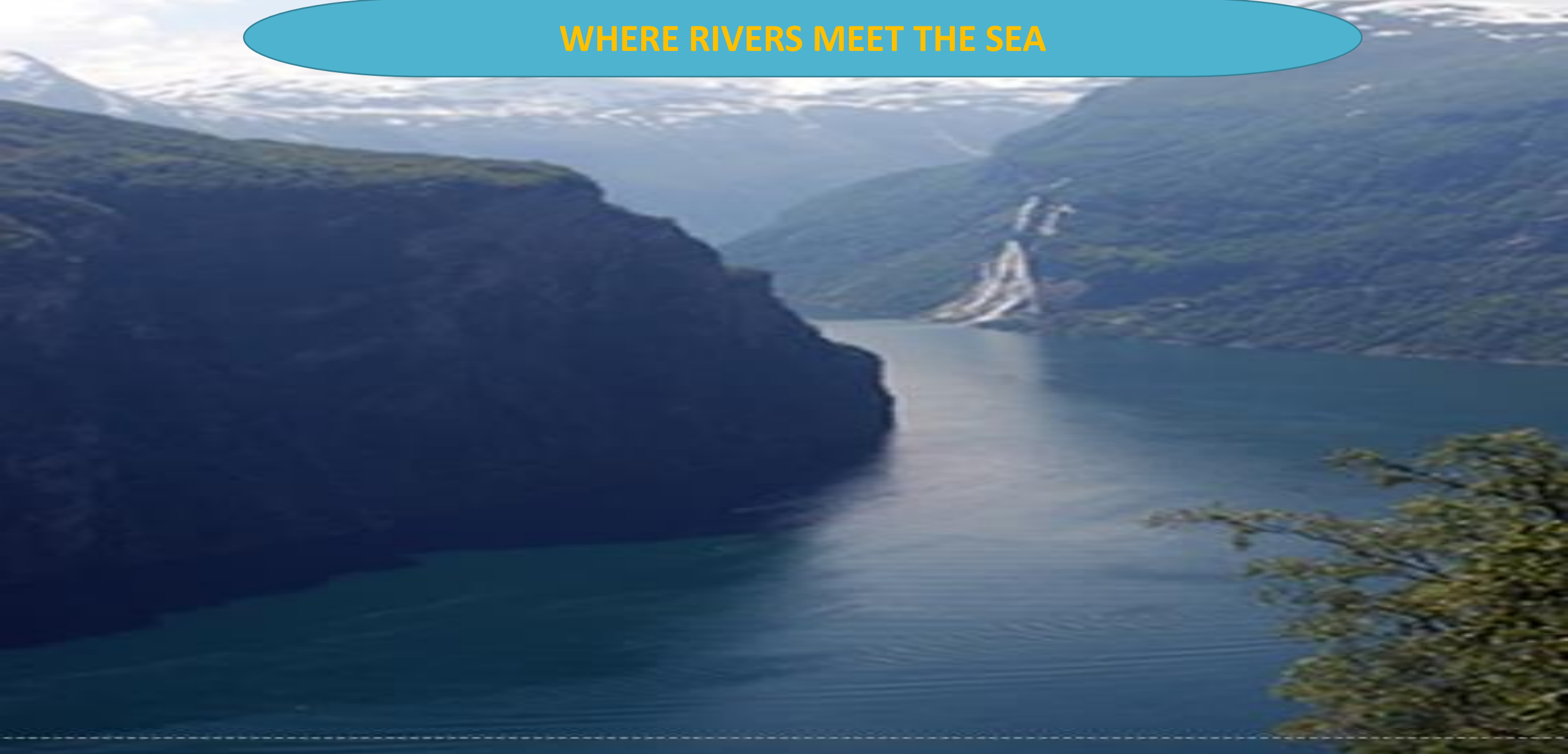


ESTUARIES

WHERE RIVERS MEET THE SEA



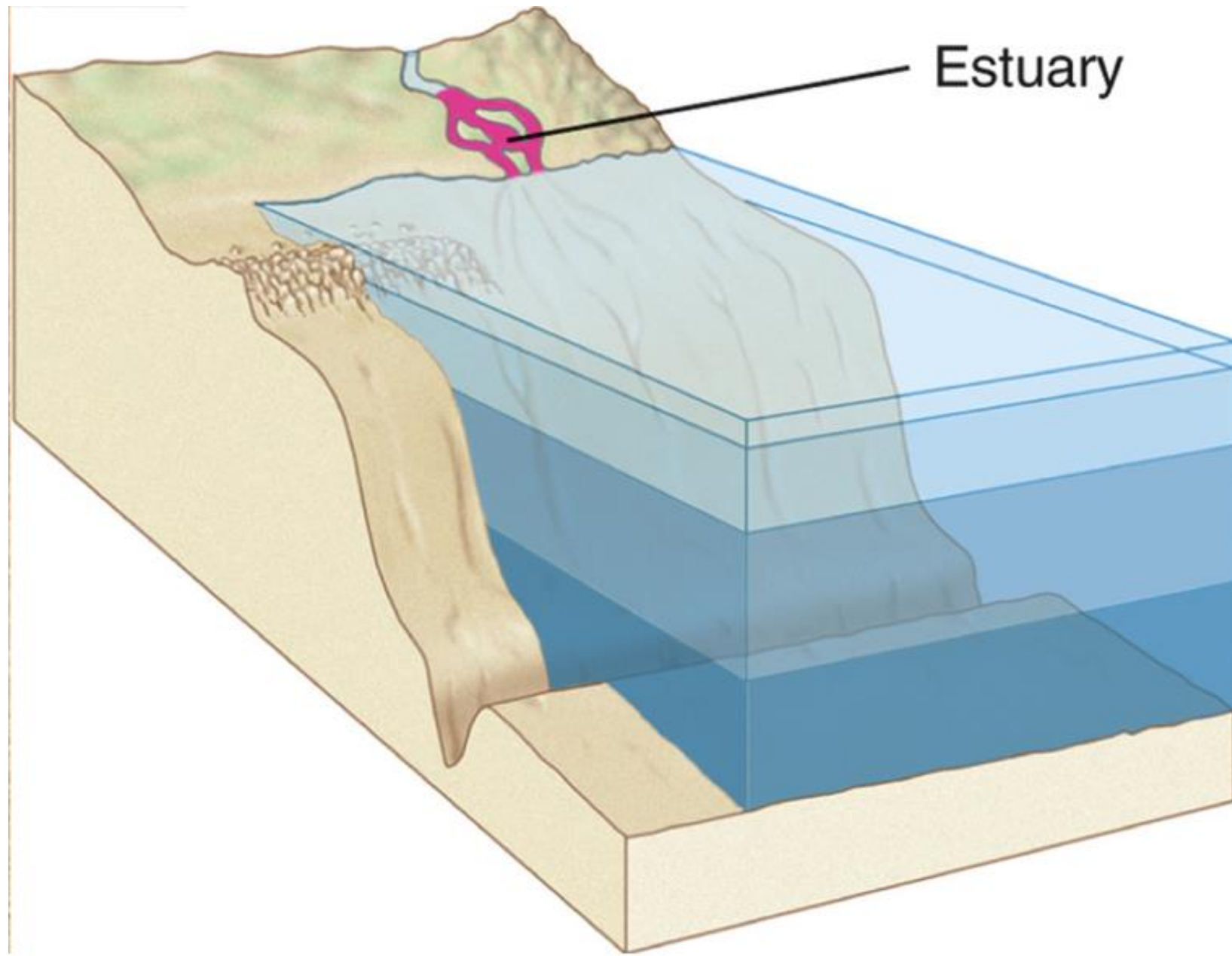
Estuaries

Origins and Types of Estuaries

Characteristics of Estuaries (Salinity, Substrate, Other
Physical Factors)

Estuaries as Ecosystem (Types of Communities, Feeding
Interactions)

Human Impact on Estuarine Communities



Estuaries are partially closed bodies of water where freshwater rivers and streams meet and mix with the salt water of the ocean

Semi-enclosed areas where fresh water and seawater meet and mix
Close interaction between land and sea
Among the most productive environments on earth
Among the environments most effected by humans

- **Estuaries are the transitional zones between the rivers and sea and have specific ecological properties and biological composition**
 - They are usually divided into three sectors- **marine or lower estuaries** having free connection with the open sea; **middle estuaries where strong salt and fresh water mixing** and **upper and fluvial estuaries characterized by freshwater water but subject to daily tidal action**
 - **Subdivided into three zone-Tidal zone; mixing zone and near shore turbid zone**

Estuaries come in all shapes and sizes. They can be called bays, lagoons and inlets

Classification of estuaries –

Based on environment-there is lack of uniformity among tropical estuaries in terms of size, shape, depth, physical and chemical feature and other environmental factor

The tropical estuaries environment can be divided into –

- **Open estuaries-** these estuaries are never isolated from the sea. example- Hooghly Matlah. The tidal impact of the system is felt upto 200 km Mahananda and Godavari is also open type
- **Estuarine coastal water-** the shallow nature of the such coastal water and their physical condition and lowered salinity and high turbidity make.
- **Blind estuaries-** the estuaries in this categories are small both in the length and catchment area during the summer the estuaries are **temporary closed by the sand bar across** the sea mouth during **this period no tidal current**. Mouth open during rainy season –many estuaries locate din Tamil Nadu and Karnataka
- **Coastal lake-** coastal lake have some forms **connection with sea and at same they receive** water from fresh water through no of river. example- Chilka (Odisha) and Pulicate (Andhara Pradesh)

Based on pattern of salinity distribution – estuaries can be divided into

Positive estuaries, negative and neutral estuaries

Positive estuaries- when fresh water inflow in estuaries exceeds evaporation

Negative estuaries- when the evaporation exceeds the inflow high rate of evaporation increased the surface salinity

Neutral estuaries- evaporation and inflow of fresh water in equilibrium. This category of estuaries is almost absent. Evaporation and inflow of fresh water are never equal.

Geomorphic classification

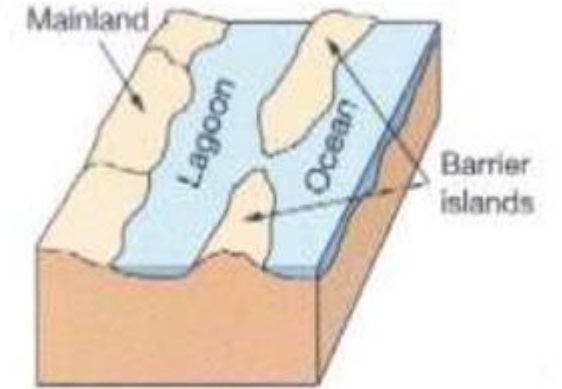
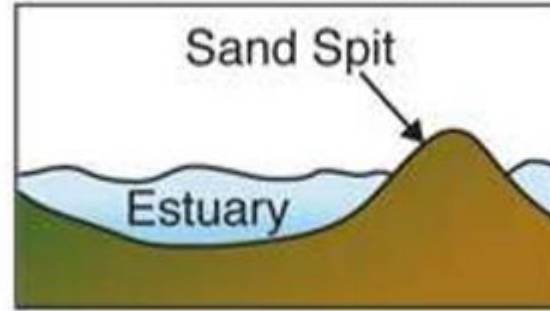
Coastal plain estuaries (drowned river valleys river)- most common type of estuaries. Formed by the lower reaches of river valleys and drowned river mouth

- formed when the sea invaded (occupied) lowlands and river mouths
- formed by rise in sea level when river valley became increasingly more flooded by melting glaciers
- Estuaries of this types are generally elongated and shallow, branches and irregular
- Most of the Indian estuaries are belong to this categories

Bar-built estuaries- formed from the accumulation of sediments that build up and create sand bars and barrier islands dividing fresh and salt water

- Enclosed shallow area may develop estuaries
- This type of estuaries have narrow connection with the sea example- **Vellar estuaries Tamil Nadu**

Bar-Built Estuary



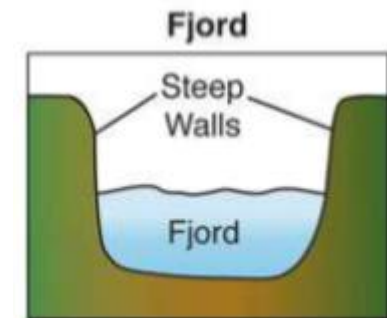
Tectonically produced estuaries-

- Tectonic Estuaries are caused by the folding or faulting of land surfaces. produced due to land slide and volcanic eruption. **San Francisco Bay**

Fjord estuaries- created from deep cuts by glaciers that later filled in by rivers

Both type of estuaries are not found in india

Fjords are U-shaped valleys formed by glacial action.



Estuarine ecosystem

In general estuaries are the most productive natural ecosystem in the world

Reason for the high productivity are –

Abundant availability of primary productive unit –phytoplankton, zooplankton benthic algae and green rooted plant (mangrove)

Oxygen content of estuaries water are high than other water body due to tidal action and current

Rapid regeneration and conservation of nutrient due to biological activity of primary consumer

Estuaries also receive organic detritus from wetland around the estuaries system

Most of the tropical estuaries are bordered by **mangrove forest** –**produced organic detritus**

Also called nutrient trap as it receive abundant nutrient from fresh water discharge

Estuaries water resources of India

Total estuaries area estimated to be – 1.44 million ha

West Bengal- 2.10 lakh ha

Odisha- 4.17 lakh ha

Andhrapradesh-0.79ha

Tamil nadu-0.56 lakh ha

Major estuaries are- Hooghly Matlah estuaries
Godavari, Krishna, Cauvery

Estuaries of east coast
Estuaries of west coast

Typical estuarine habitats and brackish water lakes in India

- Estuaries
- Brackish water lakes

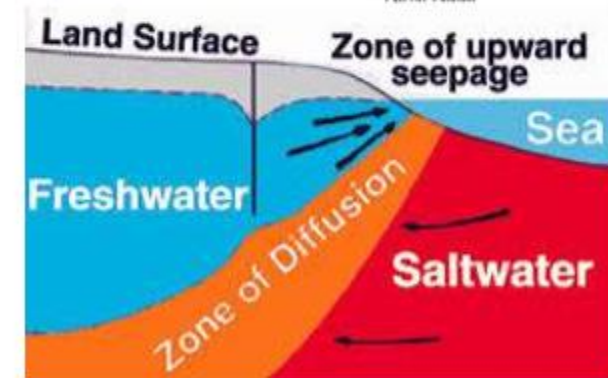
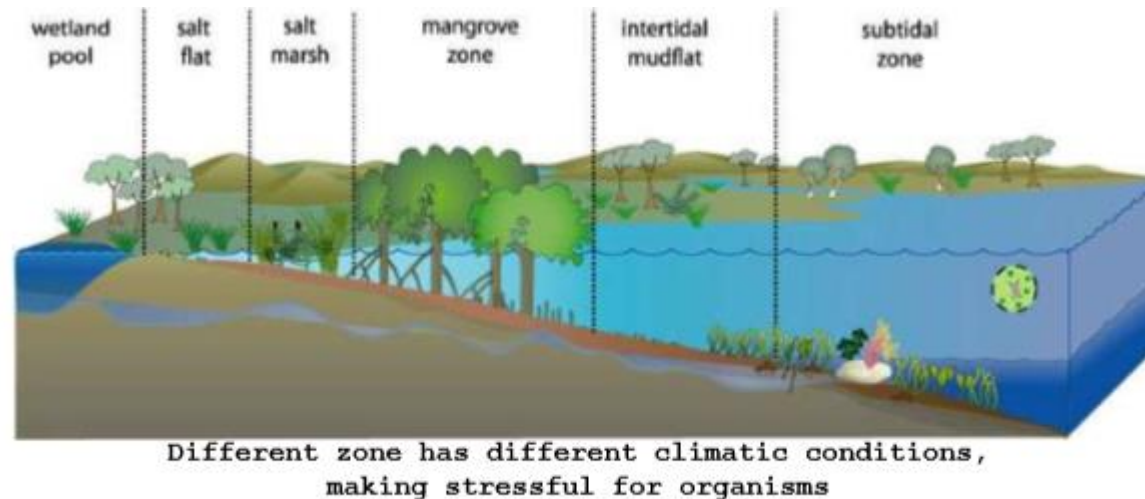


Diagram Showing Mixing Of Freshwater and Saltwater and Formation Of Brackish Water

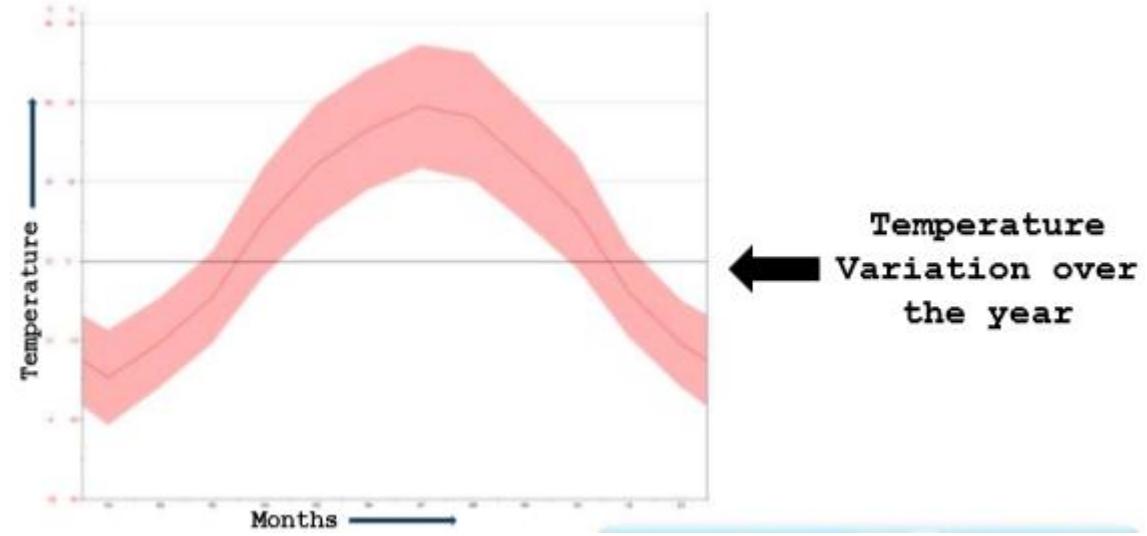
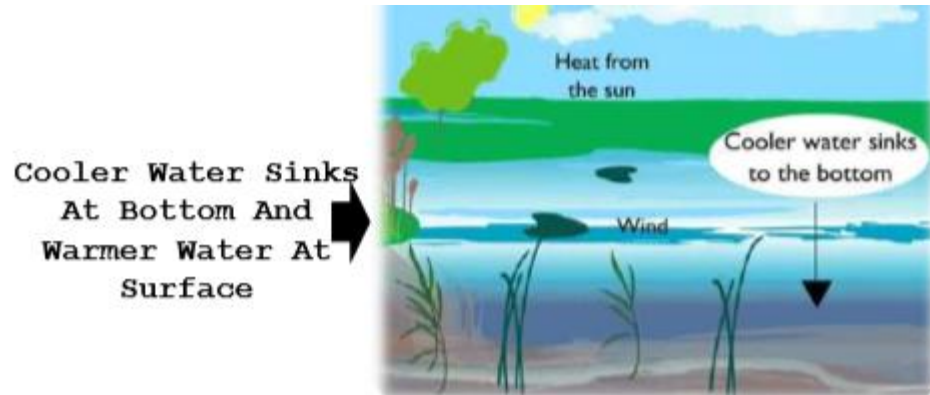
CHARACTERISTICS

- Have a unique combination of physical and chemical characteristics from the mixing of salt and freshwater
- Estuaries having large variation in several parameters and create stressful environment for organisms. This is the reason that large organisms are less in number in this area than smaller organisms.
- Estuaries are dominated by soft muddy (combination of silt and clay) substrate and is rich in organic matter.



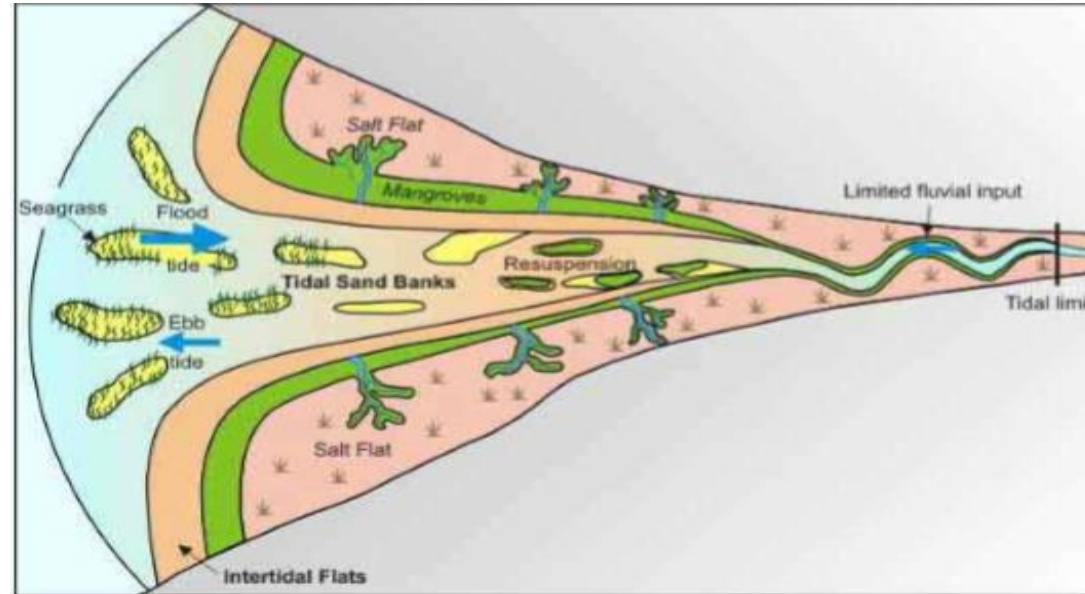
Temperature

- The Water **temperature in estuaries, except fjords, varies** markedly because of their **shallow depths** and **large surface area**.
- It heats up and cools down more rapidly under atmospheric conditions & the reason for this is freshwater input.
- The surface water have the greatest temperature range & the deeper water have lower temperature range.



Wave Action And Its Effect

- All the variations i.e, the salinity, the texture of substrate, temperature, organic matter content and available oxygen are controlled by wave action and currents.
- The wave action in estuary is small.
- deposition of fine sediments and development of rooted plants.



Deposition of fine sediments as tidal sand banks and development of rooted plants

Estuarine Current

- When dense, salty seawater flows into an estuary, it has an estuarine current. High tides can create estuarine currents.
- Saltwater is heavier than freshwater, so estuarine currents sink and move near the bottom of the estuary.
- When less-dense freshwater from a river flows into the estuary, it has an anti-estuarine current. Anti-estuarine currents are strongest near the surface of the water . Heated by the sun, anti estuarine currents are much warmer than estuarine currents

Current Velocities And Its Effects

- Velocities up to several knots can occur.
- The **highest velocities occur in middle** whereas in the **bottom and side bank** the velocity is lowest.
- The **erosion & deposition** in the estuaries are due to currents which is a natural cycle.
- However, In estuaries deposition exceeds erosion so there is a net accumulation of silt. During dry part of the year, water movement is severely reduced leading to stagnation, reduced oxygen content, formation of algal blooms and incidence of fish kills

Turbidity

- The water of estuaries is turbid because of the great number of particulates in suspension in the water.
- The turbidity is minimum near the mouth and increase with distance inland.
- The major ecological effect of turbidity is a marked decrease in the penetration of light. Thus, in turn decreases photosynthesis by phytoplankton and benthic plants, thereby reducing productivity.

Oxygen

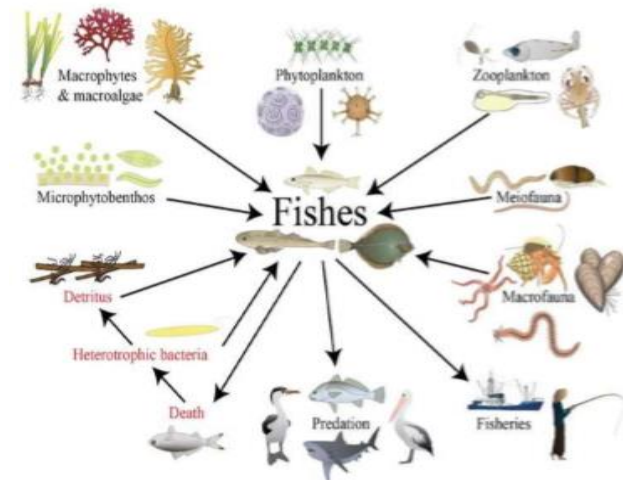
- Oxygen is also the most important factors in the estuary system.
- Since the solubility of oxygen in water decreases with increase in temperature and salinity, so the amount of oxygen varies with these parameters.
- The **high organic content and bacterial population** of the sediments exert a large oxygen demand on the water.
- Estuarine sediments are, therefore, anoxic below the first few centimeters, unless they have large no of burrowing animals such as **ghost shrimp Callianasa** and **Balanoglossus** which by their activities oxygenate lower sediment layers.
hemichordate worm

Salinity-

- In Estuaries, water level and salinity rise and fall with the tide **Salinity of the estuaries water varies between – 0.5 and 35%**
- These features also rise and fall with the seasons.
- During the rainy season, rivers may flood the estuary with freshwater and lowers the salinity. During the dry season, the outflow from rivers may slow to a trickle, the estuary shrinks and becomes much more saline.
- If the area has a diurnal tide, the organisms are subjected to two shifts in salinity every day: one as the tide moves upstream and a second as it retreats. In an estuary with semidiurnal tides, salinity changes four times a day

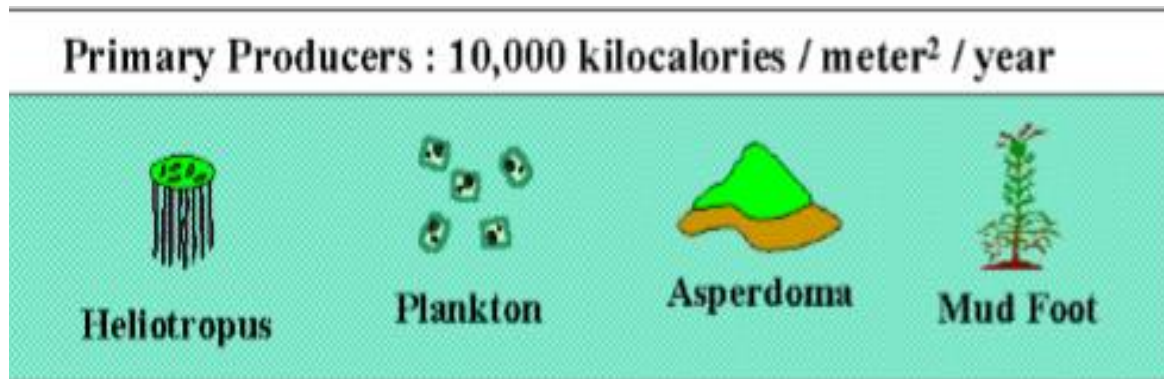
BIOTA OF ESTUARINE ECOSYSTEM

- The biota of estuaries is, in turns regulated by degree of mixing.
- Estuarine diversification is lower than river or marine because of tremendous variation in physical environment.
- Major species are restricted to the estuarine situation, such as Oyster & Crabs and those that come from sea, such as Shrimp.
- Very few species are derived from freshwater and only those that are capable of osmoregulation in the saltier environment.
- Estuaries are nursery ground for vast number of marine animals shrimps and crabs to fishes.



Primary producer

- primary producers do flourish on mudflats (**The bottoms of estuaries that become exposed at low tide often form mudflats**)
- A few seaweeds—like the green algae *Enteromorpha* sea lettuce, and some red algae—grow on bits of shell.
- **Bacteria and archaea are extremely abundant on mudflats.** They decompose the huge amounts of organic matter brought in by rivers and tides. When the oxygen is used up by decay, some bacteria produce hydrogen sulfide.
- **Diatoms and bacteria, including photosynthetic bacteria, actually account for most of the primary production on mudflats**



Infauna

- The dominant animals on mudflats burrow in the sediment and are known as infauna.
- Burrowers, like the **fat innkeeper** (*Urechis caupo*), **polychaete** (*Hesperonoe adventor*), a **crab** (*Scleroplax granulata*), a fish (*Clevelandia ios*) and other guests.
- Mudflat inhabitants that feed on detritus are:

Deposit Feeders- Animals feeding on organic matter that settles in the sediment.

Suspension Feeders- Animals, including filter feeders, that feed on particles suspended in the water column.

Many deposit feeders and some other members of the infauna are known as bioturbators because they move and mix sediment when burying or digging.

Bioturbation helps in the oxygenation of sediment

Meiofauna

- The Protozoans, nematodes, and many other minute animals that compose the meiofauna also thrive on detritus.
- The meiofauna are also known as interstitial animals.
- The larger burrowing animals, or infauna, include many polychaetes.
- Most are deposit feeders.

Epifauna

- **Very few mudflat animals can be classified as epifauna, those that either live on the sediment surface or are attached to a surface as sessile forms.**
- Crabs, *Mercenaria mercenaria* , *Mya arenaria* , *Macoma* , ghost, mud snail (*Upogebia*) shrimps and *Uca* are some examples for epifauna.
- Some of these are of considerable commercial importance

Predators

- Most important predators in the mudflat community are **fishes and birds**.
- Fishes invade mudflats at high tide, whereas birds congregate at low tide to feed.
- The most significant predators on mudflats are **wading shorebirds**. These include the **willet, godwits, dowitchers**, and many species of plovers and sandpipers such as curlews and phalaropes. **They feed on polychaetes, ghost shrimps and other small crustaceans, clams, and mud snails.**

Why High Productive

- The high productivity results from **estuaries being nutrients traps for both** physical (Based on the degree of mixing) and biological (Rapid recycling) reasons.
- Also estuarine producers, which include seaweeds and marsh grasses as well as benthic algae and phytoplankton, are capable of nearly year-round photosynthesis.
- The **higher the fluctuation of water level**, the higher the productivity, the **tides serving to remove waste and to transport food and nutrients**.

Importance of Estuaries

- The Estuaries are tremendously productive and are home to large numbers of organisms, many of which are of commercial importance.
- Estuaries also provide **vital breeding and feeding grounds** for many animals.
- Estuaries are **important stopover (halt)** and wintering areas for many **species of migratory birds**.
- The worldwide economic value of marine wetlands as sources of food and as nurseries of many food species, in **recreation and tourism**, as **sources of wood** and other materials, **in protection against storms and erosion**, as well as in the maintenance of biodiversity and water quality, is enormous
- As transition zones between land and water, estuaries are **invaluable laboratories for scientists and students studying** the complexity of biology, geology, chemistry, physics, history and social issues.

HUMAN INTERFERENCE AND THREATS TO ESTUARIES

- All around the globe estuaries - to make marinas, **artificial harbors**, and **sea-ports**. Others are filled to create everything from **industrial parks** and **urban development to garbage dumps**.
- navigation channels increases the exposure of estuaries to wave action, which often results in the destruction of salt marshes.
- Another problem in some estuaries is the reduction or elimination of normal freshwater input when rivers are dammed or diverted. **Sediment input from rivers is decreased so that erosion** of sediments by tides is not refilled.
- **Deforestation and agriculture brings about an increase in sediment**, which in estuaries like **Chesapeake Bay, decreases water quality** and increases pollution

Environmental Impacts

Dredged or filled and transformed into marinas/port, seaports, industrial parks, cities and garbage dumps

CONSERVATION AND RESTORATION OF MARSH LANDS

- The destruction of salt marshes by human activities is a major worldwide problem.
- The restoration of disturbed salt marshes to their natural condition is being carried out as part of efforts to protect and preserve coastal wetlands.
- Some biologists **encourage the natural regeneration of disturbed salt marshes**, but others prefer to **accelerate recovery by replanting dominant species**, particularly cordgrass (*Spartina*). For example, the University of Southern Mississippi operates a nursery that grows salt marsh plants that are transplanted in damaged marshes.
- The **success of replanting depends on factors such as wave action and tides**, water chemistry (salinity, dissolved nutrients), and the substrate (slope, sediment size, oxygen content).
- **Recovery can take many years**, and the **length of the recovery period depends on the degree of disturbance, environmental factors, and the relative maturity of marshes**. The more mature marshes take the longest to recover.