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SIXTH EDITION

Invitation to Oceanography

Chapter 12

Coastal Habitats

河口環流：

河流出海口往往具有各種不同的型態，例如

峽灣(Fjord)

三角洲 (Delta)

沈溺河谷(Drowned river valleys)

閂灘(Barrier beaches)

閂島(Barrier islands)（俗稱**攔門沙**）者。

Origins and Settings of Estuaries

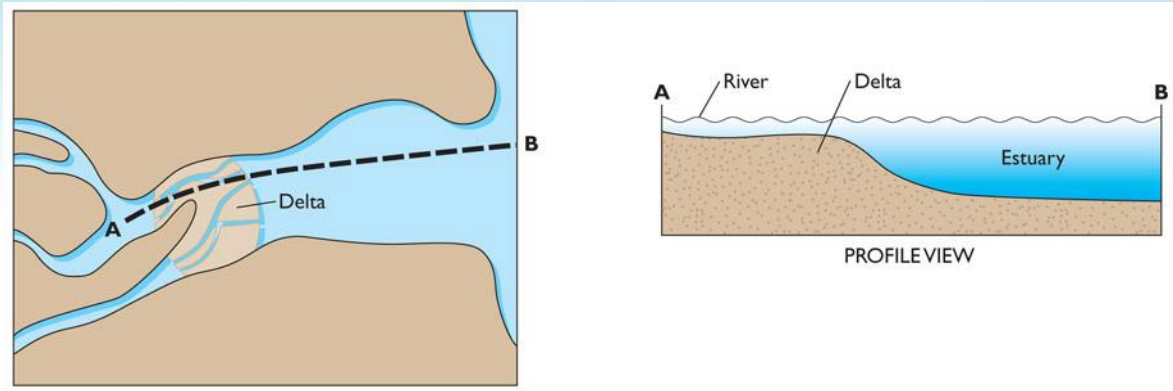


Figure 12.01a: Perhaps the most common origin is the drowning of the mouth of a river valley.

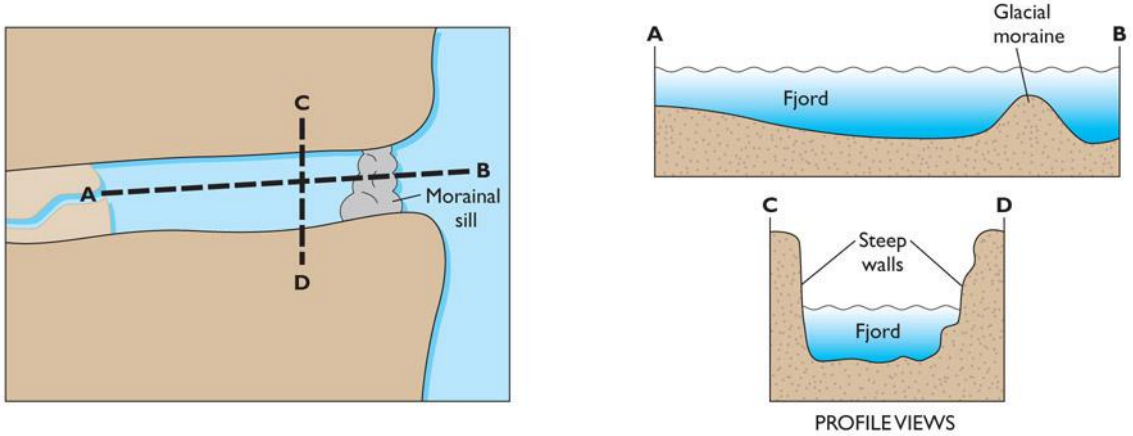


Figure 12.01b: In the high latitudes, glaciers have carved deep, narrow, steep-walled valleys and many have glacial moraines.

Origins and Settings of Estuaries

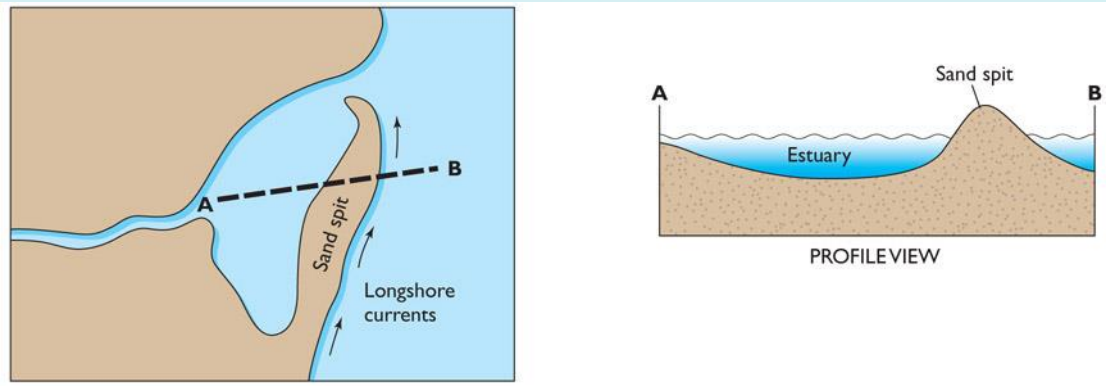


Figure 12.01c: Bar-built estuaries evolve by spit extension across an embayment.

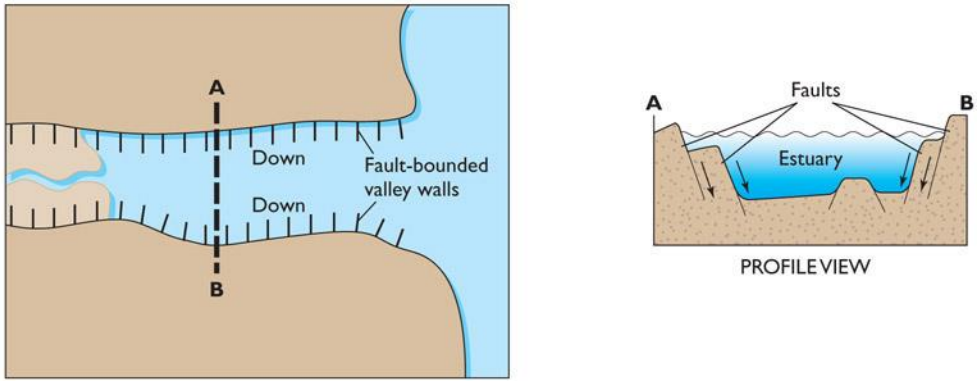
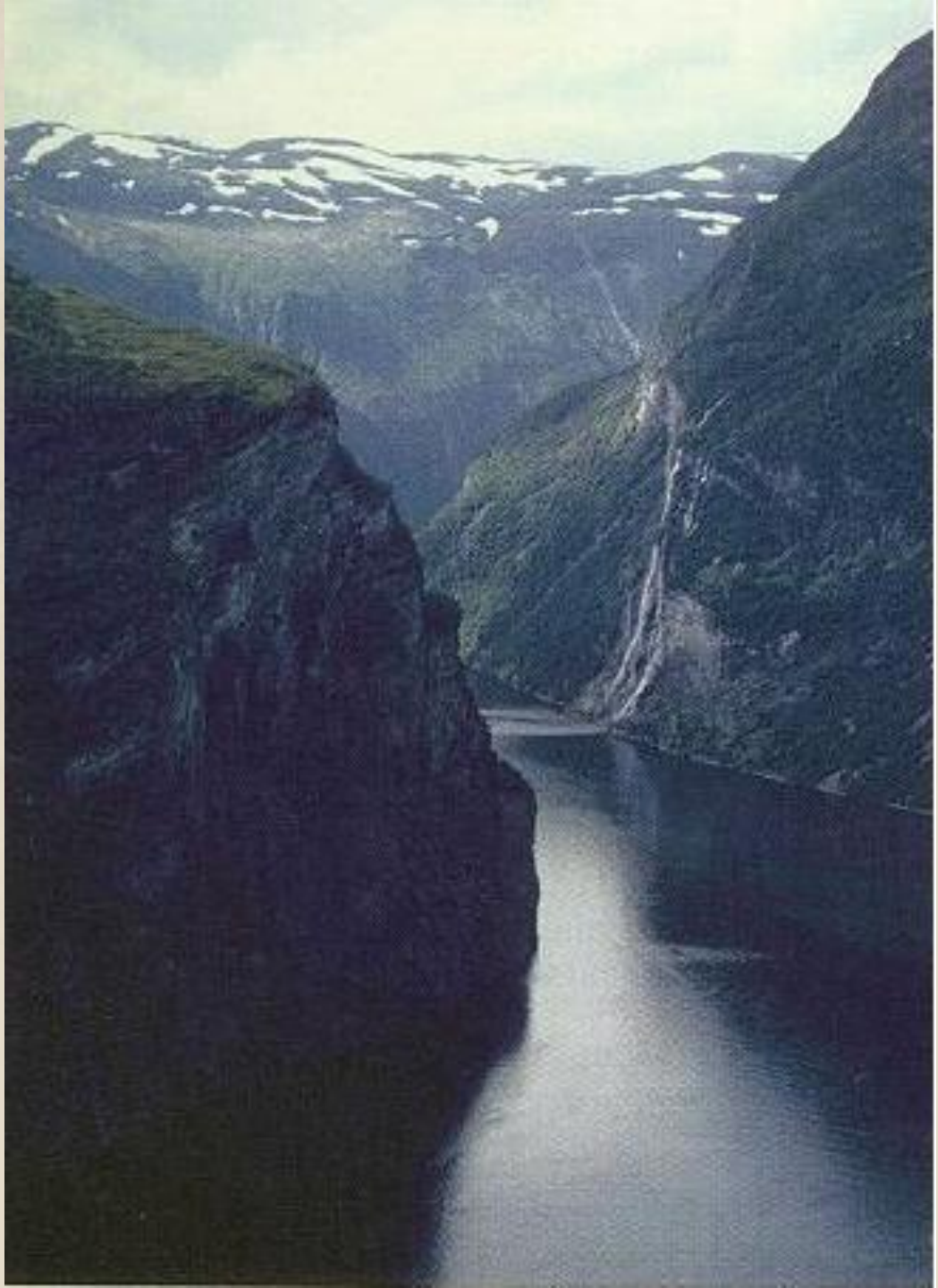


Figure 12.01d: Tectonic estuaries commonly result from block faulting.



峽灣地形是由冰川切割作用所造成的。
摘自Stowe, K. (1995)

密士西比河河口三角洲地形之衛星照片。

美國東岸Delaware Bay以及Chesapeake Bay之航照圖，顯示當地之沈溺河谷地形，在大陸與大洋接界處之細長條為閂島地形。

- Estuaries can be subdivided into three types based upon the relative importance of river inflow and tidal mixing.
  - **Salt-wedge** estuaries are dominated by the outflow from rivers.
  - **Partially-mixed** estuaries are dominated by neither river inflow nor tidal mixing.
  - In **well-mixed** estuaries tidal turbulence destroys the halocline and water stratification.

- Because river discharge and tidal flow vary, conditions within an estuary can also change.

- An estuary can be:
  - well-mixed when river flow decreases relative to tidal mixing
  - salt-wedge estuary at times of maximum river discharge

Types of Estuaries

defined by mixing characteristics between fresh and salt water inputs.

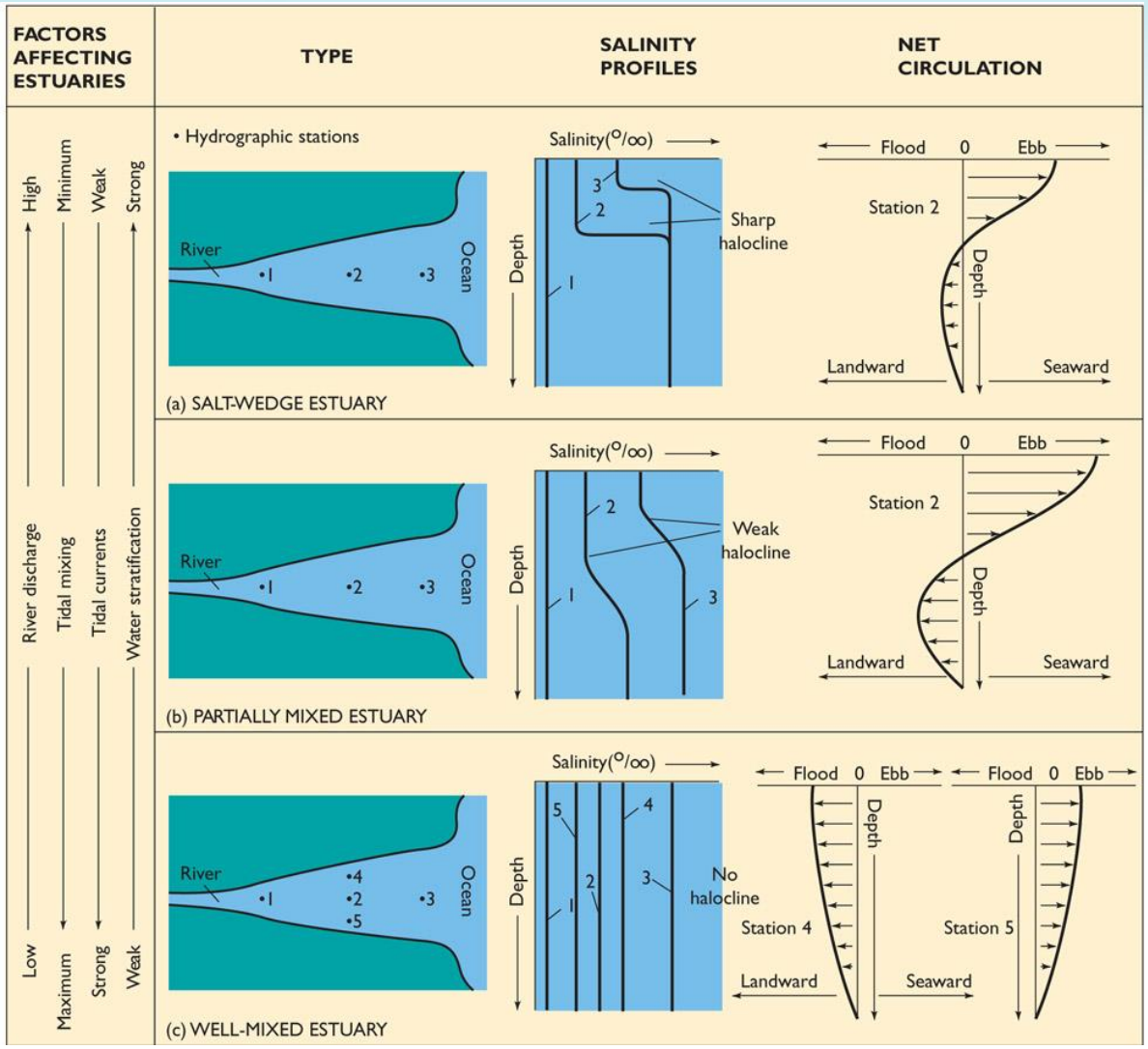


Figure 12.02: Estuaries are classified on the basis of circulation, which depends on the degree of freshwater and seawater mixing. Water mixing is controlled by the relative influence of tidal currents and river discharge as they produce a net circulation. (a) Salt-wedge estuaries are river-dominated and, as such, are highly stratified, as shown by the sharp halocline. Surface currents flow out of the estuary and bottom currents into the estuary. (b) Partially mixed estuaries have a weakly developed halocline because tidal flow mixes surface and bottom water. This results in strong incoming bottom flow and outgoing surface flow. (c) Well-mixed estuaries are tide-dominated. Consequently, they are thoroughly mixed and have no halocline. Water flows into the estuary on one side and out of the estuary on the other side.

Types of Estuaries

defined by mixing characteristics between fresh and salt water inputs.

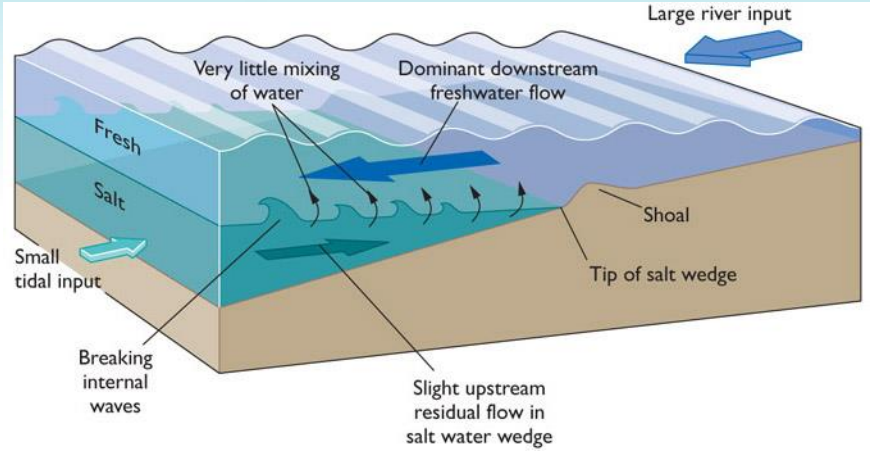


Figure 12.03a: Salt-wedge estuaries are characterized by a net landward-directed bottom current and a net seaward-directed surface current.

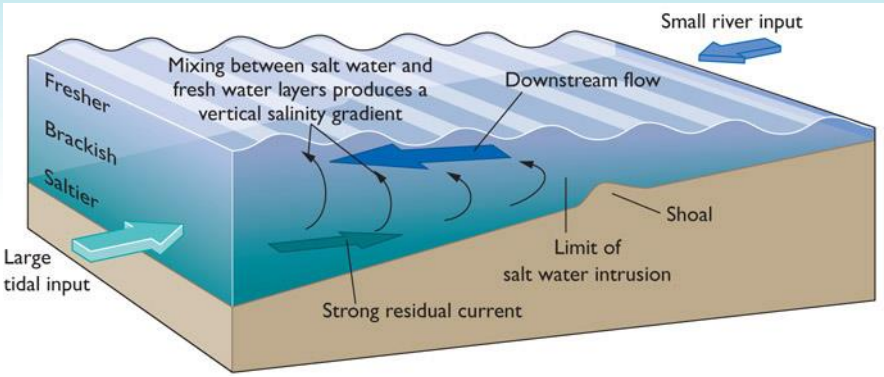


Figure 12.03b: Partially mixed estuaries have strong currents, with net landward-flowing bottom currents and net seaward-flowing surface currents.

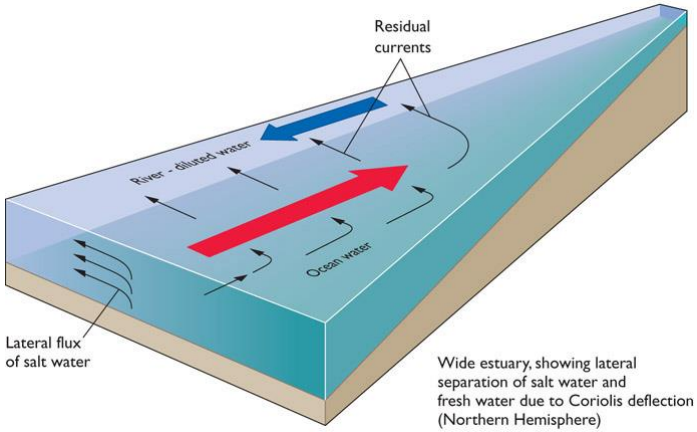


Figure 12.03c: Well-mixed estuaries have net currents that are landward-directed at all depths on one side and seaward-directed flow at all depths on the other.

- The widely fluctuating environmental conditions in estuaries make life stressful for organisms.
- Estuaries are extremely fertile.
  - Nutrients are brought in by rivers and recycled from the bottom because of the turbulence.
- Stressful conditions and abundant nutrients result in low species diversity, but great abundance of the species present.
  - These best adapted organisms outcompete all others and dominate their ecological niche.

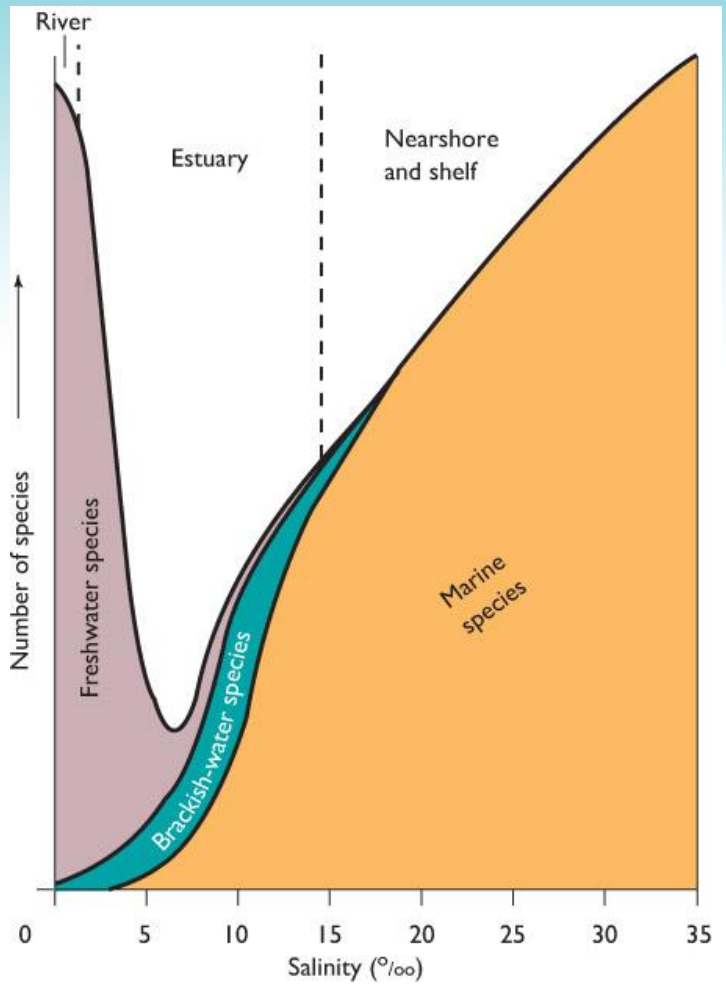


Figure 12.04: The number of species is low in estuaries compared to that in rivers and oceans.

Chesapeake Bay

Figure B12-1 Chesapeake Bay

Lagoons

•Shallow bodies of costal water that receive little if any fresh water inflow.

•They range from completely isolated to semi-enclosed.

•Lagoons can occur at any latitude.

•Their salinities vary from **brackish** (mixed with fresh water) to **hypersaline** (extremely salty) depending upon climate and local hydrology.

Lagoons vs. Estuaries

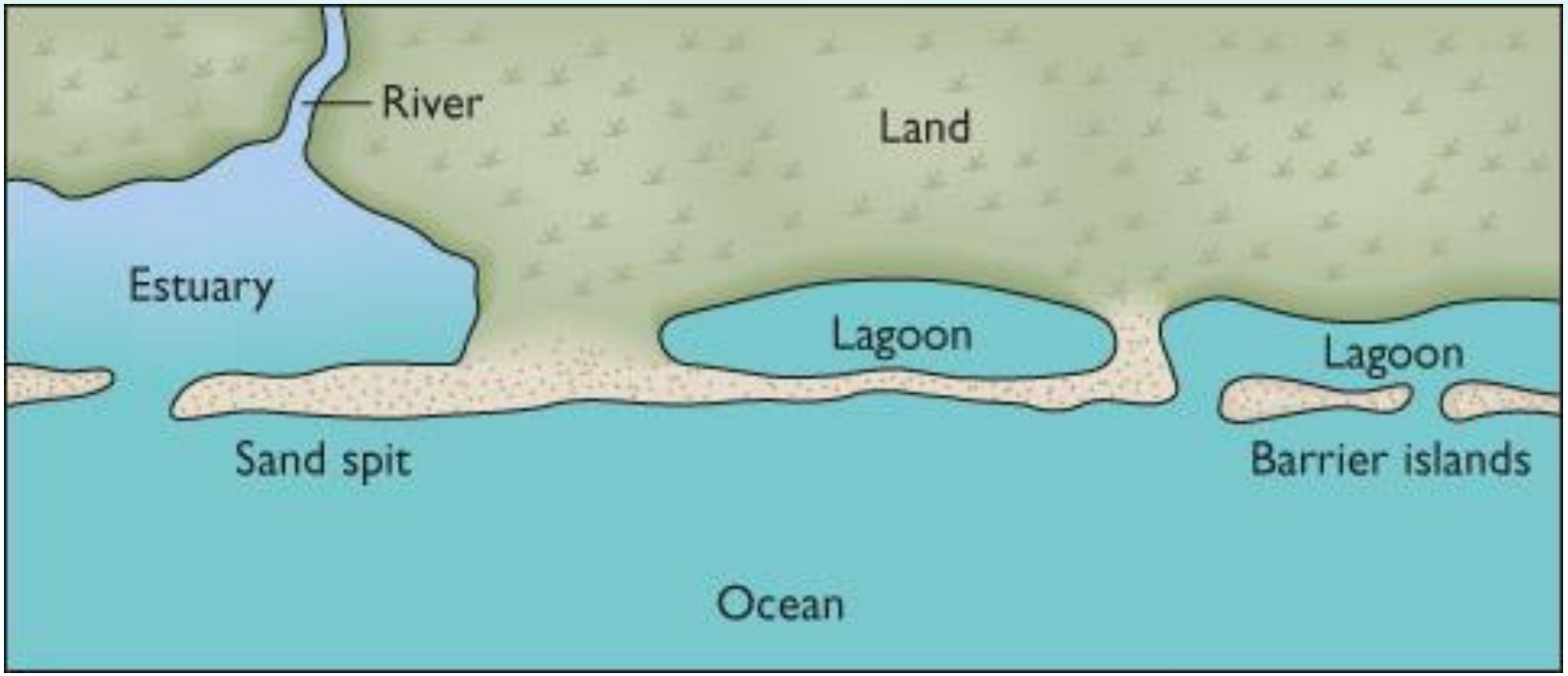


Figure 12.07: Water is exchanged with the open ocean through tidal inlets that are located between sand spits and barrier islands.

Salt Marshes

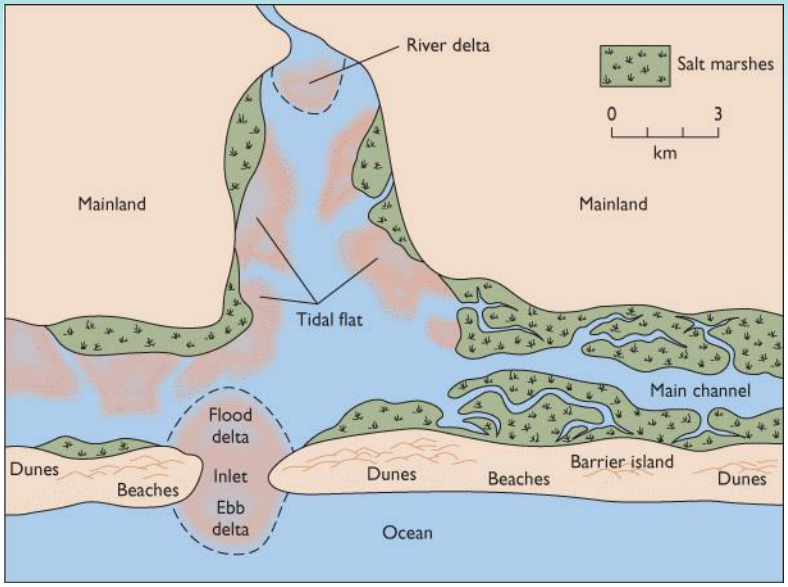


Figure 12.10a: Salt marshes grow in muds and sands that are sheltered by barrier islands.

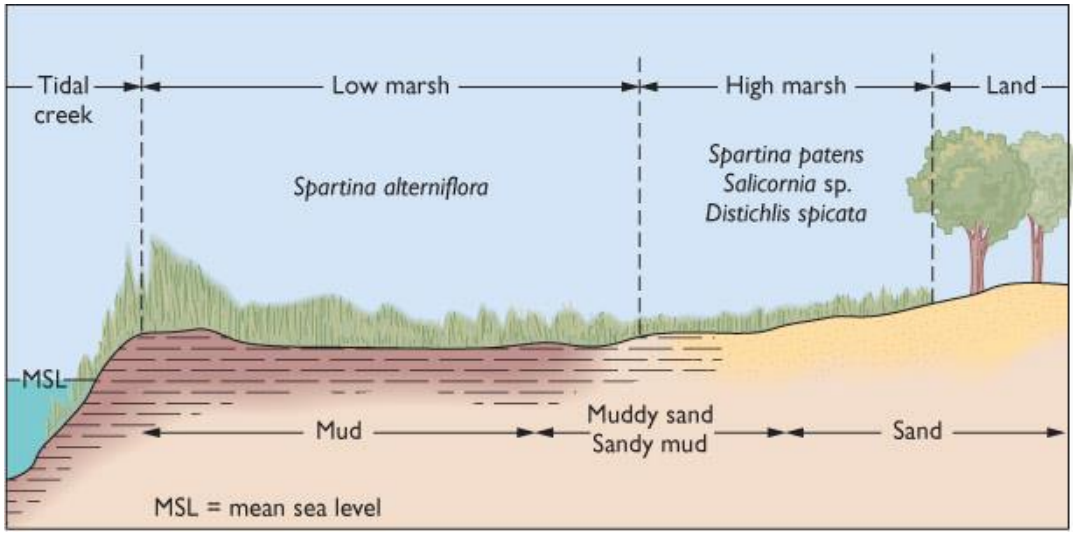


Figure 12.10c: Based on topography and characteristic plant assemblages, salt marshes are classified as low or high marshes.

Salt Marshes (Continued)

- Marshes can be divided into two parts, low salt marsh and high salt marsh.

- Often characterized by dominant grasses with different degrees of salt tolerance

- Distribution and density of organisms in salt marshes strongly reflects:
  - availability of food
  - need for protection
  - frequency of flooding

Salt Marsh Grasses

Figure 12.11a: Spartinaalterniflora

Figure 12.11b: Spartina patens

Figure 12.11c: Salicornia species

Figure 12.11d: Distichlis spicata.

Salt Marsh Evolution

A record of the interaction between river input and the coastal ocean (including sea level rise)

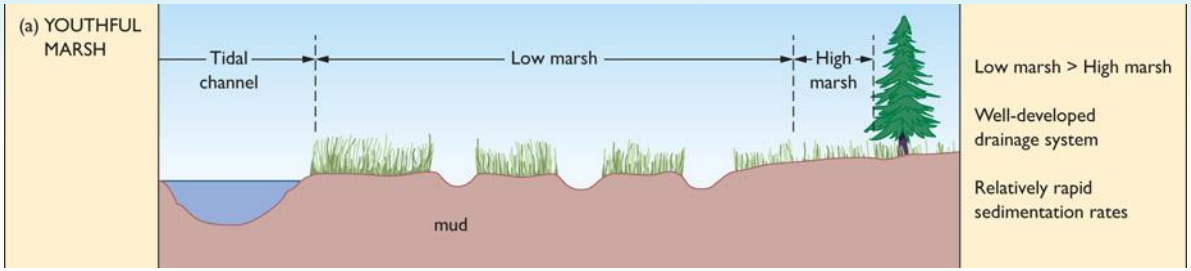


Figure B12.04a: The youthful stage of salt-marsh evolution is dominated by low marsh.

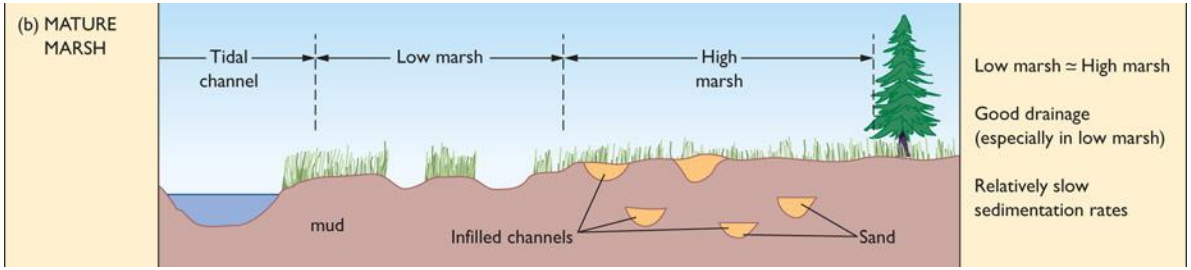


Figure B12.04b: The stage of mature development is reached when about one-half of the salt marsh consists of high marsh.

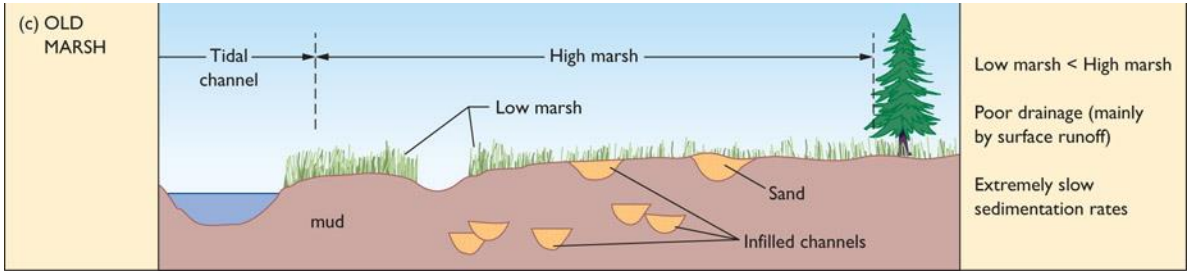


Figure B12.04c: Additional deposition of sediment causes more vertical growth of the marsh surface, until the entire wetland is high marsh, a stage called old marsh.

Salt Marsh Evolution

Position and character of the salt marsh reflects retreat or advance of the ocean/river interface

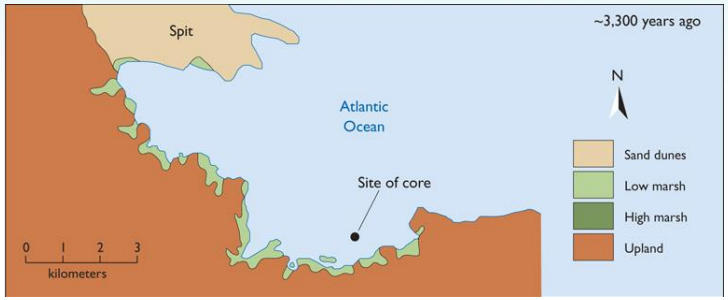


Figure B12.05a: The longshore drift of sand protects a cove from direct wave attack. Low marshes became established at many spots in the bay.

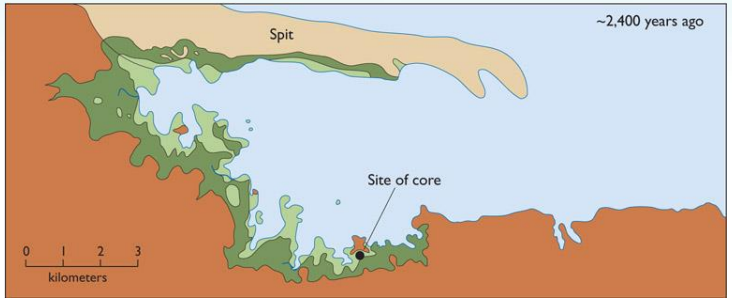


Figure B12.05b: By 400 B.C., the spit had elongated considerably, and high marsh had extended into the bay covering older low-marsh deposits.

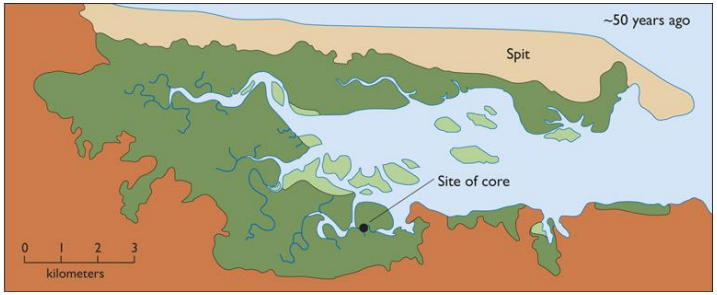


Figure B12.05c: Spit growth has continued to the present. A great deal of mud deposition and the vertical growth of the wetlands have resulted in dominantly high-marsh communities, the stage known as old marsh.

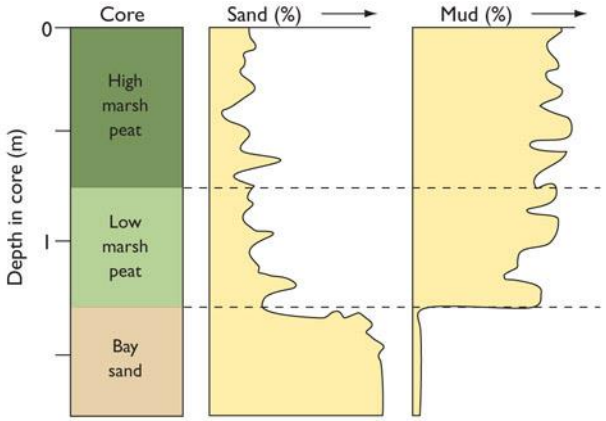


Figure B12.05d: A sediment core (located on maps a, b, and c) clearly shows the stages of marsh development.

Salt Marshes and Mangrove Swamps

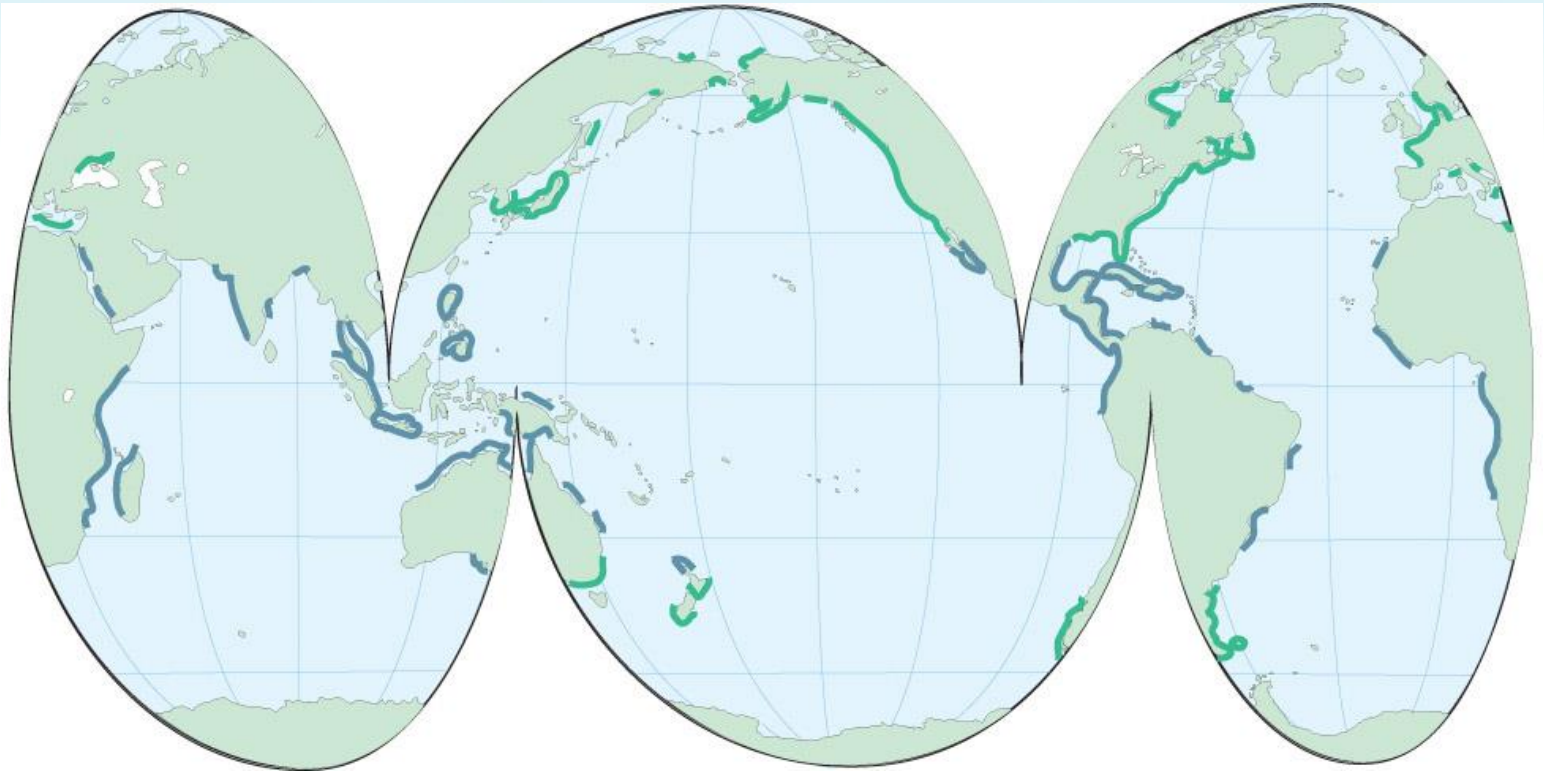


Figure 12.13: Salt marshes (green) are located in the middle and high latitudes, whereas mangroves (blue) are located in the low latitudes.

Mangroves

- Large woody trees with a dense, complex root system that grows downward from the branches.
- Mangroves are the dominant plant of the tropical and subtropical intertidal area.
- Distribution of the trees is largely controlled by:
  - air temperature
  - exposure to waves and currents
  - tidal range
  - substrate
  - seawater chemistry
- Detritus from the mangrove, largely leaf litter, forms the base of the food chain.

Florida Mangroves

Figure 12.14a: This view of a mangrove forest in southern Florida illustrates the dense tree growth and lush canopy that characterize these environments.

Figure 12.14b: Intricate networks of intertwined prop (above-ground) roots of mangrove trees provide habitats for a large variety of invertebrates and fish.

Mangrove Reproduction

- A seedling grown on a mangrove branch.
- When it matures, it drops into the water.
- It floats to a shallow mud bank, where it takes root.

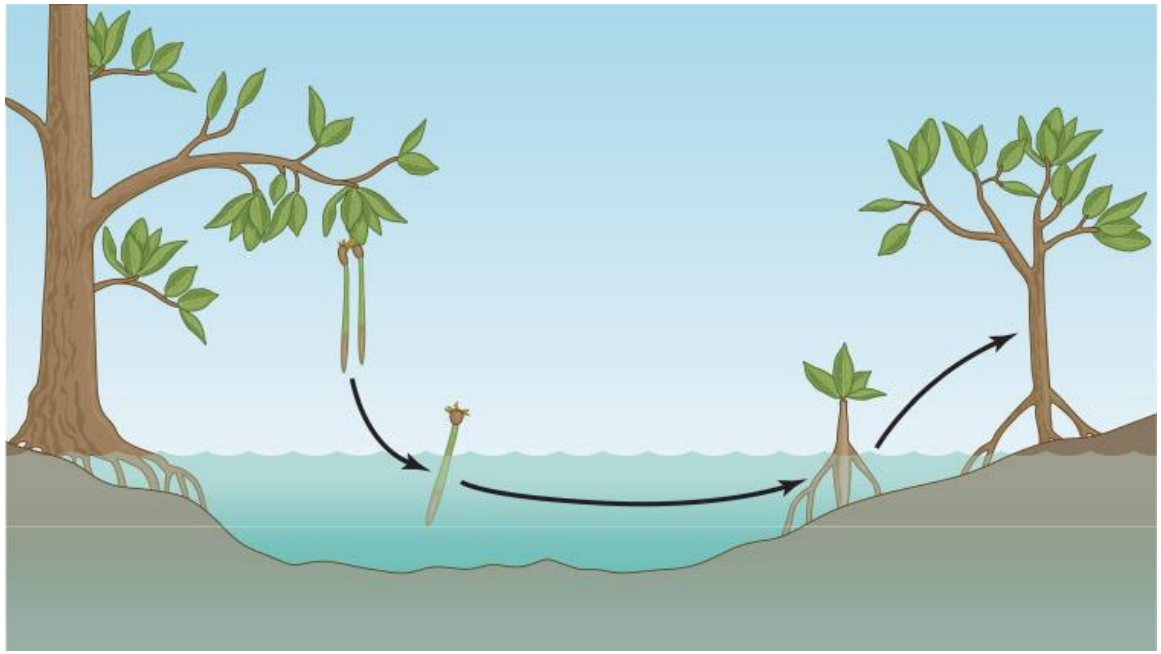


Figure 12.15: A mangrove seedling grows on a parent's branch, matures, and then drops into the water where it floats to a shallow mud bank and roots itself.

Manatees in Mangrove Forests

- Large sea mammals live in the tidal creeks of mangrove forests.

- Manatee numbers are now growing but still face challenges from:
  - Habitat and food destruction through coastal development
  - Pollution
  - Propeller strikes

Figure 12.16a: The manatee is a large marine mammal that grazes on sea grass in coastal waters.

Coral Reefs

- A **coral reef** is created by carbonate-secreting organisms.
- It is a wave-resistant, rock-like structure.
- Most of the reef is composed of loose to well-cemented organic debris of carbonate shells and skeletons.
- The living part of the reef is just a thin layer on the surface.

Corals

- Corals belong to the phylum Cnidaria.
  - The animal is the coral polyp.
  - The corallite is the exoskeleton formed by the polyp.

Figure 12.17a: Coral polyps are shown in the act of feeding.

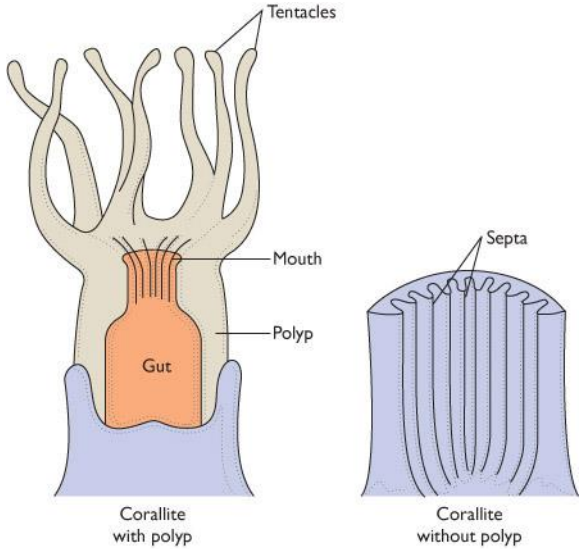


Figure 12.17b: The coral polyp has a saclike body that sits in a rigid carbonate cup. The mouth also serves as an anus; it is surrounded by stinging tentacles.

Corals (Continued)

•Corals share a **mutualistic** relationship (mutually beneficial) with photosynthetic **zooxanthallae** (unicellular algae).

•Zooxanthellae live within the tissue of the polyp.

– They can comprise up to 75% of the polyp's body weight.

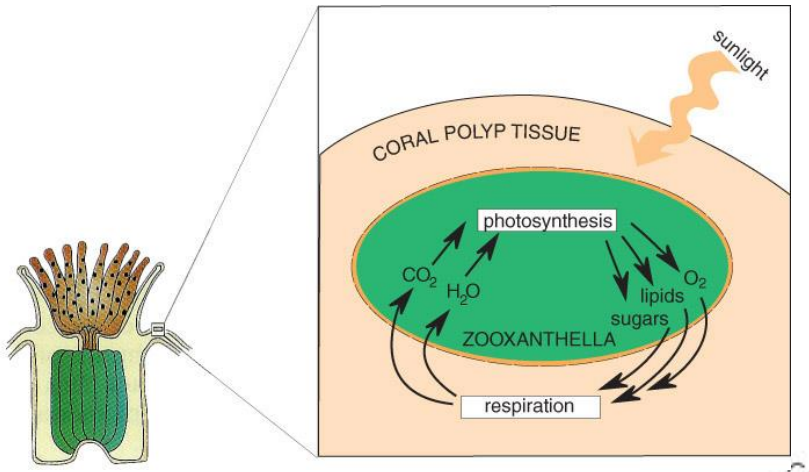


Figure 12.17d: Coral polyps provide water and CO2 to the zooxanthellae, which in turn provide sugar and O2 to the coral.

Corals (Continued)

- Corals can be either solitary or colonial.

- Coral reefs flourish in water that is warmer than 20°C
  - They are found in tropical and subtropical latitudes.

- Corals cannot survive in fresh, brackish water or highly turbid water.

- Corals do best in nutrient poor water.
  - They are easily out-competed by benthic filter feeders in nutrient-rich water (where phytoplankton and seaweed are abundant).

Coral reefs around the world

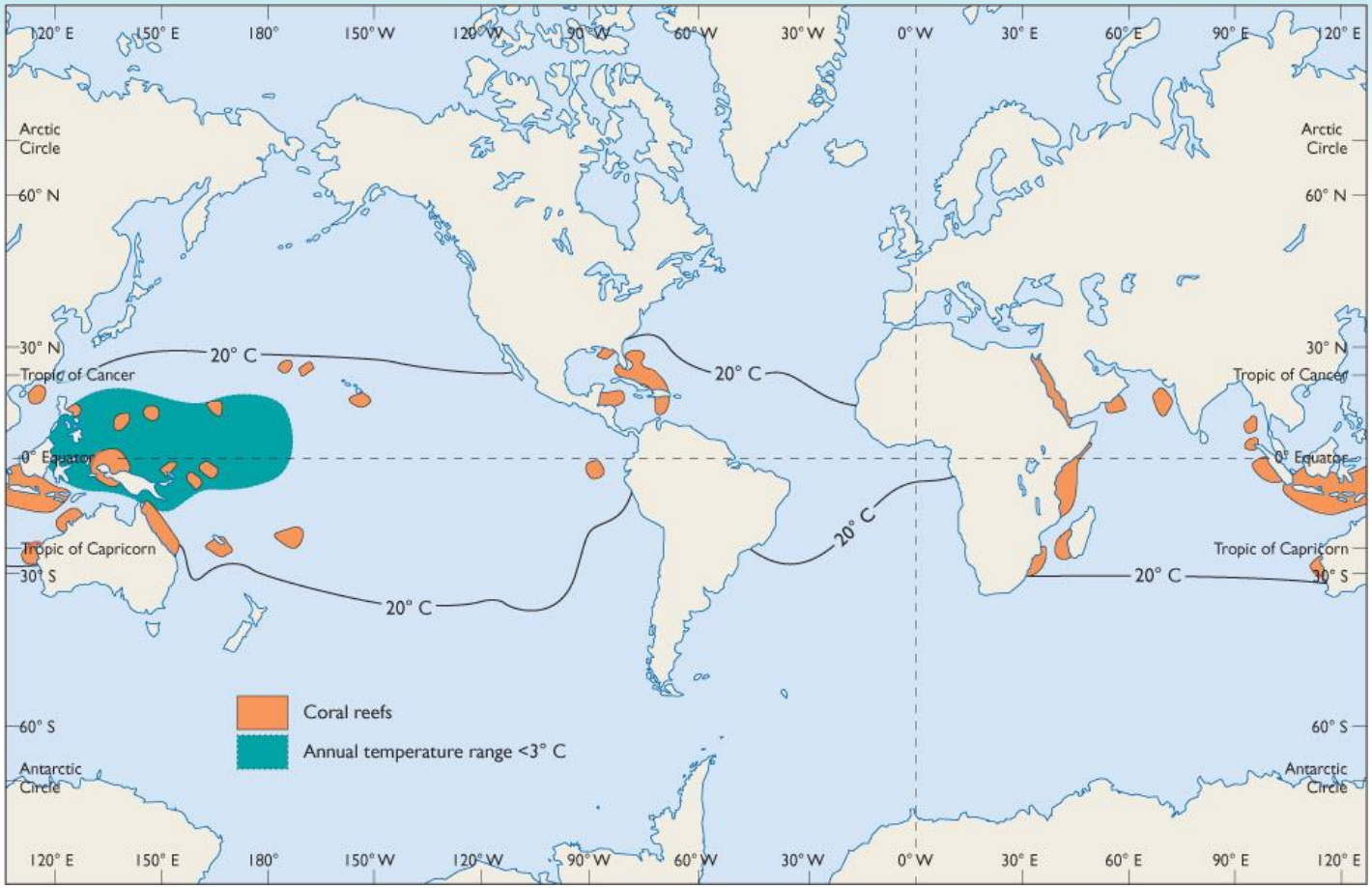


Figure 12.19: The 20° C isotherms delimits the poleward extent of coral reefs, with few exceptions.

Coral reef ecosystem

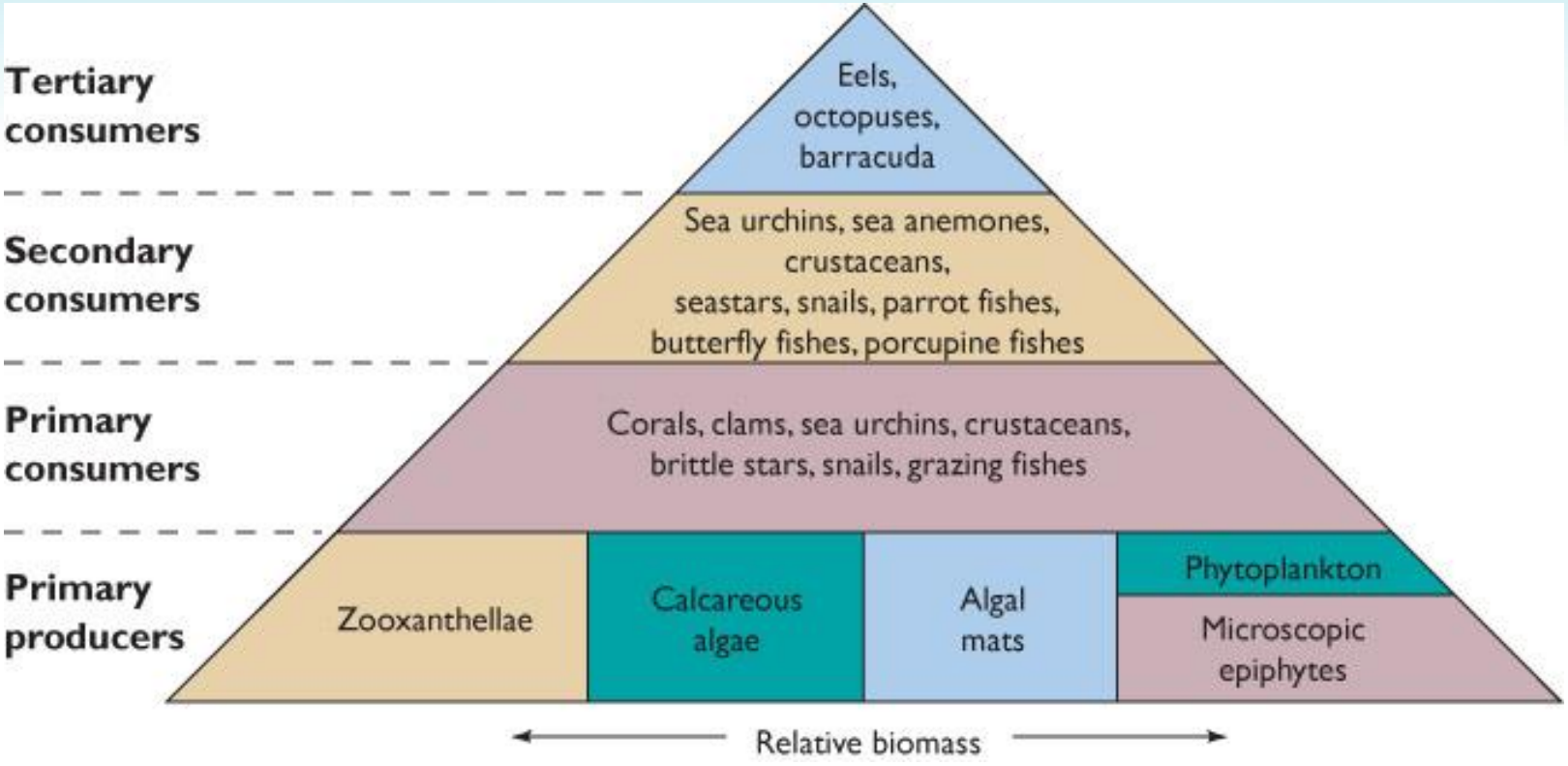


Figure 12.18: Members of a coral reef can be arranged in a simple four-level pyramid, based on trophic relationships.

Coral Growth Forms

Encrusting coral, Branching coral, Brain Coral

Figure 12.21a: Encrusting coral.

Figure 12.21b: Flat branching coral.

Figure 12.21c: Brain coral.

Figure 12.21d: Delicately branching coral.

Figure 12.21e: Robust branching coral.

Coral reefs consist of several distinct parts developed in response to their exposure to waves

- The **algal ridge** occurs on the windward side of the reef and endures the pounding waves.
- The **buttress zone** is the reef slope extending down from the algal ridge.
- The **reef face** extends downward from the buttress zone.
  - Not many colonial corals live here because insufficient light reaches this depth.
- The **reef terrace** is located landward of the algal ridge and lies at mean water level.

The Morphology and Structure of Coral Reefs

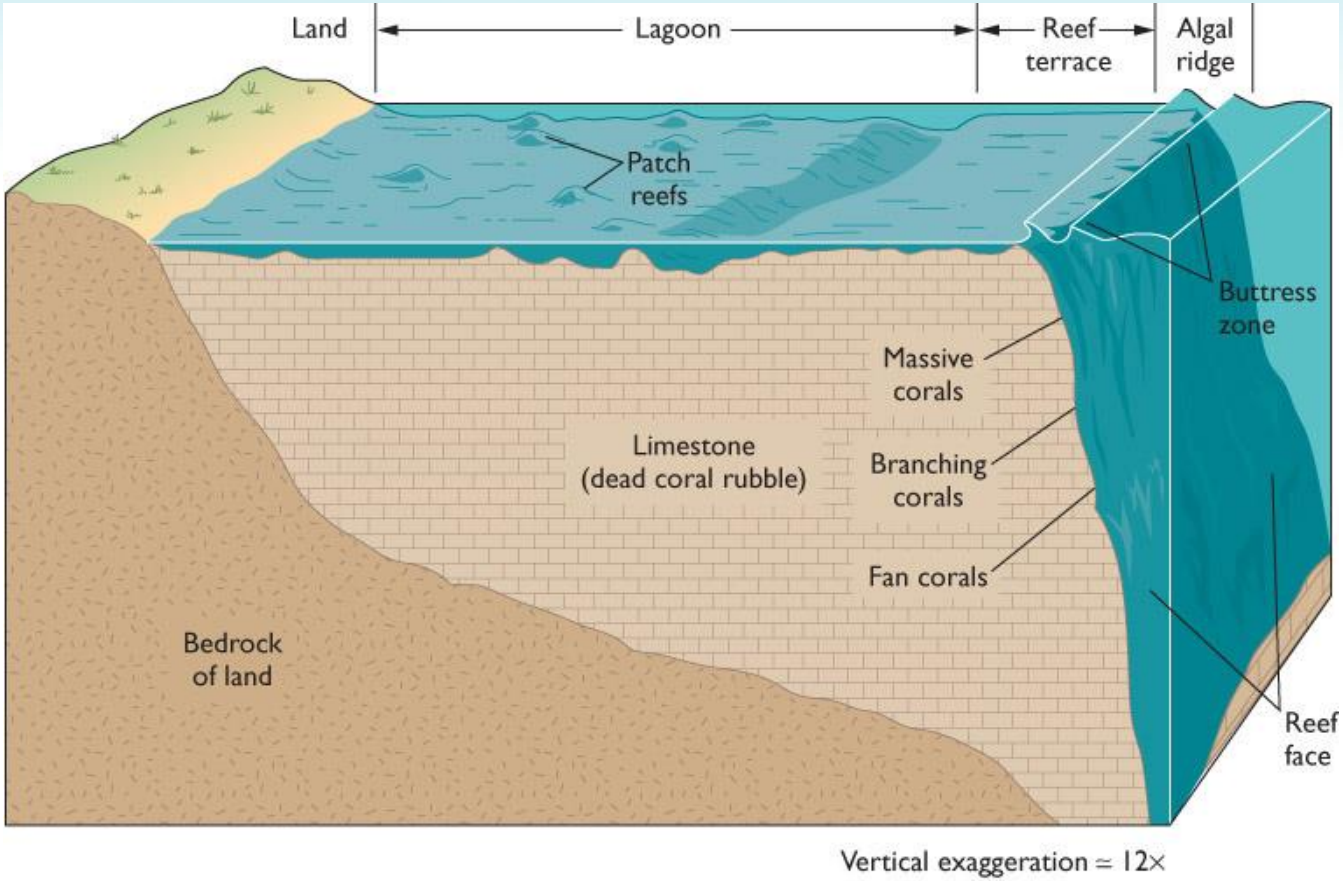


Figure 12.20a: The coral reef is divided into distinct topographic elements, the algal ridge, buttress zone, and the lagoon.

Common Reef Fishes

1) Nurse Shark
2) Reef Shark
3) Barracuda
4) Surgeonfish
5) Butterfly Fish
6) Angelfish
7) Hawkfish
8) Grouper
9) Moray Eel
10) Stingray
11) Grunt
12) Soldierfish
13) Porcupinefish

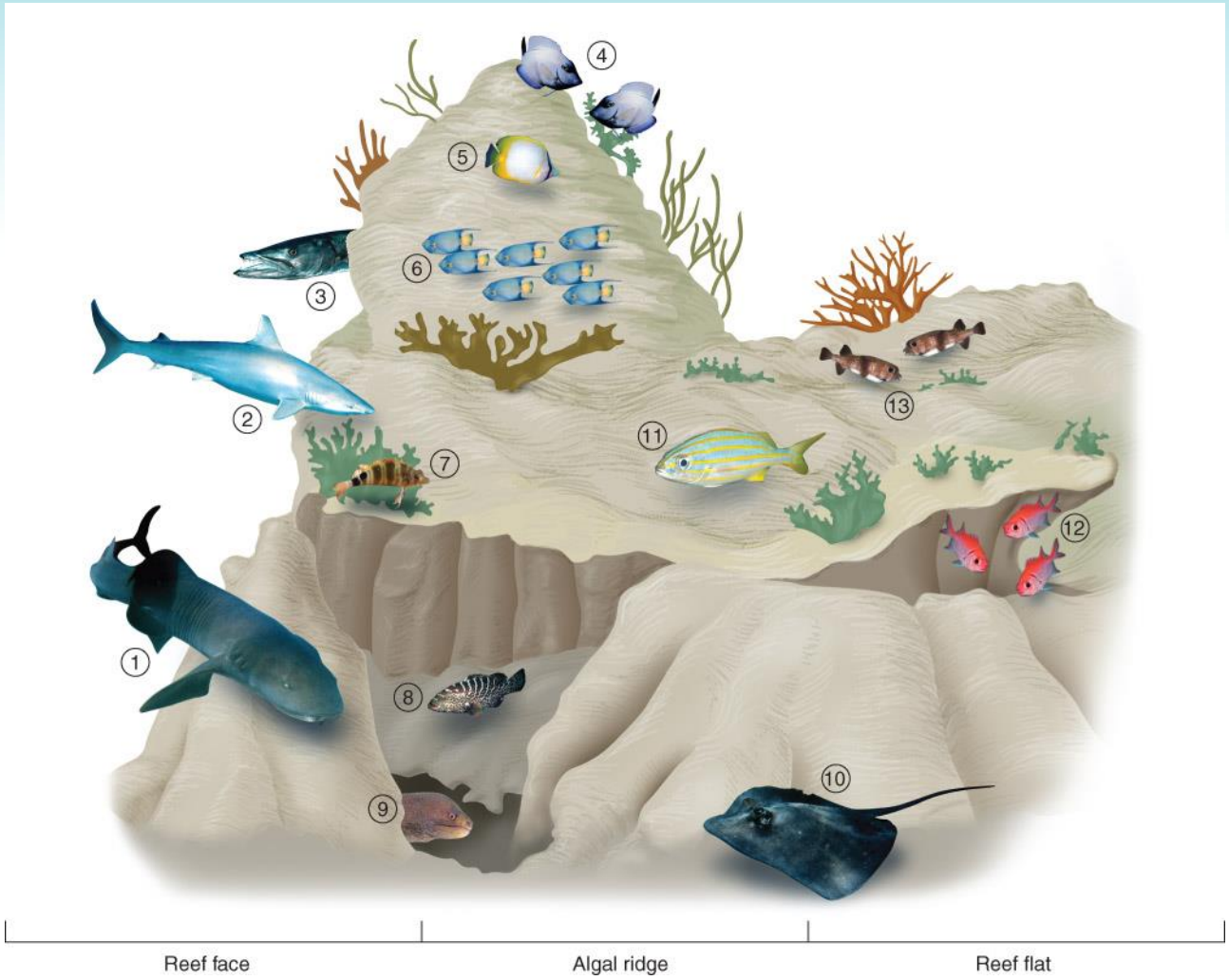


Figure 12.22: These are common fishes that inhabit Caribbean reefs.

Common Reef Fishes

Figure 12.23a: Grouper

Figure 12.23b: Angel Fish

Figure 12.23c: Soldier Fish

Figure 12.23d: Lion Fish

Figure 12.23e: Parrot Fish

Coral Growth

•Corals grow continuously upward towards the sunlight.

•As sea level rises and/or land subsides, coral reefs pass through three stages of development.

- Fringing Reef
- Barrier Reef
- Atoll

Reef Development

- **Fringing reefs** form limestone shorelines around islands or along continents
  - They are the earliest stage of reef development.

- As the land is progressively submerged and the coral grows upward, a shallow lagoon expands.
  - When the lagoon begins to separate the fringing reef from the shoreline, a **barrier reef** is created.

- In the final stage, the land vanishes below the sea and the reef forms a ring of islands, called an **atoll**, surrounding a shallow lagoon.

Evolution of Coral Reefs

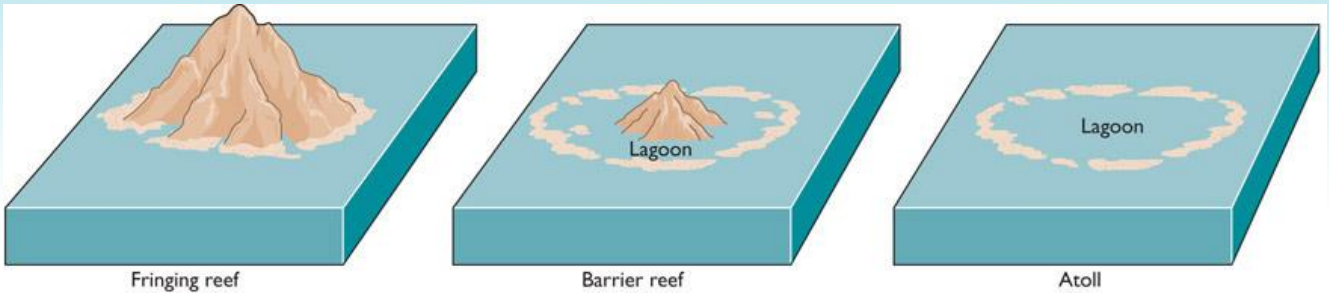


Figure 12.24a: There are three different types of coral reefs; the fringing reef, the barrier reef, and the atoll.

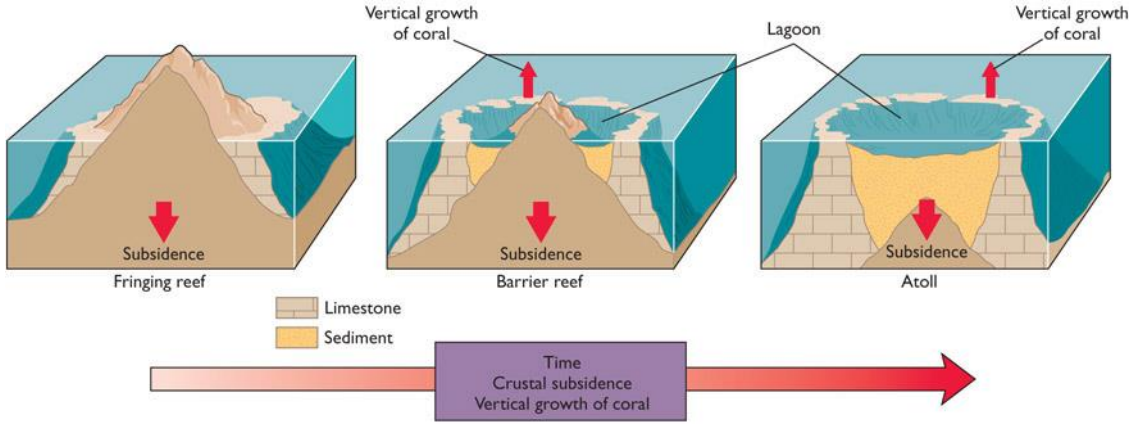


Figure 12.24b: As Charles Darwin proposed, volcanic islands were first populated by organisms living in fringing reefs that grew around their perimeters.