# Ocean-Atmosphere Interaction

## Ocean Surface Currents

**North Atlantic Subtropical Gyre**

Gulf Stream - North Atlantic - Canary - North Equatorial

**South Pacific Subtropical Gyre**

South Equatorial - East Australian - Antarctic Circumpolar - Peru

**Upwelling**

Upward movement of cold, nutrient-rich water (high productivity) to the surface.

**Downwelling**

Downward movement of surface water to deeper parts of the ocean.

**Current Divergence**

Surface waters move away from an area on the ocean's surface, along the equator. (Reason of Equatorial Upwelling)

**Converging Surface Water**

Occurs when surface waters move toward each other.

**Coastal upwelling and downwelling**

Produced by winds that parallel to the coast.

- For Northern Hemisphere, the direction of Ekman flow is 45 degrees clockwise to the direction of wind.
- For Southern Hemisphere, the direction of Ekman flow is 45 degrees counter-clockwise to the direction of wind.

**Factors Causing Upwelling (Downwelling)**

1. Offshore winds
2. Sea floor obstruction (tablemount)
3. Sharp bend on coastline

**Ekman Transport**

Caused by coastal winds, drives surface water away from the west coasts of continents.

# Deep Ocean Currents

### Difference between sea water and pure water

Taste salty, more alkaline, denser, harder to freeze.

### Factors affecting seawater density

Temperature, Salinity, Pressure.

### Function of Oceanic Conveyor-belt

Prevent extreme temperature of certain area; avoid eutrophication or lack of nutrient in certain areas. Transporting heat and substances around.

# El Nino Southern Oscillation (ENSO)

### Walker circulation cell (Under Normal Conditions)

- At East Pacific Area: High air pressure, clear, fair and dry weather, colder surface water.
- At West Pacific Area: Low air pressure, plentiful precipitation, warmer surface water.
- Abundant upwelling on the East Pacific area.
- Thermocline shaped like ／ from West to East

### El Nino Year

1. Weaker Equatorial Current from East to West
2. Reduction of upwelling at East Pacific
3. More precipitation is drawn from Central / East Pacific area
4. Warmer sea water on East Pacific
5. Drought on West Pacific

### La Nina

Stronger Walker Circulation take place, while stronger trade winds causes more upwelling. A band of cooler than normal water stretches across the pacific equator.

# Typhoon, Hurricane and Tropical Storm

### Saffir-Simpson Scale

Classify tropical storms according to their maximum sustained wind speed.

### Structure of Typhoon

Eye - Eyewall - Spiral rain band - Rain-free area

What to experience when crossing a cyclone?

- Change in win direction and speed: Increase - Maximum - Reverse Maximum - Decrease
- Changes in surface temperature and air pressure: 不知道
- Changes in weather condition: Sunny - Rain - Sunny - Storm - Very Sunny - (Repetition)

### Conditions favor the hurricanes formation

- Sea temperature above 27 degrees to 60 meter depth
- Lower pressure area far enough from equator
- No wind shear

### Path of Typhoon

1. Form from high sea surface temperatures
2. Influenced by trade winds, travel from east to west
3. Curve to the right due to Coriolis Effect (North Hemisphere)
4. Prevailing westerlies causing to move west to east
5. Energy source cut off by land or cooler water

### Storm Surge

An abnormal rise of up to several meters in the ocean level. Damaging when coinciding with high tides.

# Marine Carbon Cycle

### Ocean's Biological Pump

$CO_2$, Incorporated through photosynthesis, secretion of carbonate shells.

### Physical Pump

Downwelling process of carbon dioxide through diffusion, increasing acidity from up to down

### Biological Pump

Driven by ocean phytoplankton, absorbing carbon dioxide through photosynthesis.

# Interactions between oceans and coastal places

## Wave and wave processes

**Crest**

The tops of a wave.

**Trough**

The bottoms of a wave.

**Frequency**

Number of wave crests passing a specific point each second.

**Period**

Time required for wave crest to travel one wavelength

**Surf zone**

The area when waves approach at the shore. *Encountering water depths of less than one-half wavelength.*

- Wave speed decreases
- Waves stack up against the shore
- Wavelength decrease
- Wave height increase
- Wave steepness increase
- Wave pitch forward and break in surf zone

**Types of Breakers** 碎浪的不同种类

- Spilling breaker (Horizontal beach)
- Plunging breaker (Steep beach)
- Surging breaker (Very steep beach)

**Longshore current** 沿岸流

A type of current that moves water along a *zigzag* pattern along the shoreline.

- Cause a net movement of sand grains from upcoast to downcoast ends of a beach

**Longshore Drift** 沿岸飘砂

Sand grains that are moved along the shoreline.

**Groyne (Breakwaters)** 防波堤

A wood or concrete bar built manually on the beach, pointing away from the land.

- Encourage the local accumulation of sand to strengthen the buffering effect.

**Wave Refraction** 海浪折射

- Erosion on headlands
- Deposition in bays

Use orthogonal lines to indicate the direction of the waves travelling.

**Abrasion / Corrasion**

Wearing away of the shoreline by material carried by the waves.

**Wave pounding (Hydraulic Action)**

(The formation of cavitation 气穴) As waves break cliff face, the air trapped in cracks, joints and bedding planes would placed under great pressure, when the pressure release, the pressure is released explosively.

**Solution / Corrosion**

Dissolving of limestones by carbonic acid. Source from organism which secrete organic acids.

# Interaction between Oceans and Coastal Places

**Features of Erosional Shores**

- Wave-cut bench 海蚀台地
- Cove 小湾
- Sea Arch 海蚀拱
- Sea cave 海蚀洞
- Headland 海岬
- Sea stack 海蚀柱
- Blowhole 吹蚀穴

- Sea Cliffs 海蚀崖
- Wave-out Notch 海蚀刻槽

**Formation of Sea Arch / Sea Stack / Sea Cliff**

1. Wave refraction cause erosion on sides of headlands. Weaknesses such as joints or cracks are exploited, forming caves.
2. Enlarged caves are eroded further to form a arch.
3. Continuous erosion caused the roof of the arch to collapse and form a sea stack.

**Formation of Wave-cut Platform**

1. The original cliff experienced abrasion and corrosion, causing the whole cliff to retreat
2. The remains of the cliff forms a wave-cut platform, which is just below the sea level.
3. Such platform would reduce the energy of the waves, reducing the further extension of wave-cut platform.

**Formation of Marine terrace**

Flat platform backed by cliffs, form when a wave-cut platform exposed above sea level.

**Stranded beach deposits**

Exist meters above present shoreline, indicate the former shoreline has risen above sea level.

**Sub-aerial processes (land-based process which alter the shape of the coastline)**

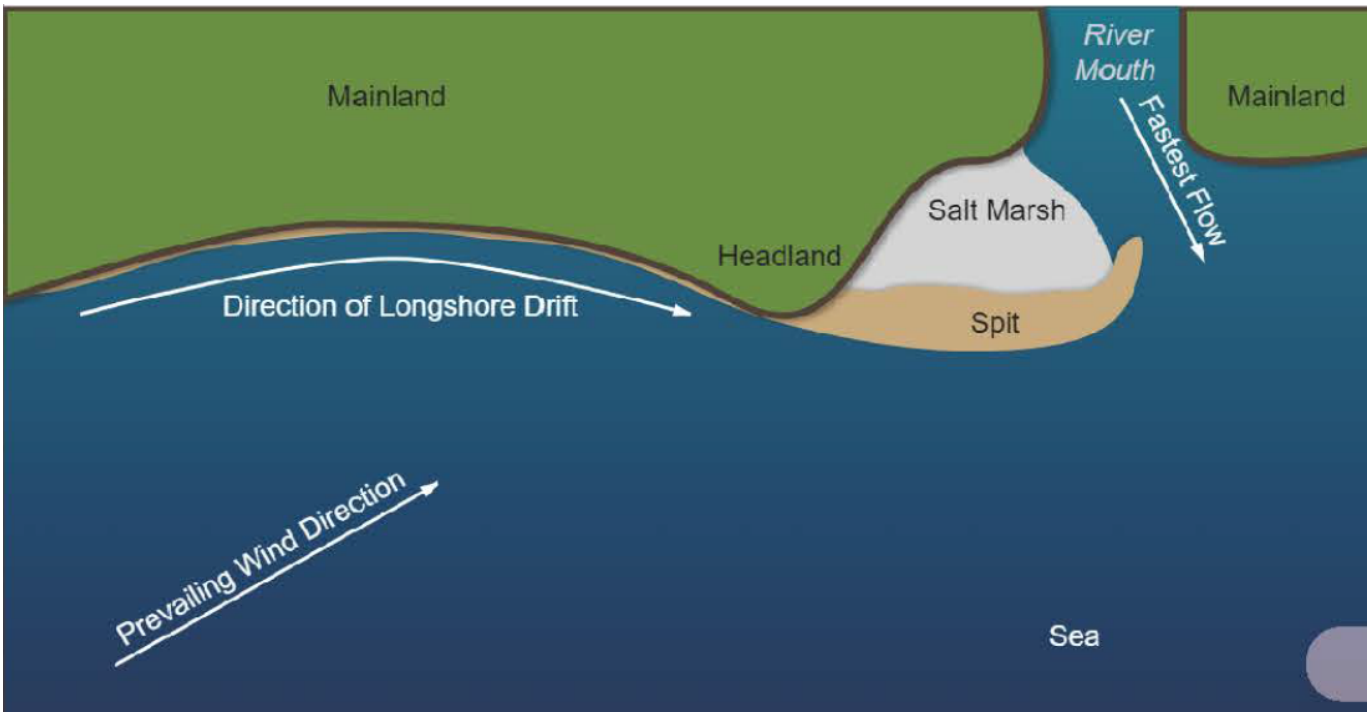
- Salt weathering: The process by which sodium and magnesium compounds expand in joints and cracks, thereby weakening rock structures.
    1. Saline water enters pore spaces, forming salt crystals.
    2. The growth of crystals exert stresses on the rock, causing it to shatter.
    3. Development of weathering pits 风化坑.
- Freeze-thaw weathering The process whereby water freezes, expands and degrades jointed rocks. Usually happen at where temperature fluctuates around 0 degrees
    1. Daytime: Water entering the crevices.
    2. Cold nights: Water freezes. Due to more volume ice occupies, it exerts pressure on crevices.
    3. Causing crevices and shattering pieces of rock from the main part.
- Biological weathering Carried out by mollusks, sponges and sea urchins. (Important on low-energy coasts)

- Solution weathering Chemical weathering of calcium by acidic water, tends to occur in rock pools due to organism secreting organic acids.
- Mass Movement Slumping and rockfalls.
    - **Rockfalls** May result from extreme weathering, storm wave action or earthquakes.
    - **Slides** Main cause of cliff retreating. Favors rocks that are jointed or having bedding planes parallel to the angle of slope.

# Functions of Depositional Shores

### Spit

Linear ridge of sediment, extends in the direction of *longshore drift*, from land into deeper water near the mouth of a bay.




### Bay Barrier

Form when the river runoff or the tidal currents of the bay is not fast enough to stop the spit from growing. The spit would extend across the bay and connect to the mainland. Often enclosed a *Lagoon*.

| | Constructive Wave | Destructive Wave |
|---|---|---|
| Feature | Swash > Backwash | Swash < Backwash |
| Wave size | Small with low energy | Large with high energy |
| Length | Long | Short |
| Height | Low | High |
| Sea-bed Gradient | Low | High |
| Frequency | Low | High |
| Offshore Bar | No | Yes |

# Coastal Sand Dunes

### Factors favor the formation of sand dunes

- Reliable supply of sand
- Strong onshore winds
- Large tidal range
- Vegetation
- Low gradient

### Types of Dunes

- Mobile Dunes
    - Embryo dunes
    - Fore-Dunes
    - Yellow Dunes
- Fixed Dunes
    - Grey dune
    - Dune slack
- Heath / Woodland

# Interactions between oceans and coastal places

### Advancing and Retreating shoreline

字面意思

### Eustatic sea level change

Change due to total seawater volume or ocean basin capacity.

**Tectonic movement**

Uplift or subsidence of continents, with continental crust's folding, faulting or tilting.

**Isostatic Adjustment** 地壳均衡学说

1. Continents sink due to heavy load of ice / piles of sediment / outpourings of lava.
2. Continents rise when these loads are removed.

**Emergent Coastlines** 出露海岸

Form as former marine landforms, including *fossil cliffs* and *raised beach*.

**Submergent Coastlines**

- Drowned beaches of wave-cut benches
- Submerged dune topography
- Drowned river valleys.

**Fjord** 峡湾

Formed by drowning of glacial troughs, features a *Deep* and *Steep-sided* estuary.

1. Glaciers on hills form a U-shaped valley when they slide downhill, named glacial troughs.
2. After the ice melted, the glacial troughs were flooded by eustatic rise.
3. Long, deep, narrow inlet with precipitous sides and hanging valleys were formed.