OCES Revision

STsAiR

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Contents

Chapter 1

Module 1 Physical Characteristics of the Ocean

1.1 The Ocean: What is it and why study it

The Ocean and atmosphere redistribute the excessive heat rceived by the Earth's surface via ocean/ atmosphere circulations.

1.2 Approaches to studying the Ocean

Approaches:

1. Observation: Research Vessel, CTD, Drifters (to meansure ocean currents), Argo Float (Temperature and Salinity) and Head-mounted Sensors.
2. Lab Experiments: Water Tank
3. Modelling: High-Performance Computers (HPC) (Cheaper)

1.3 Oceanic Flows

1. Wind-driven Circulation (Upper Ocean):

- Process in which surface winds push ocean water.
- Wind direction in the equator is from East to West.
- Warm current flows poleward and cold current flows equatorward.

2. Ocean Gyres (Mid-latitude):

- Wind-dricen circulation that is blocked by continental land.

3. Circumpolar Currents/ Antarctic Circumpolar Current (ACC) (Southern Ocean):

- Wind goes from West to East.
- Currents that will not blocked by continental land.

1.4 Temperature, Salinity and Stratification

1. Sea Surface Temperature (SST) decreases from low latitude.
2. The saltiest regions are mainly in the subtropical areas.
3. In polar regions there are also substantial salt fluxes due to sea ice freezing and melting.
4. Salnity decreases from surface to 1500m − 2000m then increases again below 1500m − 2000m
5. The Ocean Density is determined by both temperater and salinity. (Bowl-shaped pattern)
6. The density increases toward high latitude and deeper ocean.

1.5 Impacts of Stratification on Oceanic Flows

1. Ocean Stratification:

- Sea water mainly follows constant density surfaces, rather than constant depths.

2. Ocean Subduction:

- Wind-driven Gyres actually run deeper by sliding down the bowl of ocean density.

1.6 Where and how water sinks from surface to bottom

1. Wind-driven Circulation (Upper Ocean):

- More horizontal
- Driven by winds
- Transports ward/ cold water toward colder/ warmer parts of the Earth

2. Overturning Circulation (Surface and Deeper Ocean):

- More vertical
- Driven by air-sea heat exchange and by salt input via ice formation
- Transports water, heat, saltm carbon dioxide, nutrients to deep sea

3. Dense water sink in Polar regions

1.7 Where and how water rises from bottom to surface

Internal Waves can cause "Dead Zone" and it rise in the ocean interior via wave breaking. It drive the bottom water upwards across density surface.

1.8 Mesoscale Eddies

1. Size: $100 - 200$km
2. Velocity: 1 m/s or higher
3. Duration: Several weeks to months
4. It can trap cold/ warm water and bring heat from one place to another.
5. It can be find everywhere in the ocean.

1.9 MC Question

1. Where does dense water sink in the global ocean?
   (a) Polar region
   (b) Subtropical region
   (c) Termperate region
   (d) Tropical region
2. Which of the following is/are NOT blocked by lands?
   (a) Ocean gyres and circumpolar currents
   (b) Circumpolar currents
   (c) Ocean gyres
   (d) Ocean gyres or circumpolar currents, depending on the location.
3. Which of the following statements is NOT true?
   (a) Wind-driven circulation transports water to deep ocean along constant density surfaces

(b) Wind-driven circulation is driven by heat and salinity

(c) None of the other answers is correct

(d) Compared with wind-driven circulation, overturning circulation is more vertical

4. Over most of the ocean, the surface salt fluxes are related to

(a) warm and cold currents.

(b) wind direction.

(c) rain and evaporation.

(d) current direction.

5. People at sea sometimes found their vessels unmovable no matter how they fire the engines. This could be due to the presence of

(a) circumpolar currents.

(b) surface currents.

(c) mesoscale eddies.

(d) internal waves.

6. Which of the following statements is true?

(a) Excessive heat received by Earth's surface at the equator is re-distributed to other regions by the atmosphere only.

(b) Excessive heat received by Earth's surface at the equator is re-distributed to other regions by the ocean and the atmosphere.

(c) Excessive heat received by Earth's surface at the equator is re-distributed to other regions by the ocean only.

(d) The ocean and the atmosphere are not involved in the heat distribution across different regions of the Earth.

7. In what way do Mesoscale Eddies impact the ocean temperature?

(a) Mesoscale Eddies transport warm water only from one place to another in the ocean.

(b) Mesoscale Eddies transport cold water only from one place to another in the ocean.

(c) Mesoscale Eddies are not related to ocean temperature at all.

(d) Mesoscale Eddies transport cold or warm water from one place to another in the ocean.

8. Sea Surface Temperature

(a) remains largely unknown due to the lack of study.

(b) remains the same across different latitudinal zones.

(c) decreases from equator to poles.

(d) decreases from poles to equator.

9. How do ocean gyres adjust heat distribution of the ocean?

(a) Ocean gyres are not related to heat distribution in the ocean.

(b) Through warm current only.

(c) Through warm and cold currents.

(d) Through cold current only.

10. In polar regions, the salt fluxes are related to

(a) air temperature.

(b) wind and current directions.

(c) cold current.

(d) sea ice freezing and melting.

Chapter 2

Module 2a Glimpse of Marine Life

2.1 The Phylogeny of Marine Life

1. Life originated from hot and chemically-rich early Ocean
2. Life evolved from inorganic molecules to organic molecules to functional independent units
3. The three-domain system of phylogeny:
   (a) Prokaryotes (No organelle)
      → Bacteria
      → Archaea
   (b) Eukarya
      → With organelles with contain DNA
      → Evolved from Prokaryotes

2.2 Bacteria

1. Usually single-celled and lack a membrane-bound nucleus
2. Uniquitous and some live in extreme environments
3. Bacterium is one type of microorganism
4. Shapes and Arrangement:
   (a) Cocci: spherical
   (b) Bacilli: rods

(c) Vibrios: resemble rods, comma-shaped

5. Common features:

   (a) Cell envelope:
   - Plasma membrane
   - Cell Wall
   - Capsule

   (b) Cytoplasm

   (c) External structures

2.3 Archaea

1. Bacteria and Archaea cannot be distinguished by simple microscopy
2. They can be distinguished by unique rRNA gene sequences
3. Archaea are lack peptidoglycan in cell walls
4. They have unique membrane lipids
5. Some of them have unusual metabolic characteristics
6. They have different distributions:

   (a) Bacteria more abundant at top of ocean

   (b) Archaea more abundant at bottom of ocean

2.4 Phytoplankton

1. Two lifestyles of marine life:

   (a) Plakton:
   - Wandering, drift or swim weakly, unable to move consistently, such as shrimp

   (b) Nekton:
   - pelagic organisms that actively swim, such as fish

2. Phytoplankton:

- They can be both Eukaryotes and Prokaryotes
- They are autotropic plankton that generate glucose by photosynthese – the primary producers.
- They gets carbon from carbon dioxide and energy from sunlight.

3. Phytoplankton generate a large amount of atmospheric oxygen.
4. Major types of Phytoplankton:

- Picoplankton
- Diatoms
- Dinoflagellates
- Coccolithophores

2.5 Seaweeds and Marine Plants

1. Both Seaweeds and Seagrasses are important primary producers and Eukaryotics
2. And they provided food and shelter to marine animals
3. Seaweeds:

- Also known as Marine algae/ Macroalgae
- Have blade, stipe, and holdfast
- Can be used in dairy products (such as carrageenan)
- Can be used in culture microorganisms (such as agar)

4. Seagrasses:

- They are true plants that grow entirely underwater
- Trhy have flower, rhizome, and roots
- Around 60 species
- Pollen and tiny seeds are carried by water current or the face of animals

5. Kelp is a type of brown Seaweed, and the largest seaweed
6. It can be found in temperature and polar location

2.6 Animals

1. Invertebrates:
   (a) Animals without a backbone
   (b) Around 97% of anumals are invertebrates
   (c) They do not have nervous system and brain but can reproduce

(d) They can be found on ocean floor attached to solid rocks

(e) There are numerous tiny pores for filter feeding on plankton and organic matter and carries wastes away

2. Vertebrates:

   (a) Animals with a backbone

   (b) Fish:

   - Largest group of vertebrates
   - Over than half of 32000 known species of fishes are marine

   (c) Reptiles

   - Air-breathing, they have lungs instead of gills
   - They are "Cold-blooded"
   - Their body are covered with scales
   - They may lay eggs on land

   (d) Mammals:

   - They are "Warm-blooded"
   - They are active predators at the top of the food chain

2.7 Viruses

1. Virus is a noncellular particular that must infext a host to reproduce
2. They are everywhere and part of our daily lives
3. Each species of virus infect a particular group of host species
4. The viral capsid is composed of repeated protein subunits
5. The capsid packages the viral genome and delivers it into the host cell
6. Differrent virus make different capsid forms
7. Most of they are formed with "Head" and "neck"
8. The biomass of viruses are relatively low, but the abundance of viruses are the highest
9. Importance of virus:

- Limiting host population density
- Selecting for host diversity

2.8 MC Question

1. Which of the following is NOT a characteristic of marine mammals?
   (a) Give live birth.
   (b) Breathe air.
   (c) Cold-blooded.
   (d) Produce milk for the young.
2. Which of the following statements is NOT true?
   (a) None of the other answers is correct.
   (b) Some seaweeds are commercially important.
   (c) Seagrasses are true plants.
   (d) Kelp forests are highly productive.
3. Which of the following is NOT a characteristic of marine reptiles?
   (a) None of the other answers is correct.
   (b) Body covered with scales.
   (c) Breathe air.
   (d) All species lay their eggs in water.
4. Invertebrates include the following, EXCEPT
   (a) reptiles.
   (b) sponges.
   (c) octopuses.
   (d) sea stars.
5. Kelps belong to the following, EXCEPT
   (a) brown algae.
   (b) flowering plants.
   (c) none of the other answers is correct.
   (d) eukaryotes.
6. Which of the following is NOT an ecological role of phytoplankton in the marine environment?
   (a) Primary producers.
   (b) Primary consumers.
   (c) Food for primary consumers.
   (d) None of the other answers is correct.

7. Viruses are important in all ecosystems because

   (a) they can kill their hosts such as bacteria.
   (b) they help some host species to dominate over others.
   (c) some of them are primary producers.
   (d) they help balance the diversity of host species.

8. Seagrasses are important in the marine ecosystem because of all of the following, EXCEPT

   (a) Seagrasses produce oxygen and absorb carbon dioxide through photosynthesis.
   (b) Seagrasses provide shelter for many marine animals.
   (c) None of the other answers is correct.
   (d) Seagrasses provide food for many marine animals.

9. Which of the following statements is NOT true?

   (a) None of the other answers is correct.
   (b) There are only a few truly marine plant species.
   (c) All phytoplankton are eukaryotes.
   (d) Archaea are prokaryotes.

10. Viruses

    (a) are low in abundance in open ocean.
    (b) all of the other answers are correct.
    (c) must infect a host cell to reproduce.
    (d) are high in biomass in open ocean.

Chapter 3

Module 2b Glimpse of Marine Life and Interactions

3.1 The Marine Food Web

1. The Marine Food Chain:

- Primary Producers

→ Using sunlight and CO_2 to rpoduce their own food

2. Consumers: Consume other living organisms
   (a) Primary Comsumers
   → Feeding on primary producers, Herbiovres (plant-eating)
   (b) Secondary Comsumers
   → Feeding on primary consumers, Carnoviores (meat-eating)

- Decomposers

→ Break down waste by feeding on dead tissues of plants and animals, such as bacteria, sea worms and sea slugs

3. Energy lost: excretion and respiration

4. On average, only 10% of the nutrients and energy is transferred fromt he trophic level to the next.

3.2 Modes of Nutrition in the Marine Environment

1. Autotropic − Production only
2. Heterotroph − Consumption only
3. Mixotroph − Both production and consumption, such as bacteria and plankton

3.3 Photosynthesis

1. Photoautotrophs:

- Autotrophs use sunlight as energy source

2. Chemoautotrophs:

- autrophs may use energy stored in chemical compounds for the synthesis of organic food

3. Photosynthesis:

- The Chlorophyll receives sunlight and release chemical energy ATP to turn H_2O + CO_2 into O_2 and gluvose/ sugar

4. The remaining organics are accumulated in the photoautotrophs for production of biomass such as growth
5. Gain in biomass (growth) = Primary Production
6. Rate of primary production = Primary Productivity
7. Data of primary productivity are important not only for scientific understanding of the ocean but also for management of fisheries resources.
8. Primary production regulates the gaseous composition in the atmosphere

3.4 Absorption of Dissolved Organic Matter

1. Dissolved Organic Matter (DOM) is organic waste in the seawater.
2. Photoautotrophs are the most important producers of DOM
3. Microorganisms are the most important contributor of DOM
4. Viral shunt accelerates the release of DOM and helps to balance the ecosystem (avoiding dominance by certain species)

3.5 Detritus Feeding

1. All life in the ocean produce detritus, such as decaying waste or debris rich in nutrients from marine life
2. Detritus are suspended in the seawater ot deposited on the ocean floor
3. Detritus is an important food source for many different types of marine organisms, from heterotrophic microbes to invertebrates
4. Detritus come from solid waste of marine animals or dead biomass of both marine plant and anumals
5. DOM is dissolved while detritus exists in the form of particulates
6. When the detritus im the seawater column is drawn to the ocean dloor by gravity, it formed Marine Snow and they are important food source for the deep sea community
7. Heterotrophic bacteria attached to detritus
8. Types of detritus feeders:

→ Invertebrates:

(a) Suspension Feeders:
- Animals that feed on particles floating (suspended) in the water

(b) Filter Feeders:
- Suspension feeders that actively filter food particles

(c) Deposit Feeders:
- Animals that feed on organic matter that settle on the bottom

→ Active feeding (consume marine snow):

(a) fish

(b) zooplankton

3.6 Predation

1. predator and prey interact and never-ending co-evolve
2. Predator is the source of mortality for prey while prey is a source of nutrient and energy for predator
3. Their population size are like sine and cosine curve
4. Predation tactics:

- Putsuit hunting

- Ambush (Sit and Wait) (involving Camouflage, which is change of color)

5. Prey's tactics:

- Behavior
- Camouflage (Protective coloration)

3.7 Scavenging

1. Scavengers (clean-up crew) consume dead body parts / tissues that are much larger in scale and they do not consume feces
2. Scavengers are important to nutrient recycling, through breaking down large pieces of dead tissues into smaller fragments (into feces) for detritivores
3. The feces produced by scanvengers are further utilized by detritivores
4. Nothing is wasted

3.8 Parasitism

1. Parasite and host undergo continuous co-evolution
2. Very often a parasite also uses the host's body as living habitat and site for reproduction
3. A parasite foes not intend to kill the host bu the host may suffer from disease due to secondary infection by bacteria or viruses
4. The cost of defense and the loss of nutrients to parasite are needed to balance

3.9 Proto-cooperation

1. Four stages of parasitism:
   (a) Parasitism
   - One-sided benefit, parasite harms the host

   (b) Commensalism
   - ONe-sided benefit without harming the host

   (c) Proto-cooperation
   - Mutual benefits and non-obligatory

   (d) Mutualism

- Mutual benefits and obligatory

2. Example of Proto-cooperation: The Hermit Crab lose food to the Sea Anemone while the crab can gain protection

3.10 Mutualism

1. The two parties are unable to live apart
2. Zooxanthellae provide organic food to corals while corals provided shelter for zooxanthellae

3.11 MC Question

1. Marine Snow is an important food source for the following, EXCEPT
   (a) zooplankton.
   (b) deep-sea communities.
   (c) fishes.
   (d) phytoplankton.
2. Heterotrophs include the following, EXCEPT
   (a) Zooplankton.
   (b) Bacteria
   (c) None of the other answers is correct.
   (d) Phytoplankton.
3. Which of the following statements is ture?
   (a) none of the other answers is correct.
   (b) In general, only 10% of biomass and energy is transferred from one trophic level to the one below.
   (c) In general, only 10% of biomass and energy is utilized by the organisms in each trophic level.
   (d) In general, only 10% of biomass and energy is transferred from one trophic level to the one above.
4. Which of the following is the key consumer of Dissolved Organic Matter (DOM) in the ocean?
   (a) Seagrasses.
   (b) Invertebrates.
   (c) Fishes.

(d) Microorganisms.

5. Which of the following associations involves one party noticeably taking excess resources from another party?

   (a) Parasitism.
   (b) Proto-cooperation.
   (c) Commensalism.
   (d) Mutualism.

6. Detritus

   (a) are part of the DOM in the marine environment.
   (b) are important food source for many marine organisms.
   (c) are a product of photosynthesis.
   (d) all of the other answers are correct.

7. Filter feeders feed on

   (a) detritus that are deposited on the seafloor.
   (b) All of the other answers are correct.
   (c) DOM
   (d) detritus that float in seawater.

8. Which of the following is NOT true about Predation?

   (a) Predator and prey populations cycle through time.
   (b) Predator and prey interact.
   (c) Predator and prey co-evolve.
   (d) None of the other answers is correct.

9. Zooplankton are

   (a) primary consumers.
   (b) top carnivores.
   (c) primary producers.
   (d) secondary consumers.

10. Seaweed, seagrasses and phytoplankton are

    (a) heterotrophs.
    (b) photoautotrophs.
    (c) mixotrophs.
    (d) chemoautotrophs.

Chapter 4

Module 3a Marine Ecosystems: Coastal Physical Processes

4.1 Characteristics of Coastal and Shelf Sea

1. Shallow Water Depth:
   (a) Wind effect:
   - Wind is inversely proportional to wind

   (b) Friction effect:
   - Bottom friction can be readily felt by water through the water column

   (c) Amplification of Tide and Tidal Current
2. Presence of Coastline:
   (a) Bloack the water on landside, resulting convergence or divergence
   (b) Sea-level increases/ decreases, and leads surge
3. Terrestrial influences (plume):

- Fresh water discharge from land forms higher sea level
- Change buoyancy and direction of the current
- Bring right inorganic nutrients and organic matter to enhance biological productivity

4. Open ocean influences:

- Due to large-scale circulation, eddies and internal wave.

4.2 Ekman Transport

1. The combined effect of wind forcing and Earch rotation leads to Ekman Transport (Drift)
2. It is the average current within the Ekman spiral with is x-axis = Ekman transport and y-axis = diretion of wind
3. It forms sea-level difference

4.3 Coastal Upwelling

1. Wind can induce Coastal Upwelling
2. When Ekman transport moves surface water away from the coast (land), surface waters are replaced by water that wells up from below
3. In the Northern Hemisphere, coastal upwelling can be caused by winds from the north blowing along the west coast of a continent
4. The water will be replaced by the upwelled cold, deep, nutrient-laden water
5. Ekman transport $\Rightarrow$ Upwelling $\Rightarrow$ High in nutrients $\Rightarrow$ Rich biological productivity (More than 50% of the world's annual commercial fishing occurs in the upwelling zone) $\Rightarrow$ Bursts of phytoplankton $\Rightarrow$ Build up of zooplankton $\Rightarrow$ Landing of fish

4.4 Coastal Downwelling

1. Areas of downwelling are often low in nutrients and therefore relatively low in biological productivity
2. Cold coastal water is transported downslope during downwelling
3. Coastal downwelling can be caused by winds from the south blowing and water move towards the coast, water piles up and sinks towards the bottom

4.5 Estuary and Estuarine

1. The place wherer lighter freshwater and heavier seawater meet formed estuary
2. Density difference between river and sea water and easterly or westerly winds

4.6 Circulation Classification of Estuaries

1. Since the seawater colume from coean is relaticely stable, the ratio or type of estuary is mainly determined by freshwater volume from the river
2. Salt Wedge Estuary:

- river volume larger than tidal volume

3. Highly Stratified Estuary:

- River colume comparable to tidal colume but still larger than tidal volume
- Create instability and internal waves
- A net upward transport of mass and salt
- The dense seawater seldom reaches the upper estuary

4. Slightly Stratified Estuary:

- River volume small compred to tidal colume Saltwater and freshwater mix at all depths
- Salinity is greatst at the mouth of the estuary, and decreasess upstream

5. Vertically Mixed Estuary:

- River volume insignificant compared to tidal volume
- Efficient turbulent mixing
- No distinction between upper and lower layers

4.7 Tides

1. It is caused by a combination of the gravitational force of the moon and sun and the motion of the Earth
2. Two types of tides:

- Flood Tide (High Tide)
- Ebb Tide (Low Tide)

3. Tide formed by the influence of moon and it is twien that of the sun's influence
4. Tidal Bulges form by the attraction of the Earth and the moon
5. Spring Tides are formed when Earth, sun and moon are aligned
6. Neap Tides are formed when Earch, sun and moon are at an angle to each other

4.8 Waves

1. Wave are created by energy passing through water, not water mass, transporting energy from one location to another across the ocean's surface.
2. Capillary waves, wind waves and swells are near surface due to the wind effects on the air/ water interface
3. Internal waves occur within the water not on the surface when vertical density variations are present
4. Tsunamis are very long waves generated by seismic disturbances of the sea bottom or shore
5. Gravity is the restoring force for most of the waves

4.9 MC Question

1. Which of the following statements is NOT true about coastal waters?
   (a) They are transitional systems between the land and the open ocean.
   (b) None of the other answers is correct.
   (c) Wind effect is weakened in coastal waters.
   (d) Coastal waters have relatively high biological productivity.
2. The freshwater discharge from land influences all of the following parameters of coastal waters, EXCEPT
   (a) the number of tidal cycle (s) per day.
   (b) salinity.
   (c) biological productivity.
   (d) sea level.
3. The presence of the coastline is important to
   (a) all of the other answers are correct.
   (b) coastal upwelling.
   (c) the sea level.
   (d) coastal downwelling.
4. Ekman transport
   (a) is caused by the water movement between the upper layer and the bottom layer.
   (b) none of these answers is correct.
   (c) turns the ocean current at 90° to the left of the wind direction.

(d) affects sea levels.

5. Which of the following is TRUE about coastal upwelling?

   (a) Coastal upwelling results in an even distribution of biologically productive zones across global oceans.

   (b) All of the other answers are correct.

   (c) Warm and nutrient-rich water in the ocean surface is brought offshore, which enhances the biological productivity in the open ocean.

   (d) Upwelling can be initiated by wind.

6. The formation of coastal upwelling and downwelling is related to the following, EXCEPT

   (a) Wind.

   (b) Ekman transport.

   (c) None of the other answers is correct.

   (d) Friction effect.

7. Coastal waters next to estuaries have relatively high biological productivity because of

   (a) terrestrial influences.

   (b) strong coastal upwelling.

   (c) its connection with the open ocean.

   (d) strong coastal downwelling.

8. Estuarine circulation

   (a) is formed because of the salinity difference between freshwater and seawater inputs.

   (b) is formed by river plume.

   (c) is formed by intensified wind forcing in the estuary.

   (d) enhances the mixing of surface water and deeper water in the ocean.

9. Which of the following is/are the determining factor (s) of estuary classification?

   (a) River volume.

   (b) River volume, seawater volume and the number of tidal cycle (s) per day.

   (c) Both river volume and seawater volume.

   (d) Seawater volume.

10. Which of the following statements is true?

(a) Waves are merely formed by the Earth's rotation and the gravitational force of the moon and sun.

(b) Tides are not caused by external force and restoring force.

(c) Waves amplify as they reach the coast.

(d) Waves speed up as they reach the coast.

Chapter 5

Module 3b Marine Ecosystems: Subtidal, Intertidal and Estuaries

5.1 The Subtidal Ecosystems: Unvegetated Areas

1. Epifauna: Animals that live on the surface of the sediment
2. Infauna: Animals that burrow in the sediment
3. Meiofauna: Animals that live in spaces between sediment particles
4. Including coral reefs, seaagrass beds, and kelp forests
5. Including the world's most important fishing ground
6. oil and minerals are ofund on the shelf
7. Close to shore, particularly vunerable to human impacts
8. Its relaticely shallow water and its close proximity to land
9. Temperature varies more
10. Its bottom is much more affected by waves and currents than in deep water
11. More stable environment than intertidal
12. Dominated by infauna with some epidauna
13. Two types of subtital area:

- Soft-bottom subtidal

→ Detritus is an important food source, they come from currents, feves, dead individuals, and generated by the benthos

→ Suspension feeders lives in sandy bottom while deposit feeders lives in muddy sediments

- Hard-bottom subtidal

5.2 The Subtidal Ecosystems: Kelp Forests and Seagrass Beds

1. Kelp are lived in hard bottom while seagrass live in soft bottom
2. Kelp are lived in cold temperature regions while seagrass live in temperature and tropical regions
3. If there are few sea urchins, there will be a healthy kelp forest
4. Seagrass may occur at high density
5. It helped stablized sediments
6. Some herbivors feed on the leaves, but most biomass is avaliable to comsumers as detritus

5.3 The Subtidal Ecosystems: Coral Reefs

1. The largest geological features built by organisms
2. Most ree-building contain photosynthestic algae, Zooxanthellae
3. Fringing Reef ⇒ Barrier Reef ⇒ Atoll

5.4 The Intertidal: Hard Bottoms

1. The Intertidal Zone can be explored without any speciallized and expensive equipment
2. The hard bottom is dominated by epifauna
3. It procided hard substrates for organisms to attach
4. Major Physical Challenges:

- desiccation
- Temperature fluctuations

- Salinity changes
- Wave action and tides
- Oxygen availability and build-up of CO_2 at low tide

5. Spray Zone ⇒ High Tide ⇒ Mid-Tide ⇒ Low Tide
6. The upper limit is governed by physical factors
7. The lower limit is governed by biological factors
8. Space is the key limiting factor on Rocky Shores

5.5 The Intertidal: Soft Bottoms

1. How much water motion and source of sediment defined what kind of sediment accumulates in an area
2. Coarse sediments: Areas affected by waves and currents
3. The smaller the defiment size, the less oxygen in the water fillinf spaces
4. Except the top few cm is anoxic:

- No oxygen
- Contains hydrogen sulfide, which is produced by anaerobc bacteria
- Hydrogen sulfide is toxic to most animals, there has relatively little animal life

5. Sheltered and exposed beaches have different communities
6. Soft bottom are unstable and shift in response to waves, tides, and currents
7. Seagrasses are the most common large primary producers
8. Infauna and deposit feeders dominate with some epifauna
9. Fishes and birds are key predators
10. Difference in teh bill length of wading shorebirds allow them to feed on particular mudflat animals (bill = the mouthpart of a bird)
11. Suspension feeders are more common in sandy shores, while deposit feeders are more abundant in muddy shores
12. Most of the plants in sold-bottom intertidal area are seagrasses and benthic diatoms

5.6 Estuaries

1. Many arine species spend at least a portion of their lives in an estuary, mmostly as larvae
2. The fluctuating environmental conditions, mainly salinitym are so extreme that few species have evolved the necessary physiological speciallizations to survive over there. And hence there are so few Estuarine species.
3. Three types of estuarine ecosystems:

- Mudflats
- Salt Marshes
- Mangroves

5.7 The Estuarine Ecosystems: Salt Marshes and Mangroves

1. Salt Marshes:
   (a) Grassy vegetation that lives along the shores of estuaries and sheltered coasts in temperate and subarctic regions
   (b) The area is partially flooded at high tide
   (c) Sometimes they are grouped with freshwater marshes and collectively called Wetlands
   (d) Is is dominated by a few hardy grasses and other salt-tolerant land plants.
   (e)
2. Mangroves:
   (a) Trees and shrubs that live along the intertidal shores in tropical and subtropical regions
   (b) It can be found in tropical regions
   (c) Dense forest formed by mangroves are mangals
   (d) Prop roots help trees remain stable substrates
   (e) Aerial roots improve oxygen transport to roots in black mangroces
   (f) The muddy bottom is inhabited by a range of deposit and suspension feeders
   (g) Crabs are particularly common
3. Both of them have deposit feeders but the salt marshes have filter feeders while the mangroves have suspension feeders.

5.8 Coastal Eutrophication

1. Effects of Coastal Eutrophication:
   (a) Harmful Algal Blooms
   (b) Dead Zones (Hypoxia)
   (c) Fish Kills
2. Normal conditions:
   (a) Healthy food web
   (b) Healthy fisheries
   (c) Oxygenarted sediment
3. Over-enriched with nutrients:
   (a) Phytoplankton blooms and unhealthy food web
   (b) Dead cells use up oxygen
   (c) Anoxic sediment

5.9 Effects of Harmful Algal Blooms (HABs)

1. Not all red tides are harmful, plankton blooms that produce toxins is harmful
2. Red tides and HAB can be used interchangeably
3. The recent increase in HAB events off the coast of China is related tot eh increase in the use of nitrogen-based fertilizer.
4. Impact of HABS:

- food web interruption, oxygen depletion, loss of biodiversity, and poisoning and deaths of fish and otehr marine vertebrates.

5.10 Case Study: Noctiluca Blooms

5.11 MC Question

1. The particular characteristic most widely used in classifying intertidal communities is
   (a) type of substrate.
   (b) relative exposure to air.
   (c) type of seaweeds.

(d) type of tides.

2. The main source of food in muddy bottom intertidal communities is

   (a) detritus.
   (b) seaweed.
   (c) epifauna.
   (d) plankton.

3. What are expected to be relatively rare on a rocky shore.

   (a) Primary producers
   (b) Filter feeders
   (c) Deposit feeders
   (d) Carnivores

4. Which of the following statements is TRUE about the vertical zonation on rocky shores?

   (a) The UPPER limit of a certain species can be governed by space and predation.
   (b) The UPPER limit of a certain species can be governed by predation and desiccation.
   (c) The LOWER limit of a certain species can be governed by temperature changes and wave actions.
   (d) The UPPER limit of a certain species can be governed by space and desiccation.

5. One of these organisms is typically a very rare component of soft-bottom intertidal communities:

   (a) Infauna.
   (b) Deposit feeders.
   (c) Seaweeds.
   (d) Detritus feeders.

6. In a soft-bottomed intertidal community, oxygen would be most plentiful for meiofauna in

   (a) sand.
   (b) silt.
   (c) mud.
   (d) gravel.

7. The number of species inhabiting estuaries is xxx those inhabiting nearby marine or freshwater habitats mainly because of xxx.

   (a) significantly higher than, temperature fluctuations
   (b) significantly lower than, reduced predation pressure
   (c) significantly lower than, salinity fluctuations
   (d) similar to, similar light intensity

8. Salt Marshes and Mangroves are/have

   (a) same substrate types.
   (b) high in biodiversity.
   (c) all of the other answers are correct.
   (d) geographic separation in distribution (with a few exceptions).

9. Coastal eutrophication can result in all of the following, EXCEPT

   (a) none of the other answers is correct.
   (b) harmful algal bloom.
   (c) hypoxia in deeper waters.
   (d) economic loss.

10. The loss of estuaries and mangrove forests is particularly serious since these ecosystems

    (a) provide nesting or resting areas to many seabirds.
    (b) are among the most productive of all marine ecosystems.
    (c) all of the other answers are correct.
    (d) directly or indirectly provide food to many species.

Chapter 6

Module 3c Marine Ecosystems: The Deep Sea

6.1 The Physical Environment of the Deep Sea

1. Epipelagic Zone ⇒ Meso Zone ⇒ Abyssal Zone ⇒ Hadal Zone
2. Deep sea = Waters below the Meso Zone (1000m)
3. Average depths of the ocean is about 4000 meters
4. Low temperature ⇒ Anti-freeze proteins and slow metabolic rate
5. High pressure (Hydrostatic pressure increases by 1 atmosphere per 10m depth increase) ⇒ Osmolytes
6. High pressure and low temperatue affect metabolism of organisms, particularly enzyme systems, protein synthesism and physical properties.
7. Most of the deep-sea fishes have lower metbolic rayes and slower movements
8. No light ⇒ Bioluminescence by symbiotic bacteria
9. Dilute environment ⇒ opportunistic and energy saving adaptations

6.2 Sampling Gear for Deep-Sea Research

1. Underwater Vehicles:

- AUV − Autonomous Underwater Vehical
- ROV − Remotely Operated Vehicles
- HOV − Human Operated Vehicles

2. Constraints:

- Difficult and expensice
- Because of low anumal densities, large smapling gear needed
- The deeper the sampling depths, the greater the amount of cables required
- The heaview the equipment, the bigger the ship needed

3. Problem in sampling:

- Time consuming
- Slow and limited catch

6.3 Challenging the Deepest Point: The Mariana Trench

1. Challenges in the Ocean Trenches:

- Expensive
- Dangerous
- Cannot stay on the ocean floor for long
- Not many smaples can be retrieved

6.4 Discovery: Deep-Sea Chemosynthetic Ecosystems

1. Chemosynthesis is the use of inorganic compounds as energu source
2. Chemosynthesis is important for deep-sea organisms as total darkness in the deep-sea environment, so they must rely on chemical energy from bacteria, sucha s consume bacteria or symbiotic relationship with bacteria

6.5 Hydrothermal Vents

1. The very hot fluid carries dissolved metals and H_2S gas from deep beneath the ocean floor
2. Hyftothermal vents are found along areas where tectonic plates meet
3. Environmental conditions around Hydrothermal Vents:

- High Temperature

- High pressure
- Highconcentration of H_2S (hydrogen sulfide)

6.6 Cold Seeps and Gas Hydrates

1. Cold Seeps means chemicals poduced by the decay of organic matter seep out from the sea floor
2. These chemicals provide energy to support the ecosystem, such as chemosynthesis
3. Cold seeps are found near hydrothermal vents
4. Near inner edge of brine pool can find lively organism, sucha s mussels, worms and crabs
5. Outer edge of brine pool can find dead organisms becuase they are away from their energy supply
6. Gas hydrate − clean energy
7. Worms live on hydrocarbon
8. Importance of Cold Seeps:

- Biologically: Very rich biodiversity like Hydrothermal vents
- Ecologically: Very dynamic chemosynthetic ecosystem
- Natural Resources: Gas hydrate and hydrocarbon

6.7 Sea Mounts, Ocean Basins and Ocean Trenches

1. Seamounts − More diverse than other parts of the sea floor, a large underwater mountain that does not reach the water surface and rich in heavy metal
2. Seafloor − Unique ecosystems and recources
3. Ocean Trench − Long, narrow depression on the ocean floor
4. Ocean Basin − all land that is covered by sea water, including the Continental Margin
5. Ocean Ridge − A mountain-like structure formed under the sea due to colvanic eruptions ont eh ocean floor
6.

6.8 MC Question

1. Bacteria thriving around deep-sea hydrothermal vents are
   (a) the energy production mechanism of these bacteria remains largely unknown.
   (b) photosynthetic only.
   (c) photosynthetic and chemosynthetic.
   (d) mainly chemosynthetic.
2. Which of the following statements is true?
   (a) Deep-sea area is much larger in size compared to that of the habitable land on Earth.
   (b) Deep-sea area is much smaller in size compared to that of the habitable land on Earth.
   (c) Deep-sea area is of similar size as that of the habitable land on Earth.
   (d) There has been limited study in this aspect and it remains largely unknown about the comparison of the size of deep-sea area to that of the habitable land on Earth.
3. Osmolytes are important for the deep-sea amphipods to adapt to the environment because they can
   (a) stabilize protein structure and function.
   (b) reduce metabolic rate.
   (c) none of the other answers is correct.
   (d) lower body temperature.
4. The deepest of ocean waters is classified as the
   (a) Meso Zone.
   (b) Abyssal Zone.
   (c) Pelagic Zone.
   (d) Hadal Zone.
5. The challenges of conducting research in the Ocean Trenches include
   (a) not many samples can be collected for research from each expedition.
   (b) all of the other answers are correct.
   (c) the expedition is very dangerous.
   (d) the expedition is very expensive.
6. There is/are plenty of xxx in most deep-sea habitats.

(a) photosynthetic organisms

(b) light

(c) food

(d) none of the other answers is correct

7. Which of the following is TRUE about deep-sea vestimentiferan tubeworms?

(a) None of the other answers is correct.

(b) They do not rely on symbiosis to survive.

(c) They are unable to grow fast near hydrothermal vents or cold seeps.

(d) They do not have a digestive system.

8. Deep-sea organisms have special adaptations to survive through xxx pressure and xxx temperature.

(a) low, high

(b) high, high

(c) low, low

(d) high, low

9. Recent discoveries have shown the Challenger Expedition and other 19th-century oceanographic expeditions' assumption that the deep ocean had no xxx was NOT true.

(a) volcanic activity

(b) sediments

(c) biodiversity

(d) water movement

10. Deep-sea animals adapt to the light condition of the habitats by

(a) bioluminescence.

(b) less efficient muscle enzymes.

(c) all of the other answers are correct.

(d) osmolytes.

Chapter 7

Module 4 Humans and the Sea

7.1 Ocean and the climate

1. Angle of incoming sunlight affects the amount of solar energy.
2. Ocean currents, Regions' temperature, Hydrological cycle, whether and formation of tropical cyclones modulate the climate.

7.2 Ocean and global warming

1. There is an acceleration of ocean warming for all depths.
2. Impact of ocean warming:

- Melting ice ⇒ sea level rise
- Warming ocean ⇒ stronger storms
- Less ocean mixing ⇒ less nutrients at surface ⇒ less biological productivity and lower oxygen level

3. Greenhouse effect:

- The trapping of the sun's heat in the lower atmosphere

7.3 Ocean acidification

1. Ocean acidifiction is the ongoing decrease in the pH of the Oeans.
2. There is a clear connection between rising atmospheric CO_2 levels and devlining ocean pH

3. About 25% of human produced CO_2 dissolves in the seawater
4. Imapct of ocean acidification:

- make it harder for shelled organisms to build and maintain their shells and result in shell damage (degraded)
- lower diversity and reduce coral
- Food security
- Coastal protection
- Tourism
- Carbon storage and climate regulation

5. Solutions:

- Be mindful of carbon footprint

7.4 The Global Coral Reef Crisis

1. Coral reefs are found in shallow and warm waters
2. Built by corals, clams, and other calcifiers
3. Home for fish, invertebrates and larvae
4. Corals are made up of polyps that house symbiotic Photosynthesis algae, Zooxanthellae
5. The algae produce oxygen and provide nutrients to the coral
6. Values of coral reef:

- Coral reed tourism (income)
- Coral reef fishing (food)
- Natural barriers
- Source of the anticancer drug (medical drugs)
- Ecosystem

7. Coral bleaching:

- A widespread stress response to warming temperature
- When water is too warm, corals will expel the algae $\Rightarrow$ Carals turn completely white

8. Coral Reefs can't withstand extended hot periods
9. Coral Reefs become barren and skeletal
10. Solutions:

- Using Oxybenzone-free sunscreen

7.5 Resources from the Ocean

1. 17% of the world's animal protein is provided by ocean fish
2. Ocean Fish – Nutrient-Rich Source:

- Good calories and protein
- Good fat and cholesterol
- Good vitamins and minerals

3. Aquaculture production is expanding and it must continue to expand capacity
4. Wild fisheries is reaching the maximum capacity
5. Chinese seafood consumption is higher than worldwide average
6. Industrial fishing operations are often not sustainable
7. Overfishing means removing a species of fish from a body of water at a rate that the species cannot replenish in time
8. Overfishing will cause disruption of the marine food chain, such as fishes disappear, resulting in the disappearance of top predators and reducing bidiversity

7.6 Coastal pollution and other anthropogenic impacts

1. Chemical Pollution:

- Toxic Metals/ Organics
- Pesticides/ Herbicides
- Antibiotics
- Radioonuclides
- Radiation leak in Japan in 2011 increased radionuclides in marine life.

2. Physical Pollution:

- Wind and currents cause greater connections to build up, such as the Great Pacific Garbage Patch
- Microplastics: It flow from water drains, absorb hormone disruptive chemicals. Marine organisms ingest microplastics/ microbeads and they move up the food chain.
- Dredging: Removing unwanted silt/ mud from water to clear water pathways or for land reclamtion. It may harm habitats and turbid water can clog fish gills.
- Effect of Thermal Pollution:
  (a) Unable to adapt and die
  (b) Increase bateria levels
  (c) Reduce biodiversity
  (d) Disturb the food chain
- Shipping:
  (a) Cause stress and hence weakens immune system
  (b) Impairs hearing & communication
  (c) Migration
- Land Revlamation
- Non-natice Species $\Rightarrow$ Invasion Effect:

7.7 Oyster Farming and Seafood Safety

1. Mercury Exposure:
   (a) Lack of coordination
   (b) Muscle weakness
   (c) Nerve loss in hands and face
   (d) Vision changes
2. Cadmium Exposure (can be seen in Oyster):
   (a) Kidney or lung failure
   (b) Bone disease

7.8 Marine Protected Areas

1. Geographically defined areas that are designated for consercation to protext marine resources, including intertidal, sub-tidal, and pelagic encironments.
2. Aim at maintaing biodiversity
3. Protect critical habitats from damage and allow them to recover
4. Provide areas where fish can reproduce, spawn and grow to their adult size
5. Maintain local cultures, economies, and livelihoods.
6. Benefits of MPAs:
   (a) The fish biomass increased by 4 to 5 times
   (b) Length increased by 25%
   (c) Density of fish increased
   (d) Number of species increased
   (e) Coral cover increased
7. Factor to be considered for No-taking Zone:
   (a) Overfishing location
   (b) Size depending on the behavior of the species
   (c) It should be a self-sustaining areas
   (d) Cost of fishermen
   (e) Monitoring costs, bological assessment costs and enforcement costs
8. Challenges for Hong Kong marine area:
   (a) Unregulated fishing
   (b) Marine traffic
   (c) Marine pollution
   (d) Reclamtion
9. Experts required:
   (a) Scientists
   (b) Consercationists
   (c) Fishermen
   (d) NGOs

7.9 MC Question

1. Which of the following statements is TRUE about microplastics?
   (a) They can absorb toxic chemicals
   (b) They can be found in the digestive tracts of marine fishes
   (c) All of the other answers are correct.
   (d) They can enter the marine ecosystem from water drainage.
2. Marine pollution can be caused by all of the following human activities, EXCEPT
   (a) agriculture.
   (b) none of the other answers is correct.
   (c) aquaculture.
   (d) the use of health and beauty products.
3. Which of the following statements is NOT true?
   (a) Pollution is found in polar regions.
   (b) None of the other answers is correct.
   (c) The deep sea is free from pollution.
   (d) Marine pollution is generally coupled with economic activity.
4. Which of the following statements is TRUE about ocean warming?
   (a) More nutrients are available at the sea surface.
   (b) None of the other answers is correct.
   (c) It occurs at the sea surface only.
   (d) It results in stronger storms.
5. Greenhouse effect is related to all of the following, EXCEPT
   (a) higher oxygen level in the ocean.
   (b) less ocean mixing.
   (c) sea-level rise.
   (d) ocean warming.
6. The stakeholders of Marine Protected Areas (MPAs) include all of the following, EXCEPT
   (a) fishermen.
   (b) conservationists.
   (c) none of the other answers is correct.

(d) researchers.

7. Which of the following statements is True?

   (a) The global aquaculture production has been decreasing.

   (b) In terms of global seafood production, aquaculture is insignificant compared to the wild catch.

   (c) In general, industrial fishing operations are unsustainable.

   (d) The global wild catch of seafood is at its minimum.

8. Which of the following is/are related to the sustainable future of the ocean?

   (a) Natural resource management.

   (b) Consumers' choice and natural resource management.

   (c) Consumers' choice and culture.

   (d) Natural resource management, consumers' choice, and culture.

9. A warmer world is LEAST likely to result in

   (a) increased coral cover.

   (b) reduction in biodiversity.

   (c) decreased food production.

   (d) increased bacteria levels.

10. Which of the following is NOT an impact of ocean acidification?

    (a) Loss of biodiversity.

    (b) Climate regulation.

    (c) Economic loss.

    (d) Increased food security.