Subject: Basic Ecology (ZOL-502)

(BS Zoology 6th Semester)

Aquatic Ecosystems

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What are Aquatic Ecosystems?

- Aquatic ecosystems are ecosystems found in water environments. They involve interactions between living organisms (plants, animals, and microbes) and their physical surroundings in water bodies. These ecosystems are essential for maintaining global biodiversity, supporting human livelihoods, and regulating the Earth's climate.
- **Types of Aquatic Ecosystems**
- 1. Freshwater Ecosystems
- 2. Marine Ecosystems
- 3. Estuarine Ecosystem
- 4. Wetlands Ecosystem

Marine Ecosystem

- Found in oceans, seas, estuaries, coral reefs, and saltwater marshes.
- High salt concentration.
- Largest aquatic ecosystems on Earth.
- A marine ecosystem is a type of aquatic ecosystem that exists in the saltwater bodies of the Earth, including oceans, seas, coral reefs, and coastal environments. It is the largest ecosystem on the planet, covering more than 70% of Earth's surface and supporting a vast diversity of life.

Characteristics of Marine Ecosystems

Feature	Description
Salinity	High (~3.5% average salt content)
Depth & Pressure	Varies greatly from surface to deep-sea trenches
Light Availability	Sunlight penetrates only upper layers (photic zone)
Temperature	Ranges from warm at surface to freezing in deep ocean
Nutrient Distribution	Uneven; high near coasts, low in open ocean

Major Zones of Marine Ecosystem

- The marine ecosystem is divided into zones based on depth, distance from shore, and light penetration:
- **A. Horizontal Zones**
- 1. Intertidal Zone (Littoral)
- 2. Neritic Zone
- 3. Oceanic Zone
- **B. Vertical Zones (Based on Depth)**
- 1. Photic Zone
- 2. Aphotic Zone
- 3. Benthic Zone

A. Horizontal Zones

- **1. Intertidal Zone (Littoral):**
- Area between high and low tide
- Harsh, changing conditions
- Organisms: barnacles, mussels, starfish
- **2. Neritic Zone:** Extends from low tide to edge of continental shelf
- Sunlight reaches the bottom
- Rich in nutrients and marine life
- Organisms: fish, corals, seaweeds
- **3. Oceanic Zone:** Open ocean beyond continental shelf
- Nutrient-poor but covers most of the ocean

B. Vertical Zones (Based on Depth)

- **1. Photic Zone**
- Sunlight reaches (up to ~200 meters)
- Photosynthesis occurs
- **2. Aphotic Zone**
- No sunlight
- Organisms rely on detritus or chemosynthesis
- **3. Benthic Zone**
- Ocean floor, includes deep-sea trenches
- Organisms: sea cucumbers, crabs, tube worms

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Biotic Components

- **A. Producers (Autotrophs)**
- Phytoplankton: Microscopic algae that form the base of the food chain
- Macroalgae: Seaweeds like kelp and red algae
- Seagrasses: Flowering plants in shallow waters
- **B. Consumers**

Level	Examples
Primary consumers	Zooplankton, small crustaceans, mollusks
Secondary consumers	Small fish, jellyfish
Tertiary consumers	Larger fish (tuna), sea birds
Apex predators	Sharks, whales, orcas

Biotic Components

- **C. Decomposers**
- Marine bacteria and fungi
- Break down organic material and recycle nutrients
- **Energy Flow in Marine Ecosystem**
- Sunlight → Phytoplankton (producers) → Zooplankton (primary consumers) → Fish (secondary consumers) → Predators (tertiary consumers)
- **Decomposers** recycle nutrients back into the system

Importance of Marine Ecosystems

Function	Description
Oxygen Production	Phytoplankton contribute over 50% of Earth's oxygen
Carbon Sink	Oceans absorb and store CO_2, regulating climate
Biodiversity Hotspot	Coral reefs and coastal zones support millions of species
Economic Value	Fisheries, tourism, shipping, recreation
Climate Regulation	Oceans distribute heat globally via currents
Food Source	Marine fish and seafood are key protein sources worldwide

Types of Marine Ecosystems

Type	Description
Coral Reefs	Biodiverse structures formed by coral polyps in shallow tropical seas
Mangroves	Coastal wetlands with salt-tolerant trees, buffer coastlines from storms
Open Ocean	Deep, vast, and nutrient-poor but crucial for global processes
Deep Sea	Dark, high-pressure environments with unique life forms
Seagrass Beds	Underwater flowering plants that provide nursery grounds for marine life

Threats to Marine Ecosystems

Threat	Impact
Overfishing	Reduces fish populations, disrupts food chains
Pollution	Plastic, oil spills, sewage, and chemical runoff
Climate Change	Ocean warming, acidification, coral bleaching
Habitat Destruction	Coastal development, bottom trawling
Invasive Species	Disrupt native marine life

Estuarine Ecosystem

- An estuarine ecosystem is a coastal area where freshwater from rivers or streams meets and mixes with saltwater from the ocean, resulting in brackish water (a mixture of fresh and salt water).
- These ecosystems are dynamic and highly productive, serving as nurseries for many marine species, natural buffers, and filters for pollutants.

Characteristics of Estuarine Ecosystems

Feature	Description
Water Salinity	Variable – fluctuates daily with tides and seasonally with river flow
Water Movement	Influenced by tides, waves, river flow & winds
Sediment Load	High – rich in nutrients and organic matter
Light Availability	Usually good due to shallow waters
pH and Oxygen Levels	Vary widely; sometimes stressful for organisms

Types of Estuarine Ecosystems

- **A. Based on Geology**
- Coastal Plain Estuaries:
- Formed by rising sea levels (e.g., Chesapeake Bay)
- Tectonic Estuaries:
- Formed by land subsidence (e.g., San Francisco Bay)
- Bar-built Estuaries: Separated from the sea by sandbars
- Fjords: Glacially carved, deep estuaries (e.g., Norwegian fjords)
- **B. Based on Vegetation and Habitat**
- Mangroves (tropical regions), Salt Marshes (temperate regions), Mudflats, Seagrass beds and Tidal Creeks

Biotic Components of Estuarine Ecosystem

- **A. Producers (Autotrophs)**
- **Phytoplankton**: Microscopic algae that float and photosynthesize
- **Macroalgae**: Seaweeds like green, brown, and red algae
- **Seagrasses**: Submerged aquatic vegetation
- **Mangroves and Salt-tolerant Plants**: In intertidal zones
- **B. Consumers**

Level	Examples
Primary Consumers	Zooplankton, worms, mollusks, small crustaceans
Secondary Consumers	Small fish, crabs, shrimp
Tertiary Consumers	Larger fish, predatory birds (herons, egrets), seals
Apex Predators	Sharks, dolphins (in some estuarine systems)

Biotic Components of Estuarine Ecosystem

- **C. Decomposers**
- Bacteria and fungi that break down detritus (dead organic matter)
- Essential for recycling nutrients
- **Energy Flow and Nutrient Cycling**
- Sunlight → Producers (phytoplankton, seagrass) → Herbivores (zooplankton, fish) → Carnivores (birds, larger fish)
- **Decomposers** break down organic waste, returning nutrients to the system
- **Detritus-based food chains** are very prominent

Ecological Importance of Estuarine Ecosystems

Function	Description
Nursery Grounds	Many marine fish and shellfish spend their juvenile stages in estuaries
High Productivity	Nutrient-rich waters support dense food webs
Buffer Zones	Protect inland areas from floods, storms, and erosion
Natural Filters	Trap pollutants, sediments, and excess nutrients
Carbon Sequestration	Mangroves and salt marshes store large amounts of carbon
Habitat Diversity	Supports birds, reptiles, amphibians, and aquatic mammals

Economic and Social Importance

- **Fisheries**: Vital for commercial and subsistence fishing
- **Tourism and Recreation**: Bird watching, boating, eco-tourism
- **Aquaculture**: Shrimp and oyster farming
- **Cultural Significance**: Many human settlements are near estuaries

Threats to Estuarine Ecosystems

Threat	Impact
Pollution	Industrial, agricultural, and urban runoff introduce toxins, nutrients, and plastics
Habitat Loss	Reclamation for agriculture, industry, or housing
Climate Change	Sea level rise, salinity changes, stronger storms
Overfishing	Disrupts food chains and ecosystem balance
Invasive Species	Outcompete native flora and fauna

Freshwater Ecosystem

- A **freshwater ecosystem** includes all ecosystems found in **inland water bodies with low salt concentration**—typically less than 0.5% salinity. These ecosystems support a vast range of plants, animals, and microorganisms adapted to non-saline water.
- Freshwater ecosystems cover only about **2.5% of the Earth's water**, but are vital for biodiversity and human survival.

Types of Freshwater Ecosystem

- Freshwater ecosystems are broadly classified into two categories based on the nature of water flow:
- **A. Lotic Ecosystems (Flowing Water)**
- **Examples**: Rivers, streams, creeks
- **Characteristics**: Constant movement of water, often with oxygen-rich, turbulent flow
- **Habitats**: Rapids, riffles, pools
- **B. Lentic Ecosystems (Still Water)**
- **Examples**: Lakes, ponds, swamps, wetlands
- **Characteristics**: Standing or slow-moving water, stratified temperature layers in larger lakes

Key Characteristics of Freshwater Ecosystems

Feature	Description
Salinity	Very low (<0.5%)
Oxygen Levels	Generally high in flowing water; can vary in still water
Temperature	Varies with climate, depth, and season
Light Penetration	Varies with water clarity and depth
pH	Usually neutral to slightly acidic or alkaline
Nutrient Levels	Variable, influenced by surrounding land and organic matter

Biotic Components of Freshwater Ecosystems

- **A. Producers (Autotrophs)**
- **Phytoplankton**: Microscopic algae, the base of aquatic food chains
- **Aquatic Macrophytes**: Larger plants like water lilies, cattails, reeds
- **Algae**: Green, blue-green, and brown algae on submerged surfaces
- **B. Consumers**

Level	Examples
Primary consumers	Zooplankton, aquatic insects, snails, small fish
Secondary consumers	Larger fish, amphibians (frogs, salamanders)
Tertiary consumers	Birds (kingfishers, herons), large fish, otters
Apex predators	Large fish (pike, catfish), crocodiles (in some regions)

Biotic Components of Freshwater Ecosystems

- **C. Decomposers**
- Bacteria and fungi that break down dead organic matter, recycling nutrients
- **Energy Flow and Nutrient Cycling**
- Energy flows from sunlight → producers → herbivores → carnivores → decomposers.
- Nutrient cycling involves the recycling of nitrogen, phosphorus, and carbon essential for ecosystem health.

Ecological Importance of Freshwater Ecosystems

Function	Description
Biodiversity hotspots	Support diverse species of fish, amphibians, birds, and plants
Water supply	Source of drinking water for humans and animals
Agriculture & industry	Irrigation and raw water supply
Climate regulation	Influence local microclimates and carbon storage
Flood control	Wetlands absorb excess water and reduce flood risks
Recreation	Fishing, boating, tourism

Threats to Freshwater Ecosystems

Threat	Impact
Pollution	Industrial discharge, sewage, pesticides cause eutrophication and toxicity
Habitat destruction	Draining wetlands, damming rivers, urbanization
Invasive species	Disrupt native species and food webs
Over-extraction	Reduces water availability, harms aquatic life
Climate change	Alters water temperature, flow regimes, and seasonal cycles

Wetlands Ecosystem

- A **wetland ecosystem** is a unique type of ecosystem where **land remains saturated or inundated with water**—either permanently or seasonally. Wetlands act as a **transition zone between terrestrial and aquatic ecosystems**, and can be found across all continents except Antarctica.
- Wetlands include **marshes, swamps, bogs, fens, floodplains, and mangroves**, and can be **freshwater**, **brackish**, or **saltwater**.

Types of Wetlands

A. Based on Water Type

Type	Description
Freshwater wetlands	Found along rivers, lakes, or inland basins (e.g., marshes, fens)
Saltwater (coastal) wetlands	Occur in coastal zones with tidal influence (e.g., mangroves, salt marshes)
Brackish wetlands	Have mixed salinity from both freshwater and saltwater sources

Types of Wetlands

B. Based on Geography

Type	Characteristics
Marshes	Dominated by herbaceous plants (grasses, reeds); waterlogged
Swamps	Dominated by trees and shrubs; found in warm climates
Bogs	Acidic, nutrient-poor wetlands with sphagnum moss and peat
Fens	Alkaline, nutrient-rich wetlands with grasses and sedges
Mangrove wetlands	Coastal wetlands with salt-tolerant trees in tropical regions

Key Characteristics of Wetlands

Feature	Description
Hydrology	Water saturation from rain, rivers, groundwater, or tides
Soil Type	Hydric soils, low in oxygen and high in organic matter
Flora Adaptations	Plants are adapted to waterlogged, oxygen-poor conditions
Biodiversity	High; supports amphibians, birds, fish, insects, and plants

Biotic Components of Wetland Ecosystems

- **A. Producers**
- **Emergent plants**: Cattails, reeds, papyrus
- **Floating plants**: Water hyacinth, duckweed
- **Submerged plants**: Pondweed, eelgrass
- **Algae**: Phytoplankton and filamentous algae
- **Mangroves**: In coastal wetlands
- **B. Consumers**

Level	Examples
Primary consumers	Insects, snails, frogs, zooplankton
Secondary consumers	Fish, amphibians, aquatic birds
Tertiary consumers	Birds of prey, crocodiles, otters, large fish

Biotic Components of Wetland Ecosystems

- **C. Decomposers**
- **Bacteria**, **fungi**, and **invertebrates** break down dead organic matter, enabling nutrient recycling.
- **Energy Flow and Nutrient Cycling**
- Sunlight → Aquatic plants & algae (producers) → Insects/fish (primary consumers) → Birds/animals (higher consumers) → Decomposers recycle nutrients.
- Wetlands often have **detritus-based food chains**, especially in forested swamps and mangroves.

Ecological Importance of Wetland Ecosystems

Function	Description
🌊 Flood Control	Wetlands absorb excess rainfall and reduce flooding risks
💧 Water Purification	Trap sediments, absorb pollutants, and break down toxins
🌿 Biodiversity Hotspot	Provide habitat for thousands of species, including migratory birds
🌡️ Climate Regulation	Act as carbon sinks, especially peatlands and mangroves
🌾 Nutrient Cycling	Support efficient recycling of nitrogen, phosphorus, and organic matter
🐣 Breeding Grounds	Essential for spawning fish, amphibians, and bird nesting

Economic and Social Importance

- **Agriculture**: Fertile floodplains and rice paddies
- **Fisheries**: Wetlands serve as fish nurseries
- **Tourism**: Birdwatching, nature reserves, ecotourism
- **Medicinal plants and raw materials**: Papyrus, reeds, mangrove wood
- **Cultural value**: Sacred groves, religious significance in many communities

Threats to Wetland Ecosystems

Threat	Impact
Wetland drainage	For agriculture, development, or urban expansion
Pollution	Pesticides, industrial waste, sewage
Over-extraction	Excess water withdrawal for irrigation
Climate change	Alters rainfall patterns, increases sea level (affecting coastal wetlands)
Invasive species	Outcompete native wetland flora and fauna
Damming and water diversion	Reduces wetland inflow and disrupts seasonal flooding

THANK YOU