Chapter 12 Lecture

Essentials of Oceanography
Eleventh Edition

Marine Life and the Marine Environment

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Chapter Overview

• Living organisms, including marine species, are classified by characteristics.
• Marine organisms are adapted to the ocean’s physical properties.
• The marine environment has distinct divisions.
Classification of Life

- Classification based on physical characteristics
- DNA sequencing allows genetic comparison.
Classification of Life

• Living and nonliving things made of atoms
• Life consumes energy from environment.
• NASA’s definition encompasses potential for extraterrestrial life.
Classification of Life

• Working definition of life
• Living things can
  – Capture, store, and transmit energy
  – Reproduce
  – Adapt to environment
  – Change over time
Classification of Life

- Three domains or superkingdoms
  - **Bacteria** – simple life forms without nuclei
  - **Archaea** – simple, microscopic creatures
  - **Eukarya** – complex, multicellular organisms
    - Plants and animals
    - DNA in discrete nucleus
Classification of Living Organisms

• Five kingdoms
  – Monera
  – Protoctista
  – Fungi
  – Plantae
  – Animalia
Five Kingdoms of Organisms

• **Monera**
  – Simplest organisms, single-celled
  – Cyanobacteria, heterotrophic bacteria, archaea

• **Protoctista**
  – Single- and multicelled with nucleus
  – Algae, protozoa

• **Fungi**
  – Mold, lichen
Five Kingdoms of Organisms

• **Plantae**
  – Multicelled photosynthetic plants
  – Surf grass, eelgrass, mangrove, marsh grasses

• **Animalia**
  – Multicelled animals
  – Range from simple sponges to complex vertebrates
Taxonomic Classification

• Carolus Linnaeus – 1758
  – Developed basis of modern classification of organisms

• Taxonomy – systematic classification of organisms
  – Physical characteristics
  – Genetic information
Taxonomy

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species
  - Fundamental unit
  - Population of genetically similar, interbreeding individuals
## Taxonomic Classification

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<td>minita</td>
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Classification of Marine Organisms

- Plankton (floaters)
- Nekton (swimmers)
- Benthos (bottom dwellers)
Types of Plankton

• Most **biomass** on Earth consists of plankton.

  • **Phytoplankton**
    – Autotrophic – can photosynthesize and produce own food

  • **Zooplankton**
    – Heterotrophic – relies on food produced by others
Other Types of Plankton

• **Bacterioplankton**
  – Very small
  – At least half the ocean’s photosynthetic biomass
  – Likely most abundant photosynthetic organism

• **Virioplankton**
  – Smaller than bacterioplankton
  – Not well understood, may limit abundance of other plankton through infection

• **Holoplankton**
  – Entire lives as plankton
Other Types of Plankton

- **Meroplankton**
  - Part of lives as plankton
  - Juvenile or larval stages
- **Macroplankton**
  - Large floaters such as jellyfish or *Sargassum*
- **Pico(plankton)**
  - Very small floaters such as bacterioplankton
Life Cycle of a Squid

- Nektonic adult
- Mating
- Planktonic larvae (enlarged)
- Benthic egg sacs
Nekton

- Independent swimmers
- Most adult fish and squid
- Marine mammals
- Marine reptiles
Nekton
Benthos – Bottom Dwellers

- **Epifauna** live on the surface of the sea floor.
- **Infauna** live buried in sediments.
- **Nektobenthos** swim or crawl through water above the seafloor.
- Benthos are most abundant in shallower water.
- Many live in perpetual darkness, coldness, and stillness.
Benthos
Hydrothermal Vent Communities

• Abundant and large deep-ocean benthos
• Discovered in 1977
• Associated with hot vents
• Bacteria-like archaeon produce food using heat and chemicals.
Number of Marine Species

• Total cataloged species on Earth about 1.8 million
• Many marine species not yet identified due to exploration difficulties
• As many as 2000 new marine and terrestrial species discovered each year
Number of Marine Species

- More land species than marine species
- Ocean has relatively uniform conditions
- Less adaptation required, less speciation
- Marine species overwhelmingly benthic (98%) rather than pelagic (2%)
Number of Marine Species

- Census of Marine Life (CoML) -- $650 million 10 year program completed in 2010
- Discovered at least 1200 new marine species including yeti crab
- Assessed diversity, distribution, and abundance of marine organisms
Number of Marine Species

- Currently 250,000 documented marine species
Adaptations of Marine Organisms

• The marine environment is more stable than land.
• Organisms in the ocean are less able to withstand environmental changes.
Adaptations of Marine Organisms

• Protoplasm – substance of living matter
  – More than 80% of mass is water

• Marine animals do not risk desiccation.
Adaptations of Marine Organisms

• Physical support
  – Buoyancy
  – How to resist sinking
  – Different support structures in cold (fewer) rather than warm (more appendages) seawater
    • Changes in water viscosity with temperature
  – Smaller size
Adaptations of Marine Organisms

• High surface area to volume ratio
• Cube a – greater resistance to sinking per unit of mass than cube c
• Phytoplankton benefit from being small
Adaptations of Marine Organisms

- Unusual appendages to increase surface area
- Oil in micro-organisms to increase buoyancy
Viscosity and Streamlining Adaptations

• **Streamlining**
  important for larger organisms
  – Shape offers least resistance to fluid flow

• **Flattened body**

• **Tapering back end**
Reproduction

- **Broadcast spawning** – eggs and sperm directly released into seawater
- Marine organisms take advantage of water’s high viscosity to enhance reproduction chances
Temperature and Marine Life

- Narrow range of temperature in oceans
- Smaller variations (daily, seasonally, annually)
- Deep ocean is nearly isothermal
Comparison of Ocean and Land Temperatures

- **Open ocean**
  - Maximum: 32°C
  - Range: 34°C
  - Minimum: -2°C

- **Coastal ocean**
  - Maximum: 40°C
  - Range: 42°C
  - Minimum: -2°C

- **Land**
  - Maximum: 58°C
  - Range: 146°C
  - Minimum: -88°C
Ocean Temperature

• More stable than land for four reasons
  – Higher heat capacity of water
  – Ocean warming reduced by evaporation
  – Solar radiation penetrates deeply into ocean layers
  – Ocean mixing
Cold vs. Warm Water Species

- Floating organisms smaller in warmer seawater
- More appendages in warmer seawater
- Tropical organisms grow faster, live shorter, reproduce more often
- More species in warmer seawater
- More biomass in cooler seawater (upwelling)
Temperature and Marine Organisms

• Stenothermal
  – Organisms withstand small variation in temperature
  – Typically live in open ocean

• Eurythermal
  – Organisms withstand large variation in temperature
  – Typically live in coastal waters
Salinity and Marine Organisms

• **Stenohaline**
  – Organisms withstand only small variation in salinity
  – Typically live in open ocean
• **Euryhaline**
  – Organisms withstand large variation in salinity
  – Typically live in coastal waters, e.g., estuaries
Salinity Adaptations

• Extracting minerals from seawater

• High concentration to low concentration
  – Diffusion
  – Cell membrane permeable to nutrients, for example
  – Waste passes from cell to ocean

Diffusion

Initial state

Final state
Diffusion

- Cell membrane
- Nutrient
- Waste
Osmosis

• Water molecules move from less concentrated to more concentrated solutions

• Osmotic pressure
  – In more concentrated solutions
  – Prevents passage of water molecules
Osmosis

- **Isotonic** – organism’s body fluid salinity same as ocean
- **Hypertonic** – seawater has lower salinity than organism’s fluids
- **Hypotonic** – organism’s fluids have lower salinity than ocean
Marine vs. Freshwater Fish

**Freshwater fish** - Hypotonic = low osmotic pressure

- Water absorbed through skin by osmosis
- Large volume of dilute urine
- Does not drink

**Saltwater fish** - Hypertonic = high osmotic pressure

- Drink large volume of salt water
- Secretion of salts
- Small volume of concentrated urine
- Loss of water by osmosis
- Loss of salt
Dissolved Gases

- Animals extract dissolved oxygen \((O_2)\) from seawater through **gills**.
- Gills exchange oxygen and carbon dioxide directly with seawater.
- Low marine oxygen levels can kill fish.
- Gill structure and location varies among animals.
Gills on Fish

- Gill arch
- Gill rakers
- Lamellae

Water in

Water and carbon dioxide out

Oxygen absorbed
Carbon dioxide released
Water’s Transparency

• Many marine organisms see well.
• Some marine organisms are nearly transparent.
  – Elude predators
  – Stalk prey
Adaptations to Marine Environment

- **Camouflage** through color patterns
- **Countershading** – dark on top, light on bottom
Camouflage and Countershading
Deep Scattering Layer

• Daily migration of many marine organisms to deeper, darker parts of ocean
• Dense concentration of organisms creates “false bottom” recorded on sonar readings
• Protection from predators
• Causes increased vertical mixing of ocean waters
Deep Scattering Layer

- **Daytime**
- **Twilight**
- **Nighttime**
- **Dawn**

- **Depth**
  - 0 m (0 ft)
  - 500 m (1640 ft)
  - 1000 m (3280 ft)

- **Deep Scattering Layer (DSL)**

- **Predators**
  - **Daytime Predators**
  - **Crepuscular Predators**
  - **Nocturnal Predators**

- **DSL ascends**
- **DSL descends**

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Disruptive Coloration

• Large, bold patterns, contrasting colors make animal blend into background
Water Pressure

• Increases about 1 atmosphere (1 kg/cm$^2$) with every 10 meters (33 feet) deeper
• Many marine organisms — no inner air pockets
• Collapsible rib cage (e.g., sperm whale)
Water Pressure

• Many fish have **swim bladder**
  – Adjusts buoyancy and allows fish to regulate depth
Divisions of the Marine Environment

• **Pelagic** (open sea)
  – Neritic (< 200 meters) and oceanic

• **Benthic** (sea floor)
  – Subneritic and suboceanic
Pelagic Environment

- Divided into biozones
- **Neritic Province** – from shore seaward, all water < 200 meters deep
- **Oceanic Province** – depth increases beyond 200 meters
Oceanic Province

- **Epipelagic**
  - Only zone to support photosynthesis
  - Dissolved oxygen decreases around 200 meters

- **Mesopelagic**
  - Organisms capable of bioluminescence common
  - Contains dissolved oxygen minimum layer (OML)
Ocean Province

• Bathypelagic and abyssopelagic zones – 75% of living space in oceanic province

• Bioluminescence common in mesopelagic and deeper
  – Ability to biologically produce light

• Detritus feeding shrimp – predators at depth
Ocean Zones Based on Light Availability

- **Euphotic** – surface to where enough light exists to support photosynthesis
- **Disphotic** – small but measurable quantities of light
- **Aphotic** – no light
Benthic Environments
Benthic Environments

- **Supralittoral** – transition from land to sea floor above spring high tide line; spray zone
- **Subneritic** – spring high tide shoreline to 200 m, about ½ the continental shelf
  - **Littoral** – intertidal zone
  - **Sublittoral** – shallow subtidal zone
    - **Inner** – extends to depth where marine algae no longer grow attached to ocean bottom
    - **Outer** – inner sublittoral to shelf break or 200 m
Suboceanic Province

- **Bathyal** – continental slope
- **Abyssal**
  - More than 80% of benthic environment
  - Animal tracks in abyssal clay
- **Hadal**
  - Below 6000 m
  - Only deep trenches on continental margins
End of CHAPTER 12
Marine Life and the Marine Environment