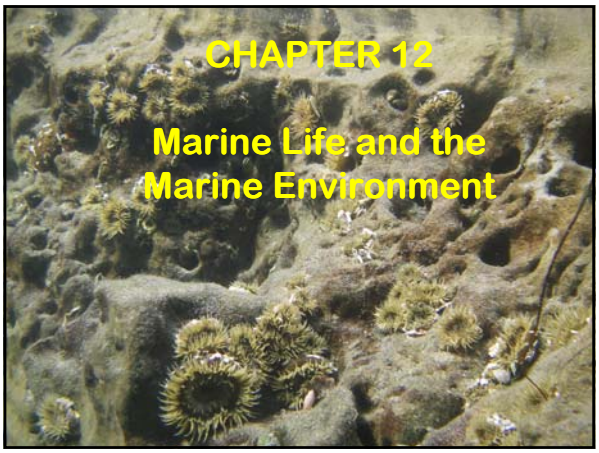
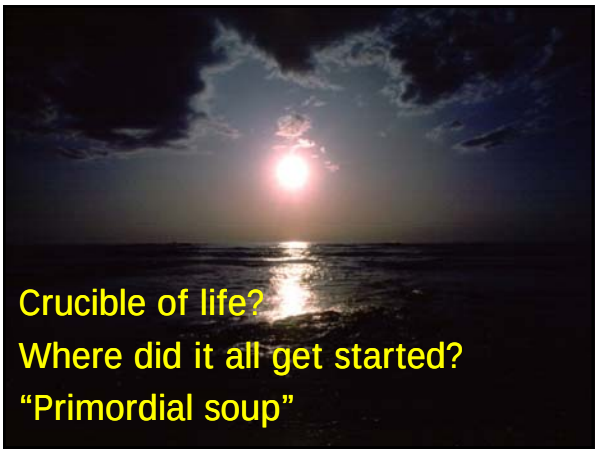




Chapter Overview

- 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

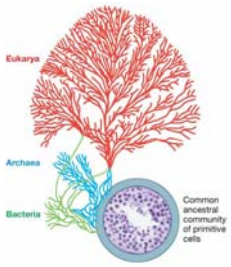
- Living and nonliving things made of atoms
- Life consumes energy from environment.
- NASA’s definition encompasses potential for extraterrestrial life.

Classification of Life

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

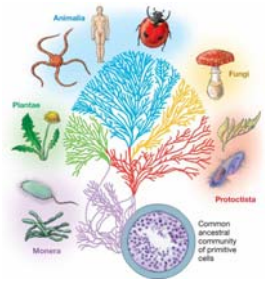
Classification of Life

- 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

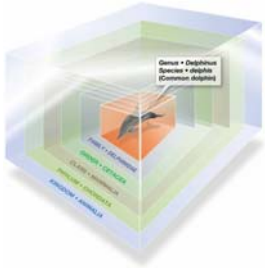
- Plantae
  - Multicelled photosynthetic plants
  - Surf grass, eelgrass, mangrove, marsh grasses
- Animalia
  - Multicelled animals
  - Range from simple sponges to complex vertebrates

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

TABLE 12.1 TAXONOMIC CLASSIFICATION OF SELECTED ORGANISMS

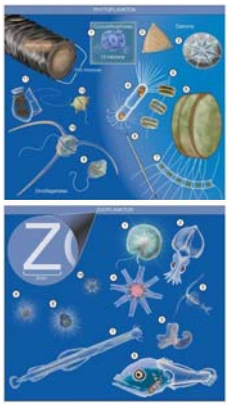
Category	Human	Common dolphin	Killer whale	Bat star	Giant kelp
Kingdom	Animalia	Animalia	Animalia	Animalia	Protoctista
Phylum	Chordata	Chordata	Chordata	Echinodermata	Phaeophyta
Subphylum	Vertebrata	Vertebrata	Vertebrata		
Class	Mammalia	Mammalia	Mammalia	Asteroidea	Phaeophyceae
Order	Primates	Cetacea	Cetacea	Valvatida	Laminariales
Family	Hominidae	Delphinidae	Delphinidae	Oreasteridae	Lessoniaceae
Genus	*Homo*	*Delphinus*	*Orcinus*	*Asterina*	*Macrocystis*
Species	*sapiens*	*delphis*	*orca*	*miniata*	*pyrifera*

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



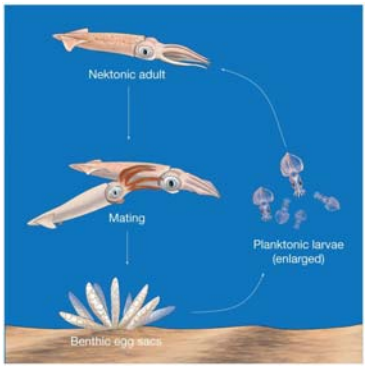
Other Types of Plankton

- 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*
- Picoplankton
  - Very small floaters such as bacterioplankton

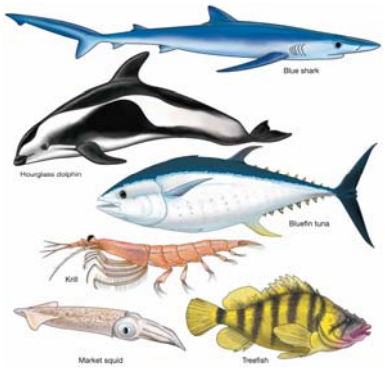
Life Cycle of a Squid



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

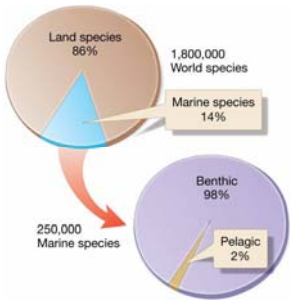
- More land species than marine species
- Ocean has relatively uniform conditions
- Less adaptation required, less speciation
- Marine species overwhelmingly benthic (98%) rather than pelagic (2%)

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

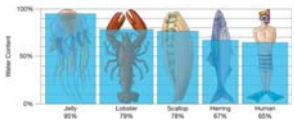


Adaptations of Marine Organisms

- 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.

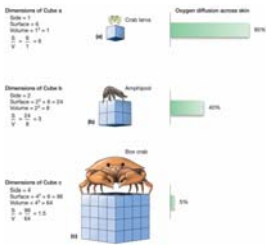


Adaptations of Marine Organisms

- 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

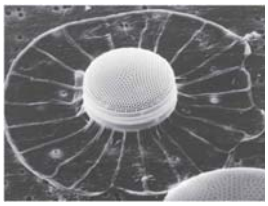
Adaptations of Marine Organisms

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



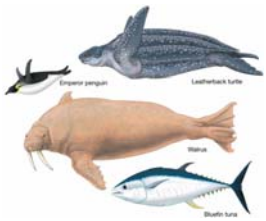
Adaptations of Marine Organisms

- 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



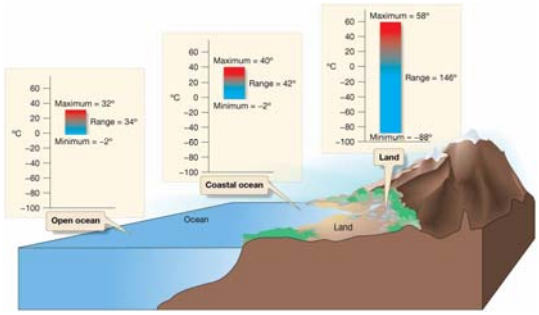
Reproduction

- 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



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 orgsnisms 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

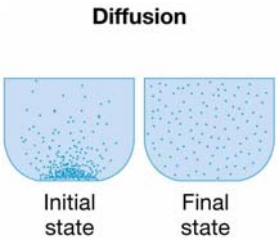
- Stenothermal
  - Organisms withstand small variation in temperature
  - Typically live in open ocean
- Eurythermal
  - Organisms withstand large variation in temperature
  - Typically live in coastal waters

Salinity and Marine Organisms

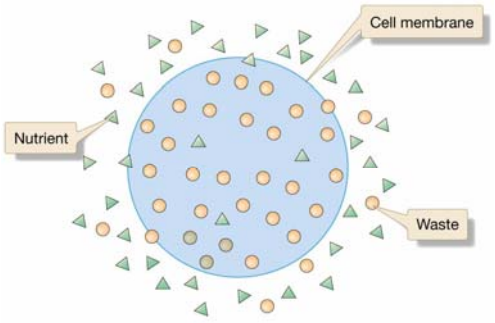
- Stenohaline
  - Organisms withstand only small variation in salinity
  - Typically live in open ocean
- Euryhaline
  - Organisms withstand large variation in salinity
  - Typically live in coastal waters, e.g., estuaries

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

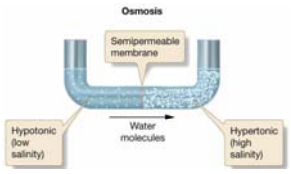


Diffusion



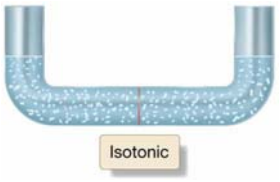
Osmosis

- Water molecules move from less concentrated to more concentrated solutions
- Osmotic pressure
  - In more concentrated solutions
  - Prevents passage of water molecules

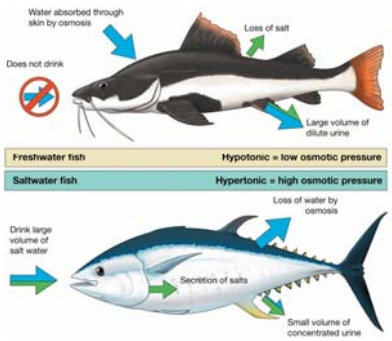


Osmosis

- 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



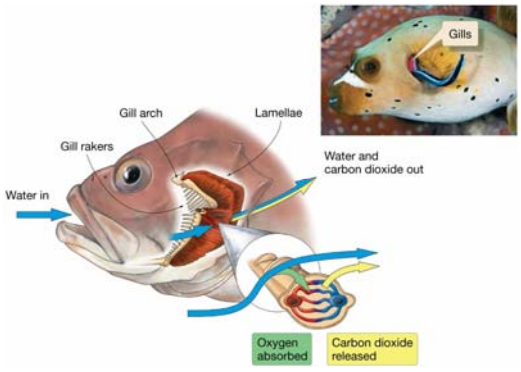
Marine vs. Freshwater Fish



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



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

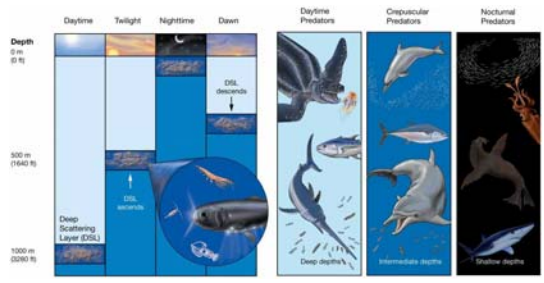
Camouflage and Countershading

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



Disruptive Coloration

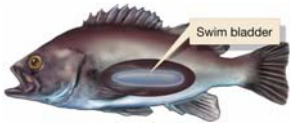
- Large, bold patterns, contrasting colors make animal blend into background

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

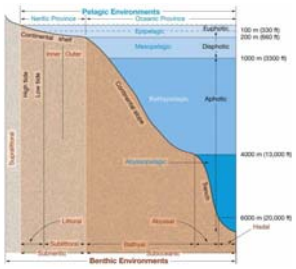


Divisions of the Marine Environment

- Pelagic (open sea)
  - Neritic (< 200 meters) and oceanic
- Benthic (sea floor)
  - Subneritic and suboceanic

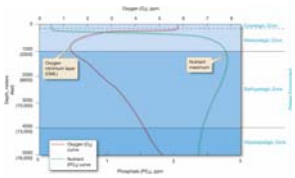
Pelagic Environment

- 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)



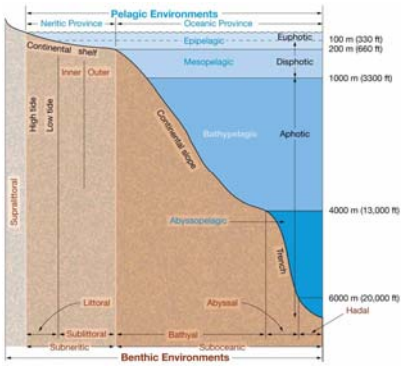
Ocean Province

- 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 atttached 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