

Marine Science Study Guide

Ocean Exploration

Introduction to Marine Science

- **Types of Marine Scientists**
 - **Marine biologists:** They study marine plants and animals, their development, population dynamics, and adaptability, and interaction with the environment.
 - **Marine geologists:** Study the ocean floor, plate tectonics, volcanic processes, the climate, and much more.
 - **Marine chemists:** They study the atmosphere, seafloor, and the seawater. They study the impacts of chemical processes on currents, climate, and marine organisms.
 - **Physical Oceanographers:** Study processes in the ocean (waves, tides, and currents). They explore the ocean's interaction with the atmosphere and the land.
- **Marine scientists have tried to reduce the sea star population with these methods:**
 - Divers have tried to capture and cut the sea stars.
 - They have collected sea stars and buried them on land.
 - They have also tried injecting sea stars with poison, but this method results in more toxins in water.
 - Sending autonomous drones to find and inject sea stars with poison.

Ocean Exploration

- **Three important abiotic components:** water chemistry, geology, and physical factors.
- **Water Chemistry**
 - Salinity of seawater: 35 parts per thousand
 - Seawater contains trace minerals, dissolved gases such as carbon dioxide and oxygen, and nutrients.
- **Geology**
 - The Earth's crust is divided into **plate tectonics** (some of it is underwater).

- The **continental plates** in the ocean create underwater, trenches, volcanoes, trenches, mountain ranges, and much more.
- **Physical Factors**
 - **Pressure:** Increase of 1 atm for every 10 meters of depth in the ocean.
 - **Oxygen:** Oxygen-rich waters tend to be in the bottom because cold water holds more oxygen (dissolved) than warm water.
 - **Temperature:** Underwater, there are thermoclines which are layers of water with different temperatures.
 - **Water movement:** Interactions such as waves, tides, and currents.
 - **Light:** Not enough light for photosynthesis 200 meters deep into the ocean.
 - **Nutrient Availability:** Nutrients such as carbon, nitrogen, and phosphorus are found in the ocean.
- These are some **technological advances** which have helped marine scientists explore more about the ocean: SCUBA (self-contained underwater breathing apparatus), Submarines and HOVS, ROV, and AUV.
 - HOV – Human-occupied vehicle
 - ROV – Remotely operated vehicle
 - AUV – Autonomous underwater vehicle
- **Scuba divers** use weighing systems to stay underwater because human bodies have such good buoyancy.
 - **Buoyancy** – ability to float in a liquid
- Marine scientists use models/maps to compare data or make predictions.
 - Examples of models used: Map of sea surface temperatures, map of sea ice concentration

Ocean Zones

- **Epipelagic Zone**
 - This zone extends to about 200 meters of depth from the surface.

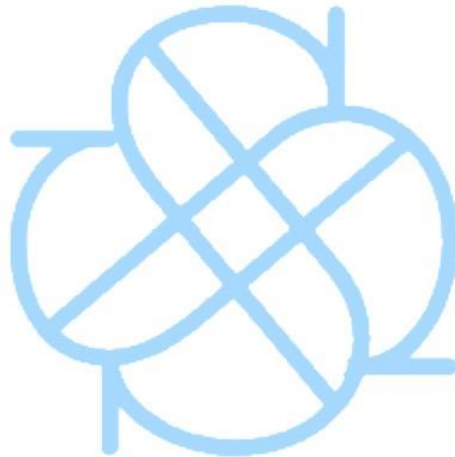
- Also known as the **sunlight zone**.
- **Mesopelagic Zone**
 - Extends from 200 to 1,000 meters
 - Some amount of light but not enough for photosynthesis to occur.
 - Also known as the **twilight zone**
- **Bathypelagic Zone**
 - Extends from 1,000 to 4,000 meters
 - No visible light
 - Immense water pressure
 - Also known as the **midnight zone**.
- **Abyssopelagic Zone**
 - Water temperature: near freezing
 - Extends from 4,000 to 6,000 meters of depth
 - Also known as the **abyss**
- **Hadal Zone**
 - Below 6000 meters from the surface
 - Mostly contains deep water trenches, mountain ranges, and canyons.
- It is important to study **methane** in the ocean because it can tell us about biological activity around the seeps, act as a source of energy for land, destabilize sediments on the ocean floor, and impact global warming.
 - Methane can also affect the activity in the atmosphere.
- **Movement** in the ocean: waves, tides, surface currents, and deep-water currents.
 - **Waves:** They are caused by wind and can carry energy over long distances. The wave energy is usually transferred through the water molecules rather than the water moving along the wave.
 - **Tides:** They are caused by the gravitational pull of the moon and sun. The moon has more influence on tides as it is much closer to the Earth.
 - **Spring Tides:** a tide which occurs around a full moon, this is when there is a larger tidal range than usual.
 - **Neap Tides:** a tide which occurs around a quarter moon, this is when the tidal ranges are smaller than usual.

- **Surface Currents:** They are caused by strong winds which blow over the ocean.
 - **Coriolis effect:** It is the effect caused by the Earth's rotation which deflects the bodies in the northern hemisphere to the right and the ones in the southern hemisphere to the left.
 - **Gyres:** a ringlike system of currents in the ocean.
- **Deep-water currents:** vertical movement of water
 - **Upwelling:** warm water is moved away from surfaces by currents, cold water replaces it
 - **Downwelling:** denser water sinks to the sea floor
- The **South Ocean Current** carries dense and oxygen-rich water which sinks near Antarctica into the Indian and Pacific Oceans.
- **Ocean "conveyor belt"** – pushes water from the ocean surface back to the bottom of the ocean.

Properties of Water

- **Composition:** Approximately 85% of the ocean is made of sodium and chloride. Almost every natural element in the periodic table can be found in the seawater.
- **Source:** These minerals come mostly from the rocks on land. Hydrothermal vents and active underwater volcanoes also contribute to these minerals found in the ocean.
- **pH:** Seawater has a basic pH value of approximately 7.8.
- **Concentration:** concentration of salt in the ocean water can vary from 32 to 37 ppt depending on the location or the season. The formation of sea results in a layer of water which has high salinity level because of the freezing water.
- **Proportion:** Ions are constant throughout the ocean. The consistency relates to the interconnections between the oceans.
- **Different phase changes of water:**
 - Melting
 - Freezing
 - Vaporization
 - Condensation
 - Sublimation

- Deposition
- These affect the **density** of seawater: salinity, temperature, and depth.
 - Seawater has salt ions and other minerals dissolved in it.
 - Temperature: Cold water is denser than warm water.
 - Shallow water is less dense than deep water.
- **Density differences** in the ocean are responsible for many deep ocean currents which circulate around the world.
- These **properties of water** are why water is important to life on Earth.
 - Low Vapor Pressure
 - High Boiling point
 - Lower Density as solid



Water World

Plate Tectonics

- **Two prominent theories** regarding the formation of mountain ranges and continents.
 - Contraction Theory
 - Theory of Continental Drift
- The evidence which suggested that the continents might have been connected in the past are:
 - The similarities between coastlines of continents such as South America and Africa.
 - Similar fossils were found in continents which are now separated by the 7 oceans.

- The rock patterns and glacial deposits in different continents.
- **Asthenosphere**
 - It's a liquid with a consistency similar to plastic. It's located in the bottom layer of the mantle.
- There are **two types of crust**: oceanic crust and continental crust:
 - **Oceanic crust** is the thinner part of the Earth's crust.
 - Made mostly of basalt
 - **Continental crust** is the thicker part of the Earth's crust.
 - Made mostly of granite

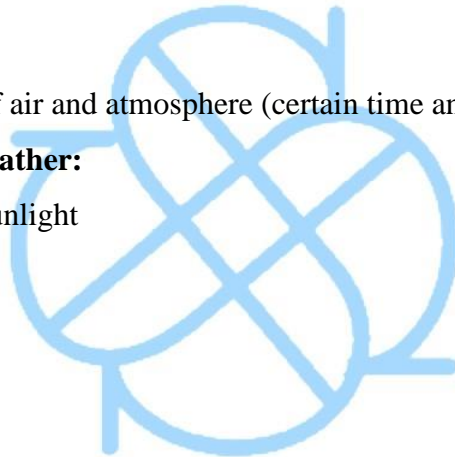
Ocean Formation

- **Water in the oceans**
 - All of the oceans are connected and what affects one part of the ocean can affect the rest of it.
- Where did the water for the oceans come from?
 - **Inside-out model**
 - The water was bonded to many minerals in the mantle when the Earth was first formed. Evidence shows that the water was brought to surface through volcanic action inside the Earth.
 - **Outside-in model**
 - Most of the water came after the Earth formed.
 - Evidence suggests that the water might have mixed with the materials in the Earth's upper layers and it also might have been because of volcanic action.
- **Ocean features**
 - **Abyssal Plain**: Underwater plain which lies between the continental rise and a mid-ocean ridge.
 - Covers more than 50% of the Earth's surface.
 - Depth between 3,000 and 6,000 meters.
 - **Continental Shelf**: It extends away from the ocean's coastline.

- **Continental Slope:** Slope is the area between the continental shelf and the ocean floor.
- **Volcanoes:** These volcanoes may be completely submerged underwater or they can create high mountains which can rise above sea level.
- **Guyot:** An ancient volcano whose top has eroded over time.
- **Seamount:** Underwater mountain which has a pointed peak.
 - The top is still submerged.
- **Trench:** Long, narrow opening in the crust.
- **Mid-Ocean Ridge**
- **Tsunamis:** Ocean waves created by sudden displacements resulting from any volcanic activity.

Ocean's Impact on Weather

- **Weather** is the state of air and atmosphere (certain time and place).
- **Factors that cause weather:**
 - Latitude and Sunlight
 - Pressure
 - Precipitation
 - Temperature
 - Clouds
 - Humidity
 - Wind
- These are a few stories of how weather affects living things.
 - Hurricane devastates sea turtle nests
 - Wind and Tidal Surges (Mangrove Population)
 - Severe Storm which disrupts food web and coral reef
- **Air pressure, temperature, and density** affects the air molecules in which strong storms are formed.
- Heat energy from the sun to air and water is a result of a process known as **convection**.
 - **Convection:** the movement of currents which results from differences in the temperature.



- What causes these natural disasters?
 - **Tropical cyclone:** warm, moist air, wind, and warm ocean water
 - **Tornado:** warm, humid air, cooler air, wind shear, and a cold front (w/ low pressure)
 - **Blizzard:** cold air, a high-pressure system, and moisture
 - **Flood:** heavy rainfall or coastal storms
- **National Oceanic and Atmospheric Administration (NOAA)** – the meteorologists at the Aircraft Operations Center train to become flight directors for their heavy aircraft unit (helpful during hurricanes).
 - They have to fly through unusually high wind speeds.

Ocean's Impact on Climate

- **Greenhouse effect:** A process where gases in the atmosphere trap the radiation from the sun. It also retains heat.
- **Global Warming:** The overall temperature of the atmosphere has been increasing.
 - Results from the greenhouse effect
- **Climate Change:** A long-term effect/change in climate.
 - Includes weather patterns and temperature
- **Heat Sink:** A system which can absorb heat without a phase change or temperature difference.
 - **How does the increase in the amount of heat in the ocean affect weather and climate?**
 - Rising sea surface temperatures (develops stronger tropical storms)
 - Sea levels which rise due to the melting sea ice
 - Currents can lead to differences in climate patterns around the world.
- **Currents:**
 - They are constantly in motion and try to keep temperatures consistent around the world.
 - **Ocean Currents:** Movement in the ocean with continuous flow because of temperature, wind, and water salinity.
 - **Jet Streams:** Quick currents of air which move from east to west.

- **Carbon Sink:** Natural systems in our environment that absorb and store carbon.
- **Zooxanthellae:** microscopic algae (symbiotic relationship with some coral).

Air and Sea Interactions

- **Biogeochemical cycles:** Chemicals are transferred between the environment and many living systems through these pathways.
- **Transpiration:** Water moves from plants to our atmosphere.
- **Evaporation:** Water moving from ocean to clouds.
- **Evapotranspiration:** Water moving from plants to sky.
- **Condensation:** Water moving from sky to clouds.
- **Precipitation:** Water moving from clouds to ground.
- **Photosynthesis:** this process involves energy from the sun light, water, and CO²
 - Produces glucose and oxygen for plants
- **Respiration:** Cellular process which uses oxygen and other organic substances
 - Releases stored energy
 - Produces carbon dioxide
- **Decomposition:** Breakdown of a larger substance into simpler substances
 - Often, it is broken down by fungi or bacteria
- **Gas Exchange:** Diffusion of gases
 - Diffusion from a region of higher concentration to a region of lower concentration.
- **Emissions:** The production of something from a particular source.
- The **nitrogen cycle** is crucial to the ocean food webs.
 - It is a biologically limiting element.
- **Hypoxic:** low oxygen
- **Fixation:** In this process, nitrogen (inorganic) from the atmosphere is converted into inorganic compounds.
 - Usually caused by microorganisms
- **Ammonification:** Process in which decomposers convert organic nitrogen to ammonia.
- **Nitrification:** Oxidation of an ammonia compound,
 - Results in nitrite and nitrate compounds.

- **Assimilation:** Forms organic nitrogen compounds from other inorganic nitrogen compounds.
- **Denitrification:** Movement of nitrogen from nitrates (in soil) to the nitrogen gas in the atmosphere.

Oceans in Motion

Seasons of Change

- **Ecosystem:** living in an environment which also has abiotic components.
- **Ecological succession:** changes in the species of an ecological community.
 - Two types of ecological succession (can happen over really short periods of time)
 - **Primary:** Begins in a new environment which is lacking vegetation.
 - **Secondary:** Occurs in an environment with preexisting soil or after an existing ecosystem was destroyed.
- **Pioneer Species:** species which are the first organisms to have arrived.
- **Phytoplankton:** microscopic marine plants
 - Form the base of many ocean food webs
- **Zooplankton:** microscopic marine animals
 - Primary consumers in numerous ocean food webs
- **Three ocean's systems are:**
 - Open, closed, and isolated

Surf's Up

- **Parts of a wave:**

- Crest
- Trough
- Equilibrium
- Amplitude
- Wavelength
- Wave height
- Frequency
- **Four steps which cause a wave to break:**
 - Wave height increases
 - Top part moves faster than bottom part of the wave
 - Wavelength meets the seafloor and bottom part of the wave slows down
 - Top part of the wave crashes into the water resulting in waves breaking.
 - This means that the wave depth is getting closer to the height of the wave.
- **Medium:** substance which makes transfer of energy easier
- **Refract:** occurs when the direction of the waves change
 - The waves tend to pass from one medium to another.
- **Wave interference:** Event in which two waves combine to form a final wave with a greater or lower amplitude.
 - **Constructive interference**
 - Displacement of two waves in the same direction.
 - **Destructive interference**
 - Displacement of two waves in opposite directions.
 - **After interference**
 - The two waves collide.
- **Ways that a medium can affect a wave**
 - Absorption
 - Refraction
 - Reflection
 - Diffraction

Sound in the Sea

- **Echolocation:** location of objects that is reflected by sound energy.
- **Sound energy** travels significantly faster than in air.
 - Many factors affect the speed of sound underwater.

Highways of the Sea

- Different types of tides
 - **Semidiurnal Tide**
 - Two high tides and two low tides
 - Water level is consistent each day
 - **Mixed Semidiurnal Tide**
 - Two high tides and two low tides
 - Water level varies
 - **Diurnal Tide**
 - One high tide and one low tide
- **Deep water waves:** waves in water which are deeper than half the wavelength
- **Shallow water waves:** waves that are shallower than 1/20 their wavelength
- **Fetch:** distance on the surface of the ocean over which the wind blows.
- **Wind-driven waves:** Caused by strong winds during a tropical storm.
- **Tidal Waves:** Caused by tides (not Tsunamis).
- **Tsunamis:** A huge displacement of water from an underwater volcanic activity or movement.
- **Types of waves**
 - Surging Breakers
 - These waves move into the shore without breaking.
 - Plunging Breakers
 - Spilling Breakers

Coastal Dynamics

- **Types of coasts**
 - Based on *location*
 - **Active coasts**

- Pacific US Coast
 - Atlantic US Coast
 - **Passive coasts**
- Based on *formation*
 - **Active coasts**
 - Deltas
 - Nile River Delta
 - Volcanic coasts
 - Hawaiian Islands
 - **Passive coasts**
 - Marine-Deposition
 - Barrier Island, Mexico
 - Other
 - Built by marine organisms like mangroves or coral reefs
 - Great Barrier Reef, Australia
- **Benthic Zone:** lowest ecological region in the ocean
- **Intertidal**
 - Region between low tide mark and high tide mark
- **Littoral Zone:** Area near shore where the sun shines on the water.
 - Region between the lowest and highest tides.
- **Supralittoral Zone:** a splash zone
 - Always above the high tide
- **Sublittoral Zone:** region between the high tide mark and low tide mark
- **Tidepools**
 - Wave Action
 - Temperature (during low tides, the water tends to reach extreme temperatures)
 - Air Exposure
 - Salinity
 - Predation
 - At low tides, marine organisms have a higher risk of being exposed to coastline predators.

Marine Life

Marine Biodiversity

- **Adaptations:** traits which are a result of natural selection.
- **Endemic species:** they are unique to a certain geographic location
 - Marine Iguanas
 - Galapagos Penguins
- **Divergent Evolution**
- **Convergent Evolution**
 - **Analogous structures:** a structure with similar functions in 2 different species.
- **Parallel Evolution**

Marine Biodiversity and Biotechnology

- **Gene pool:** set of all genes
- **Genetic Modification**
 - Coding Sequence is isolated from DNA.
 - Desired gene is inserted into the DNA of an organism.
 - The embryos of the next generation of the same species contain this new genetic material in their DNA.
 - The modified fish now has the desired or inserted trait.

Ocean Health

- Algae that grows in high concentrations cause an occurrence known as an **HAB**.
 - **Karenia Brevis**
 - They grow in regions with high salinity.
 - **Lyngbya**

- Causes swimmer's itch
- Destroys aquatic ecosystems
- **Gymnodinium Catenatum**
 - Causes paralytic shellfish poisoning
 - Primary Producers
 - Consumed by shellfish, copepods, or dinoflagellates
- **Karlodinium Veneficum**
 - Found in subtropical regions
 - Toxic to fish
 - Effects on human beings are not known yet
- **Gambierdiscus Toxicus**
 - Warm tropical and subtropical waters
 - Causes the condition called ciguatera fish poisoning
 - Humans can get this if they eat the fish with this poison
 - Does not cause shellfish poisoning
- **Pathogens:** infectious agents which result in diseases.

Marine Populations

- What does HAB impact in each ocean zone?
- **Epipelagic Zone**
 - Sea Turtles
- **Mesopelagic Zone**
 - Fish (their gills stop functioning properly)
- **Bathypelagic Zone**
 - Invertebrates
- **Abyssopelagic Zone**
 - Cannot get much oxygen (hypoxic zone)
 - Reduction of the amount of mixing in the ocean water.

Animal Adaptations

- **Evolution by Natural Selection**

- **Overproduction:** causes competition for survival.
- **Variation:** Might hurt an organism's survival rate.
- **Heritability:** Inherited from different generations.
- **Differential Production:** Variation of survival and reproduction rates
- **Descent with Modification:** Heritable traits help them evolve and survive
- **Artificial Selection:** genetically modifying a breed intentionally for a desired trait
 - Humans can influence the evolution of other species through artificial selection.

Marine Habitats

- **Various parts of an ecosystem:**
 - **Ecosystem:** living things in a region
 - A physical environment
 - **Habitat:** physical location in an ecosystem
 - **Population:** group of the same species that live in the same location
 - **Species:** similar organisms which can produce fertile offspring
- **Coastal Ecosystems**
 - Intertidal Zones
 - Estuaries, Salt Marshes, and Mangroves
 - Eutrophication
 - Stimulates the excess growth of algae
 - Seagrasses
 - Kelp Forests
 - Coral Reefs
 - Continental Shelf
 - Neritic Zone (stretches from the low tide mark out to the continental shelf)

Aquatic Interactions

Marine Ecosystems

- **Biotic**
 - Living things – can grow or reproduce
 - Examples: animals, insects, protists, plants, fungi, and bacteria
 - Matter that comes from other living things (organic matter)
- **Abiotic**
 - Cannot reproduce
 - Cannot grow
 - Examples: sunlight, air, water, temperature, rocks
 - Inorganic matter (these factors were never alive)

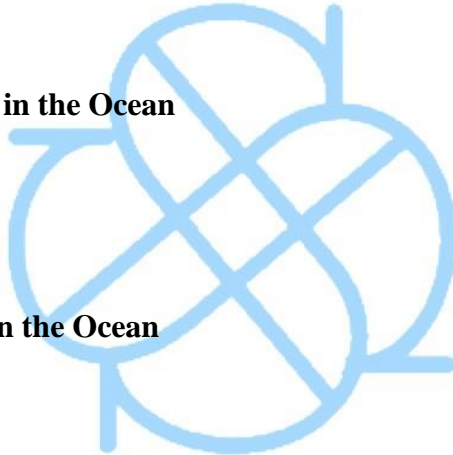
Food Webs and Energy Transfer

- **Primary producers** – they produce organic matter using an energy source and inorganic matter
- **Primary consumers** – organisms which directly eat producers
- **Secondary consumers** – organisms that eat primary consumers
- **Food chains** – they only follow one path of energy
- **Food web** – shows how plants and animals are connected in an ecosystem
 - Shows their dependency on each other to survive.
- **Decomposers** – Organisms who break down dead, organic matter.
- **Examples of organisms in an ecosystem/food web**
 - Clams (primary consumers)
 - Crabs (primary consumers)
 - Whale (Secondary Consumers)
 - Starfish (Secondary Consumers)
 - Flat Fish (Secondary Consumers)
 - Polar Birds (Tertiary consumers)
 - Seals (Tertiary consumers)
 - Bacteria (decomposers)
- **Trophic Levels, energy sources, and examples**

- **Primary Producer (autotroph)**
 - Energy source: photosynthesis or chemosynthesis
 - Example: some bacteria, algae, plants
- **Primary Consumer (heterotroph, herbivore)**
 - Energy Source: manatees, zooplankton
- **Secondary Consumer (heterotroph, carnivore)**
 - Energy Source: feeding on primary consumers
 - Example: Seals, Tuna
- **Decomposer (saprotroph)**
 - Energy Source: Dead organisms or waste products
 - Example: Fungi, insects, bacteria

Marine Relationships

- **Harmful Interactions in the Ocean**
 - Predation
 - Parasitism
 - Competition
- **Helpful Interactions in the Ocean**
 - Mutualism
 - Commensalism
- **Ecological forecasting:** method which uses data to predict any future changes in ecosystems



Human Impact on Marine Life

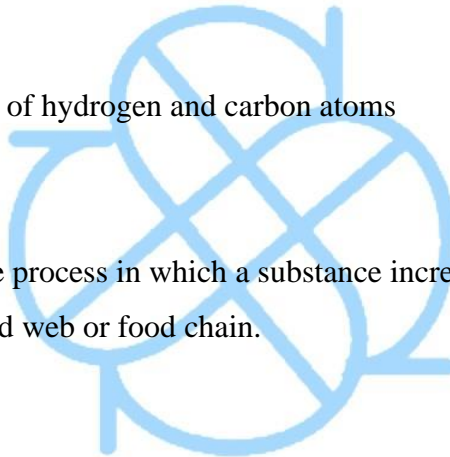
- **Downsides of Marine Shipping**
 - Oil Spills
 - Ballast Water
 - Waste and Sewage Dumping
 - Physical Damage
 - Emission of Greenhouse gases

Biotechnology and Environmental Conservation

- **Bioluminescence:** production of light through an organism
 - Example: Zebrafish
- **Biotechnology Applications**
 - Biomimicry
 - Tries to solve problems based on other examples in our nature.
 - Biochemical Engineering
 - Bioprospecting
 - Discovering new ways to produce more biologically helpful resources and then sell them for commercial purposes.
 - Environmental Biotechnology

Marine Pollution

- **Hydrocarbons:** chains of hydrogen and carbon atoms
 - Methane
 - Propane
- **Biomagnification:** The process in which a substance increases in concentration when it travels upward in a food web or food chain.



Marine Conservation

Marine Conservation

- **Microplastics** – plastic smaller than 1 mm
- **Impacts of Marine Debris**
 - Ingestion
 - Habitat damage

- Economic cost
- Entanglement & Ghost fishing
- Hazard to navigation
- Non-native species
- **Invasive species**
 - They reproduce quickly.
 - Can harm the ecosystem.
- **Native Species**
 - Also called indigenous species
 - They exist in a region because of natural processes.
- **Non-native Species**
 - They're brought from a new area intentionally
 - Can act as food crops, pest control, or pets in the ecosystem

Research Management

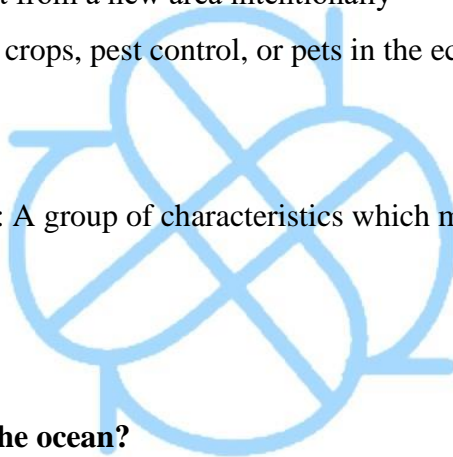
- **Environment Quality:** A group of characteristics which measure the quality of the environment.

Marine Resources

- **How do humans use the ocean?**
 - Commercial Shipping lanes
 - Oil rigs
 - Unexploded military ordnance
 - Artificial reefs
 - Fisheries Management Zones
 - Undersea cables
 - Recreation

Future of an Ocean Planet

- **Renewable Resources**
 - Tidal Power



- Biological Resources
- Recreation
- **Non-renewable resources**
 - Petroleum
 - Salts & minerals
 - Sand & Gravel
 - Methane Hydrates
 - Natural Gas

Works Cited

FLVS Course – Marine Science, <https://www.flvs.net/flex/courses#highschool/83>

