Report Card 9. Some Interrelationships between Temperature, Salinity, pH, Chlorophyll, Oxygen, Nutrients, and Turbidity in Seawater (Physiochemical factors)

Seawater is a complex and dynamic environment influenced by multiple interconnected factors that shape its composition and ecological balance. The relationships between temperature, salinity, pH, chlorophyll, oxygen, nutrients, and turbidity are essential for understanding marine ecosystems and their response to natural and anthropogenic changes.

These physiochemical parameters can influence the appearance (morphology) of a plant or animal to match the environment it lives in. Not only can they alter how it looks, but also its internal workings (physiology), food availability, energy requirements, susceptibility to disease (stress), the toxicity of certain compounds, longevity, or behaviour based on the different things happening around it, like other living things such as predators and or competitors.

Temperature and Salinity:

- Temperature and salinity gradients play a significant role in driving ocean currents and circulation patterns. These currents, in turn, influence the distribution of nutrients, organisms, and heat across the ocean.

- Water temperature is affected by: Season, Time of day, Sunlight (solar radiation), Atmospheric heat transfer, Weather (wind and rain), Turbidity (water cloudiness), Meeting of water bodies (rivers, streams, storm drains, etc.), Depth and Anthropogenic (human-induced) factors.

- Changes in salinity levels can affect the metabolism (rate at which they use oxygen and food) of marine organisms and the distribution of species in an area. These changes in salinity can be caused by various factors, such as droughts, storms, or human activities like urban runoff and sewer discharge. Monitoring salinity levels is essential to ensuring the well-being of marine life and ecosystems.

- Salinity is simply a measure of dissolved salts in water. It is typically expressed in parts per thousand (ppt), or ‰. Fresh water has a salinity of 0 to 0.5 ppt. Estuaries can have varying salinities from 0.5-30 ppt depending on the sampling location and its proximity to freshwater inputs or the ocean. As an approximation, the average salinity of ocean water is 35 ppt.

A **thermocline** refers to a distinct temperature boundary that can form within a body of water, characterized by a significant change in temperature with depth. In the sea these may be formed when the sea is very calm and not mixed by wind and waves. As an example, the depth at which a change of temperature by one-degree Celsius or more within one meter of depth may be considered by some as a thermocline point.

Sometimes the temperature of seawater near the surface may become warmer due to sunlight and heat exchange with the atmosphere, while the deeper layers are colder. The thermocline in stratified water is the area where this temperature change is most evident, and its depth can vary depending on factors such as the time of day, season, and location.

The presence of a thermocline can have significant implications on the distribution of aquatic life and can affect various physical and biological processes within the water body. For instance, it can influence the vertical movement of nutrients and plankton, affecting the distribution of fish and other organisms that rely on these resources.

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A **halocline** is a specific type of stratification or layering within a body of water where there is a rapid and significant change in salinity with increasing depth.

In some waterbodies, the surface layers have lower salinity due to freshwater inputs from rivers and rainfall, while the deeper layers often have higher salinity. The halocline is the region where this change in salinity is most pronounced, and it can vary in depth and intensity depending on environmental factors (temperature, wind and rain).

The presence of a halocline can have significant ecological consequences, as it can affect the distribution of marine organisms and influence the mixing of water masses within the ocean.

- The amount of dissolved oxygen (DO) that can be retained in saltwater is lower than in freshwater when all things are equal. In the ocean, the average annual DO concentrations in surface water vary from 9 mg/L in colder regions to 4 mg/L near the equator (warmer), and the DO levels decrease as you go deeper into the ocean.

pH and Carbon Dioxide (CO2) Levels:

- pH, which stands for “power of hydrogen”, is a measure on a 14 point scale of the acidity or alkalinity of seawater. pH is measured on a logarithmic scale. Meaning that a 1.0 change in pH (positive or negative) is a difference of a factor of 10. Thus a pH of 8.0 is 10 times more basic (alkaline) than 7.0 and 100 times more basic than 6.0.

- Increased carbon dioxide (CO_2) levels from activities like fossil fuel combustion contribute to ocean acidification, lowering seawater pH.

- As CO_2 dissolves in seawater, it forms carbonic acid, leading to a decrease in pH. Lower pH can impact marine organisms with calcium carbonate shells or skeletons, such as corals and molluscs, making it harder for them to build and maintain their structures.

- When phytoplankton and macro algae undergo photosynthesis, they transform CO_2 from the water into carbohydrates and oxygen. This process reduces the CO_2 levels in the water, which in turn lowers the acidity. The greater the phytoplankton bloom and the longer thde daylight duration, the more significant the reduction in acidity and the higher the pH levels. While other factors do impact pH, the quantity of phytoplankton is a leading influencer.

- Once a phytoplankton bloom is over, and the phytoplankton die and decomposes, there is a release of CO_2 into the water, making the water more acidic and lowering the pH levels.

- Human activities, such as sewage overflows or runoff, can cause marked short-term fluctuations in pH, and, depending on the severity, can be extremely harmful to plants and animals. Extreme pH changes can stress aquatic organisms.

Chlorophyll and Nutrients:

- Phytoplankton use chlorophyll and other pigments to photosynthesize, absorbing carbon dioxide to produce fuel.

- Chlorophyll is a pigment essential for photosynthesis in marine phytoplankton. It serves as an indicator of primary productivity, representing the presence of microscopic plants at the base of the marine food web.

- Chlorophyll-a can serve as an important marker for primary production in marine waters in response to nutrient and light levels, and is important in determining water quality. The average concentration of chlorophyll-a reflects the varying levels of biological productivity found in maritime regions. Trends observed in different locations indicate the development of chlorophyll-a regardless of its magnitude.

- Nutrients such as nitrogen and phosphorus are important for phytoplankton growth (for diatoms, silica, though not a nutrient can also be a limiting factor). Higher nutrient concentrations can lead to increased chlorophyll production, stimulating algal blooms. However, excessive nutrient loading, often from human activities, can result in harmful algal blooms and subsequent oxygen depletion.

Oxygen and Nutrients:

- Oxygen is vital for aquatic life and supports various biochemical processes. It is essential for respiration by marine organisms.

- Nutrient availability can influence oxygen concentrations in seawater through biological processes. High nutrient levels can lead to algal blooms, followed by increased microbial decomposition as the blooms die off. This decomposition consumes oxygen, potentially causing hypoxic (low-oxygen) conditions.

Turbidity and Sediment Transport:

- Turbidity refers to the cloudiness or haziness of water caused by suspended particles such as sediment, algae, and organic matter.

- Turbidity can impact light penetration and photosynthesis in water. Suspended sediments also transport nutrients and contaminants, affecting water quality and potentially smothering sensitive habitats.

Interplay and Ecosystem Dynamics:

The factors (temperature, salinity, oxygen, pH and turbidity) do not act in isolation; they interact in complex ways that shape marine ecosystems:

- Eutrophication: High nutrient levels can lead to eutrophication, causing algal blooms. These blooms consume oxygen during decomposition, leading to oxygen-depleted zones, impacting marine life.

- Climate Change: Rising temperatures and altered CO_2 levels influence pH, particularly in offshore waters affecting marine organisms' ability to build calcium carbonate structures.

- Upwelling: Oceanic upwelling events bring nutrient-rich cold waters to the surface, promoting high primary productivity and supporting diverse marine life.

Understanding the relationships between these physiochemical factors is vital for managing marine ecosystems, fisheries, and overall ocean health. Continuous monitoring and integrated research efforts are crucial to predicting ecosystem responses to changing environmental conditions and developing effective conservation strategies.

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Report

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