2020

KNYSNA BASIN PROJECT

KNYSNA ESTUARY WATER QUALITY WORKBOOK

NOS'PHAMANDLA NDAMANE & NTOMBIZODWA VUNDLA

Table of Contents

This guide was developed through funding received from Table Mountain Fund

Introduction to workbook

Water quality describes the condition of water with reference to its chemical, physical and biological characteristics. These are monitored with respect to the intended use of the water, in the case of the Knysna estuary for recreational activities such as swimming and the ability of marine animals to live there. It is important to monitor these characteristics to identify whether the water contains any pollutants and if it complies with local and international standards. It is also to ensure that water is safe for animals and humans.

The Knysna Estuary Monitoring Platform (KEMP) was established by the Knysna Basin Project, with the overarching aim of providing a platform to monitor the water quality and hydrological processes of the Knysna estuary and to use the data generated to provide guidance to management and conservation authorities.The aim of this workbook is to inform teachers and environmental educators about the Knysna estuary: what it is, why it is important and how water quality affects life in an estuary.

This workbook may be used in conjunction with the Curriculum Assessment Policy Statement (CAPS) document, below is a table which summaries where one can apply the literature in this workbook.

Grade	**Topic**	**Link to workbook**
Natural Science: Grade 4 Term 1	Habitats for animals	Estuaries act as nurseries for many animals and there is an array of habitats that surround estuaries such as salt marshes, rocky shores and seagrass.
Natural Science: Grade 5 Term 1	Plants and animals on Earth	Estuaries are home to many animals and plants and the water quality of the estuary affects plants and animals.

Natural Science: Grade 6 Term 1	Ecosystems and food webs	Explore the array of habitats that surround estuaries such as salt marshes, rocky shores etc and the threats they face. Also, look at the different food chains within an estuary.
Natural Science: Grade 6 Term 2	Water pollution	Explore how water quality affects the diversity and functions of the estuary. Also, how surrounding communities contribute to polluting the estuary.
Geography: Grade 7 Term 4	Management of resources: Eco-tourism	Explore the value of the estuary within the eco-tourism sector and how poor water quality would impact this.
Natural Sciences: Grade 9 Term 2	Acids, bases & pH	The workbook aids in explaining what pH is and how it affects marine animals.
Geography: Grade 10 Term 4	The world's oceans	Use the Knysna estuary as a close to home example to illustrate the relationship between humans and water and explore the use of KEMP as a strategy for estuary water management.
Life Science: Grade 11 Term 4	Human Impact on the environment: Water quality	Explore how the freshwater from surrounding catchments (Bongani, Bigai, Salt and Knysna river) are impact by humans and how that ultimately feeds into the estuary.

Knysna estuary: What is all the fuss about?

An estuary is a body of water where the sea and a river meet. They are an important link between the land and ocean. The Knysna estuary is the most important estuary in South Africa in terms of conservation importance and roughly 42 % of South Africa's estuarine biodiversity is found within this system. The Knysna estuary contains the largest eelgrass beds in South Africa and is home to the Endangered Knysna seahorse (*Hippocampus capensis*), which depend on this habitat type. These are just some of the features that highlight the ecological importance of this estuary and the crucial need to ensure its long-term conservation. The Knysna estuary is not only ecologically important, but also functions as an important tourist attraction, providing much needed economic support for the town and surrounding communities. Many local communities also depend on it for subsistence in the way of fishing and/or bait collection.

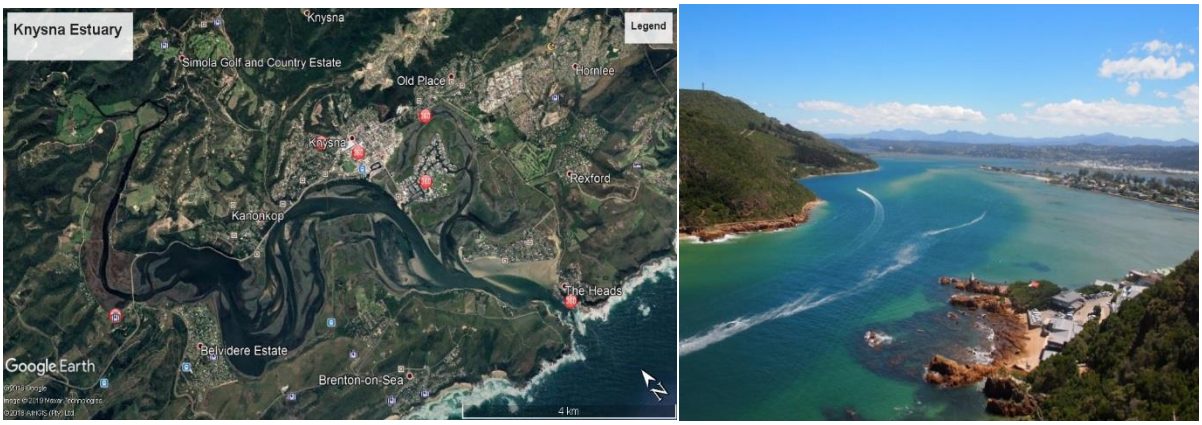

Figure 1: Knysna Estuary.

The Knysna estuary is Knysna's most important ecological and economical asset. To continue to reap the benefits from this asset, the estuary and its biota need to be maintained in a healthy ecological state. Good water quality is integral to a healthy estuary. It is our responsibility as society and professionals to understand the hydrological and biological characteristics of the estuary, monitor patterns and changes over time, assess potential human impact on the estuary, and to use this information to successfully manage and conserve this system.

Hydrological regimes of the Knysna estuary

Hydrological regimes refer to the variations in the state and characteristics of a water body often influenced by water flow, temperature and salinity. Each regime is different due to the temperature and salinity value. This effect is called the thermohaline (the effect of temperature and salinity combined) character of the estuary.

In the Knysna estuary the thermohaline character is described as a bay regime near the ocean (From the heads to the railway bridge). This regime is well flushed by tidal flows and has temperatures and salinities similar to the ocean. Near freshwater (rivers) it has an estuary regime (from the white bridge to the inflow of the Knysna river) due to freshwater inflow and stratification. In between these two (bay and estuary) regimes is the lagoon regime (from the railway bridge to the white bridge). This regime has salinities close to ocean salinity but higher temperatures. Compared to the two other regimes, this one is flushed less rapidly and has long residence times (meaning water stays here for a longer time). This regime disappears during strong freshwater inflow (floods) and expands during low freshwater inflow (drought).

Stratification in estuaries

Stratification in an estuary refers to the formation of different water layers. It occurs as a result of different densities between two water layers and can also arise as a result of differences in temperature (cold water is heavier than warmer water), salinity (freshwater is lighter than saltwater) or a combination of both. Ocean water has a higher density than freshwater due to its high salinity.

Stratification in estuaries is important because of the restricted mixing of freshwater and ocean water. In stratified estuaries the lower saline water is replaced more rapidly since less dense freshwater inputs do not mix but floats.

To further illustrate the different water densities, one may conduct the experiment below:

Needs:

1. 2 x clear glasses
2. 2 x eggs
3. Salt water
4. Tap water
5. Colourant

Method:

1. Fill one of the clear glasses with tap water and the other glass with salt water,
2. Place one egg in the glass filled with tap water, you will notice that this egg sinks to the bottom of the glass,
3. Place the other egg in the glass filled with salt water, this egg will float on top of the water,
4. Colourant can also be added to the different types of water to distinguish between the two.

Similarly, in estuaries less dense water will float on top of water with a high density therefore resulting in a stratified body of water. This can affect the movement of animals in the water as well as the quality of the water.

What is the Knysna Estuary Monitoring Platform (KEMP)?

The Knysna Estuary Monitoring Platform is a water quality monitoring programme located within the Knysna estuary. Water quality data is collected by two monitoring stations within Thesen Islands Marina and at Thesens Jetty respectively. At each station, a permanently deployed Hach sonde collects data on a real-time, 24/7 basis and measurements are taken on an hourly basis. This fine scale data collection enables us to observe all weather and environmental events that take place, such as freshwater floods (an overflow of water from rivers) and upwelling events (a process where deep cold water rises towards the surface as a result of strong easterly winds blowing across the ocean surface) as well as assess the potential impact from drought and sea level rise. Physio-chemical (relating to both the physical-things you can see ,taste, touch and smell, and chemical interactions of substances) parameters measured from station 1 (co-ordinates: 34°3'0.53"S and 23°3'3.97"E) and 3 (co-ordinates: 34°2'58.41"S and 23°2'43.99") include:

- Dissolved oxygen (mg/l and % saturation)
- salinity
- pH
- temperature
- depth

A weather station (Station 3 - 34°2'58.41"S and 23°2'43.99") located at Thesens Jetty measures the following:

- wind speed
- wind direction
- rainfall per hour
- absolute air pressure
- air temperature
- sun brightness

The data collected by the sondes are logged on a data logger located at each monitoring station. From here the data is uploaded to a database which can be accessed online (www.hach.zednet.ac.za). Data is uploaded every four hours.

The aims of KEMP

- Conduct long-term water quality monitoring of the Knysna estuary to provide data for research and management purposes.
- Generate real-time, 27/7 monitoring data to gain insight into the water quality dynamics of the estuary, with a focus on specific environmental events such as upwelling and floods and potential impacts from drought and human encroachment.
- Generate a long-term water quality data set to record trends and changes of the system.
- Collect long-term depth and water quality data to assess potential impacts from climate change and sea level rise.

Figure 2: KEMP weather stations.

Based on the information on the estuary, given above, one may use the quiz below to test the knowledge of the learners. There will be mini activities under each parameter that the learners may do to test their knowledge.

General estuary-related questions

1. Which estuary is the most **biologically** important in South Africa?
    a) Buffalo
    b) Knysna
    c) Swartvlei
    d) Klein
2. What percentage of South Africa's estuarine biodiversity is found in the Knysna Estuary?
    a) 100 %
    b) 20 %
    c) 42 %
    d) 84 %
3. *Hippocampus capensis* is the scientific name for the?
    a) Giraffe
    b) Elephant
    c) Blue bottle
    d) Knysna Seahorse
4. Name the most important habitat for seahorses in the Knysna estuary.
    a) Eel grass
    b) Rocks
    c) Sand
    d) Algae
5. Name the characteristics of water studied under water quality?
    a) Chemical and physical only
    b) Chemical, physical, biological, and radiological
    c) Chemical, biological, and radiological
    d) Biological, and radiological only

6. What does KEMP stand for?
7. How many monitoring stations does the KEMP programme have?
8. List the 5 physiochemical parameters measured at station 1 and 3.
9. List the 6 weather parameters measured at station 3.
10. Name 2 environmental events that KEMP can observe.

It is important to understand each physiochemical parameter and know how it is measured or tested. Listed below are some of the parameters that are measured by KEMP.

Dissolved Oxygen

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. Non-compound oxygen, or free oxygen (O_2), is oxygen that is not bonded to any other element. The bonded oxygen molecule in water (H_2O) is in a compound and does not count toward dissolved oxygen levels. Oxygen is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. It is measured in mg/l or percentage saturation. In limnology (the study of lakes), dissolved oxygen is an essential factor second only to water itself. A dissolved oxygen level that is too high or too low (can cause suffocation) can harm aquatic life and affect water quality.

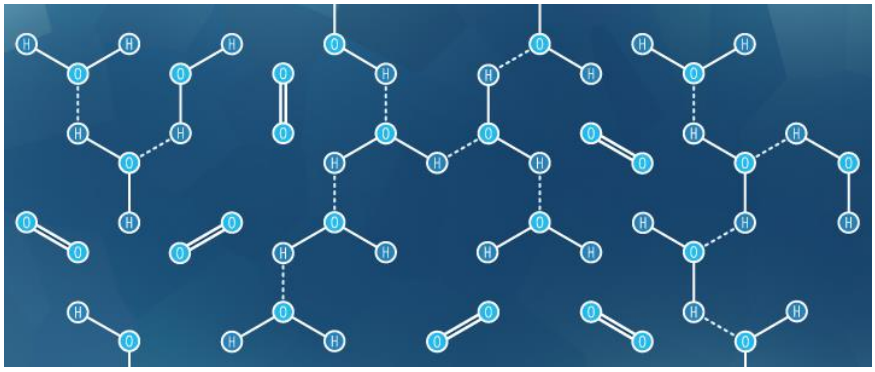

Figure 3: Water molecules with free dissolved oxygen molecules in between.

Dissolved Oxygen and Aquatic Life

Dissolved oxygen is necessary for many forms of life including fish, invertebrates, bacteria and plants. These organisms use oxygen in respiration (breathing). The amount of dissolved oxygen in an estuary's water is the major factor that determines the type and abundance of organisms that can live there. Most aquatic animals obtain oxygen for respiration through their gills, while plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. The amount of dissolved oxygen needed varies from creature to creature. Eutrophication (excess of nutrients in water body) that stimulates the growth of aquatic plants can result in the depletion of dissolved oxygen as they use it for respiration at night. Photosynthesising ocean plants such as phytoplankton, kelp and algal plankton produce majority of the oxygen we breath.

Where Does DO Come From?

Oxygen enters the water through two natural processes: (1) diffusion from the atmosphere and (2) photosynthesis by aquatic plants. The mixing of surface waters by wind and waves increases the rate at which oxygen from the air can be dissolved or absorbed into the water. The aeration of water can be caused by wind (creating waves), rapids, waterfalls, ground water discharge or other forms of running water. Man-made causes of aeration vary from an aquarium air pump to a hand-turned waterwheel. Dissolved oxygen is also produced as a product of photosynthesis from phytoplankton, algae, seaweed and other aquatic plants.

Questions:

1. What is dissolved oxygen?
2. Why is it important to measure dissolved oxygen?
3. What is the study of lakes called?
4. Name 2 ways in which oxygen enters the water?
5. Name 4 natural and 2 man-made ways to aerate water?

pH

Percentage hydrogen (pH) is a measure of how acidic or basic a solution is. pH is measured on a log scale that ranges from 0 to 14. A change on the pH scale of 1.0 pH unit indicates that hydrogen ion activity differs by a factor of 10, therefore, hydrogen ion activity at pH 4 is 10 times greater than at pH 5. Solutions with a pH of less than 7 are acidic, and those with a pH greater than 7 are basic (or alkaline). Distilled water is neutral and has a pH of 7. Knowledge of pH is important because most aquatic organisms are adapted to live in solutions with a pH between 5.0 and 9.0. pH of the Knysna estuary is usually around 8.3. The pH in an estuary tends to remain constant because the chemical components in seawater resist large changes to pH. Biological activity, however, may significantly alter pH in an estuary.

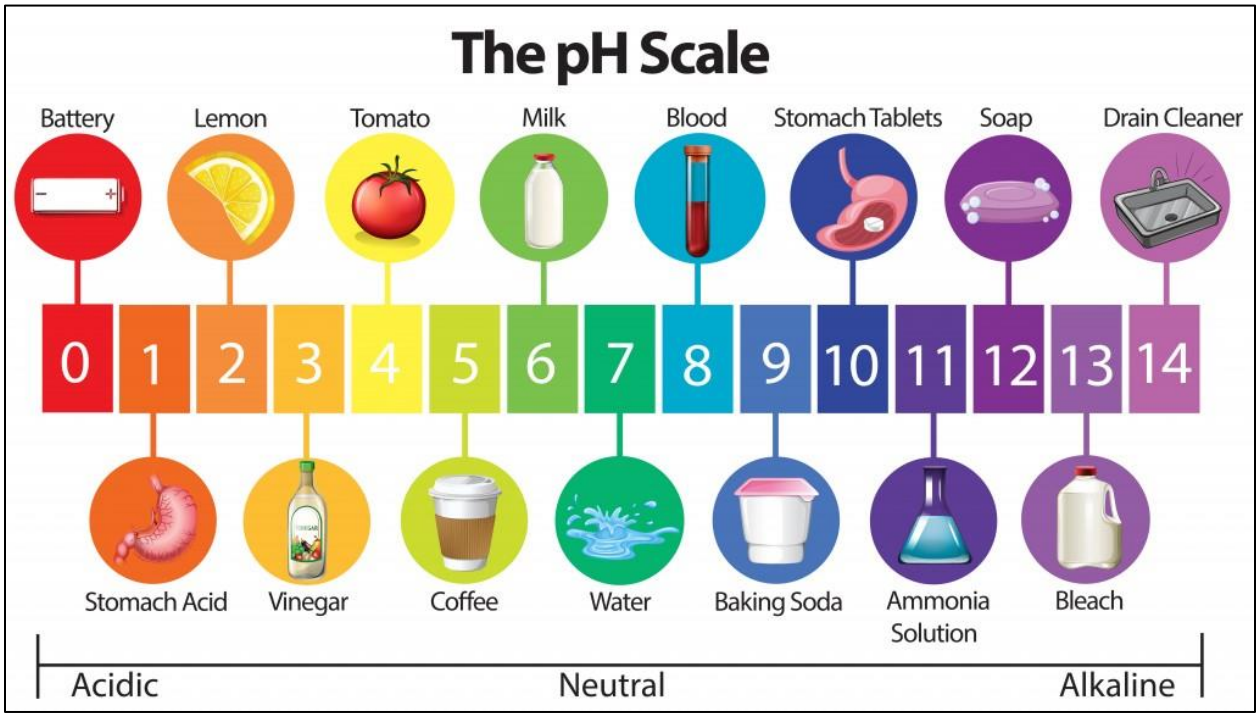

Figure 4: pH scale.

Through a process called photosynthesis, plants remove carbon dioxide (CO_2) from the water and expel oxygen (O_2). Since CO_2 becomes carbonic acid when it dissolves in water, the removal of CO_2 results in a higher pH, and the water becomes more alkaline, or basic. When algae naturally begin to increase in estuaries during the spring, pH levels tend to rise. An overabundance of algae (called an algal bloom) may cause pH levels in an estuary to rise significantly, and this can be lethal to aquatic animals.

Questions:

1. What does pH stand for?
2. What is pH?
3. What is the range on the pH scale?
4. Give the pH range for the following:
    a) Acidic
    b) Neutral
    c) Alkaline (basic)
5. Name two natural events that result in an increase in pH?
6. What pH range are most aquatic animals accustomed to living in?
7. What is the approximate pH of the Knysna Estuary?

Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. It is essentially a measurement of how cloudy or clear the water is, or, in other words, how easily light can be transmitted through it. The unit of measurement for turbidity is NTU which stands for **Nephelometric Turbidity Unit**. As sediments and other suspended solids increase in the water, the amount of light that can pass through the water decreases. Thus, the cloudier the water, the greater the turbidity. As algae, sediments, or solid wastes increase in the water, so does turbidity.

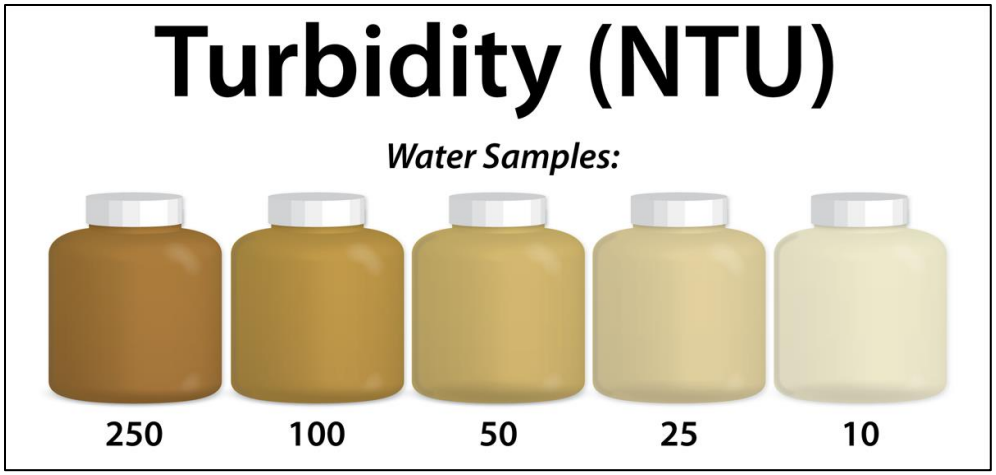

Figure 5: Turbidity scale.

Turbidity affects organisms that are directly dependent on light, like aquatic plants, because it limits their ability to carry out photosynthesis. This, in turn, affects other organisms that depend on these plants for food and oxygen. A high turbidity can also affect animals with gills as it clogs gills.

Scientists often consider turbidity of the water in connection with other factors to get a better understanding of its causes and consequences. For example, high levels of turbidity can identify problems with shoreline erosion, or sewage processing facilities not functioning properly.

Questions:

1. What is turbidity?
2. What is the unit of measurement for turbidity?
3. What cause water to become more turbid?
4. What is the problem with turbidity? (What natural cycle does it affect?)

Temperature

One important thing we can tell from water temperature is how much oxygen can be dissolved into the water.

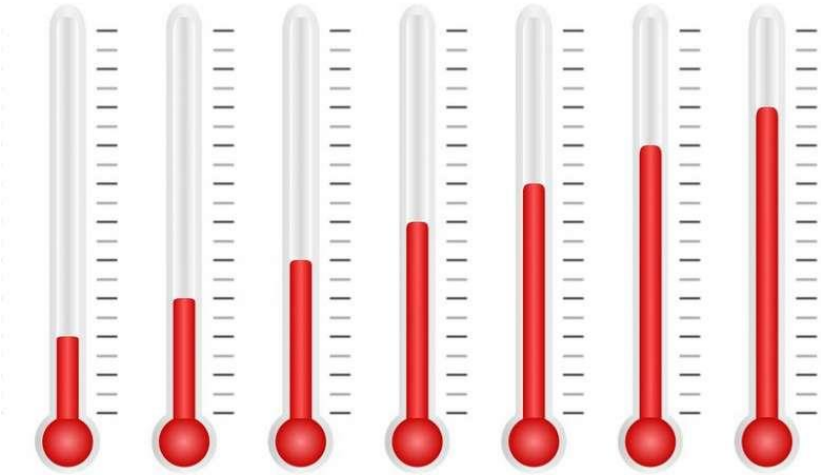

Figure 6: Temperature range.

Dissolved oxygen is critical for the survival of animals and plants that live in the water. As the water temperature increases, the amount of oxygen that can dissolve in the water decreases. For example, fresh water at 0°C can contain up to 14.6 mg of oxygen per litre (mg/l) of water, but at 20°C, it can only hold 9.2 mg of oxygen per litre. Thus, seasonal water temperature (and dissolved oxygen) is an important indicator of habitat quality for many estuarine species. Dissolved oxygen can also be measured in percentage saturation (% Sat). The temperature of the water also tells us what types of plants and animals can live in the estuary. All plants and animals have a range of temperatures in which they thrive. If the water in the estuary is outside the normal seasonal temperature range in which most estuarine organisms can comfortably live, it is probably an indication that something is adversely affecting the health of the estuary.

Questions:

1. What is the unit of measure of temperature?
2. What does the temperature of water tell us?

Tides

Estuaries are very shallow compared to the open ocean. Water levels in an estuary typically rise and fall with the daily tides, but they are also affected by the weather and freshwater inflow from rivers. In the Knysna Estuary, tides rise and fall twice during a 24-hour day. Tides are caused by the moon's gravitational pull generating a tidal force. This force causes the Earth and its water to bulge out on the side closest to the moon and the side furthest from the moon. Tides play a vital role in having a healthy estuary. They flush out the system and provide nutrients to keep the food webs functioning. There are different zones in water bodies, these zones are influenced by different factors such as the tides, temperature, salinity and light intensity. The supratidal zone is the upper region, it is only covered during storms and extremely high tides. Only a few animals live in this zone due to the prolonged exposure to the heat in summer or low temperatures in winter.

The intertidal zone is the area between the mean low tide and mean high tide. It is also a transition zone between the ocean and land. This zone is further divided into three different states, low tide when it is exposed to the air, middle tide, which is submerged and exposed for equal amounts of time and high tide when it is submerged in water. Animals living in this zone must be able to adapt to changes in temperature, salinity and be able to withstand wave action.

The subtidal zone is the region below the intertidal zone. This zone is constantly covered by water and more stable than the intertidal zone. Factors such as temperature, water pressure and light intensity remain constant therefore making it a more comfortable zone for animals.

Questions:

1. What causes the tides of the estuary to fluctuate?
2. How do tides assist in estuary functionality?
3. What are the different zonation's of an estuary?

Salinity

Under laboratory conditions, pure water contains only oxygen and hydrogen atoms, but in the real world, many substances are often dissolved in water, like salt. Salinity is the concentration of salt in water, usually measured in parts per thousand (ppt). The salinity of seawater in the open ocean is remarkably constant at about 35 ppt. Salinity in an estuary varies according to one's location in the estuary, the daily tides, and the volume of fresh water flowing into the estuary.

In estuaries, salinity levels are generally highest near the mouth where the ocean water enters at 35 ppt, and lowest upstream where freshwater flows in (0 ppt). Actual salinities vary throughout the tidal cycle. Salinity levels usually rise during the summer when higher temperatures increase levels of evaporation in the estuary. Estuarine organisms have different tolerances and responses to salinity changes.

Salinity also affects chemical conditions within the estuary, particularly levels of dissolved oxygen in the water. The amount of oxygen that can dissolve in water, or solubility, decreases as salinity increases. The solubility of oxygen in seawater is about 20 percent less than it is in fresh water at the same temperature. Salinity has a huge effect on what species can exist in aquatic environments.

Questions:

1. What is salinity?
2. What is the unit of measurement for salinity?
3. What is the salinity of seawater and freshwater?
4. How does spring change the salinity of the estuary?
5. How does summer affect the salinity of an estuary?
6. How does salinity affect estuarine organisms?