STREAM

Environmental Parameters Explained

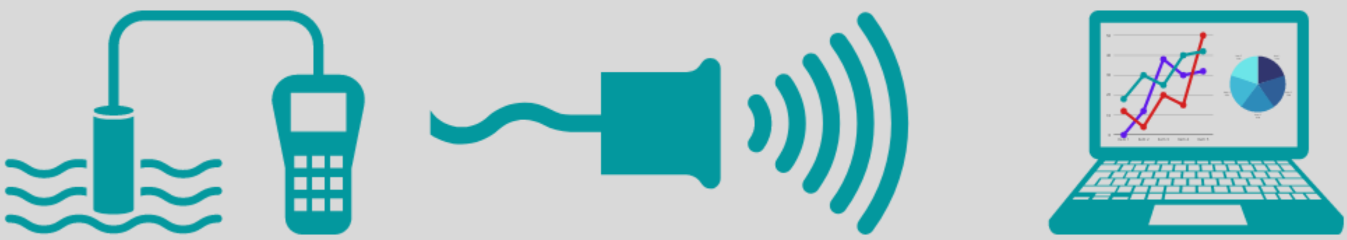
What are environmental parameters and why do we monitor them?

Environmental parameters

We measure parameters to gain an insight into an environment for any of the following reasons:

- We are concerned about the area, and we want to protect a specific species or ecosystem.
- We want to gather initial information (Baseline data) on an environment so that we can quantify the effects of future climate change and human pressures.
- We suspect that a particular activity is harming the environment, and we want to provide proof of this to regulatory bodies.

The STREAM project uses sensors to continuously monitor these environmental parameters. The advantage of continuous monitoring over spot sampling (e.g., once a day/ month) is that the information we collect is frequent, allowing us to track changes in the environment and draw conclusions as to what may have caused them.



For example:

A pollution event that may have been triggered by heavy rainfall in the area causing contaminants to enter the marine environment, in this case, we can use STREAM weather station data on rainfall and our water sampling Sonde to indicate the precise moment these events occurred. This is very important as this event may have been overlooked by a traditional sampling programme which may define the area as having good environmental status simply because that was the situation when it was sampled.

For this reason, scientists and governments are interested in spatially and temporally detailed monitoring programmes. The STREAM project will provide data to agencies responsible for monitoring the environment in both Ireland and Wales to allow them to make accurate decisions on the environment and climate change.

Environmental Parameters

Temperature

Temperature is one of the most important parameters that we measure in the aquatic environment, it is essential for the survival of both flora and fauna as all species have a distinct temperature range in which they can operate. Temperature is also important regarding the chemistry of water with chemicals behaving differently, e.g., the dissolved oxygen content of the water has an inverse relationship with temperature, with cooler waters capable of holding more oxygen. The physical movement of water is influenced heavily by temperature with cooler/ denser water usually found deeper in the water column. For the STREAM project temperature is reported in degrees Celsius (°C).

Salinity

Conductivity is the measure of a liquids ability to conduct an electrical current. The conductivity of a liquid is proportional to its ionic concentration. Conductivity is measured as siemens (S) and is reported as mS/cm or µS/cm, by measuring both conductivity and temperature we can calculate salinity. Salinity allows us to measure the "saltiness" of the liquid we are interested in, with freshwater being less salty than marine waters. We use the Practical Salinity Scale which results in unitless values since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C. This is important as many nutrients including Phosphate and Nitrogen behave differently depending on the salinity of the aquatic environment in which they are present. Salinity will also impact flora and fauna which have specific salinity gradients in which they can survive.

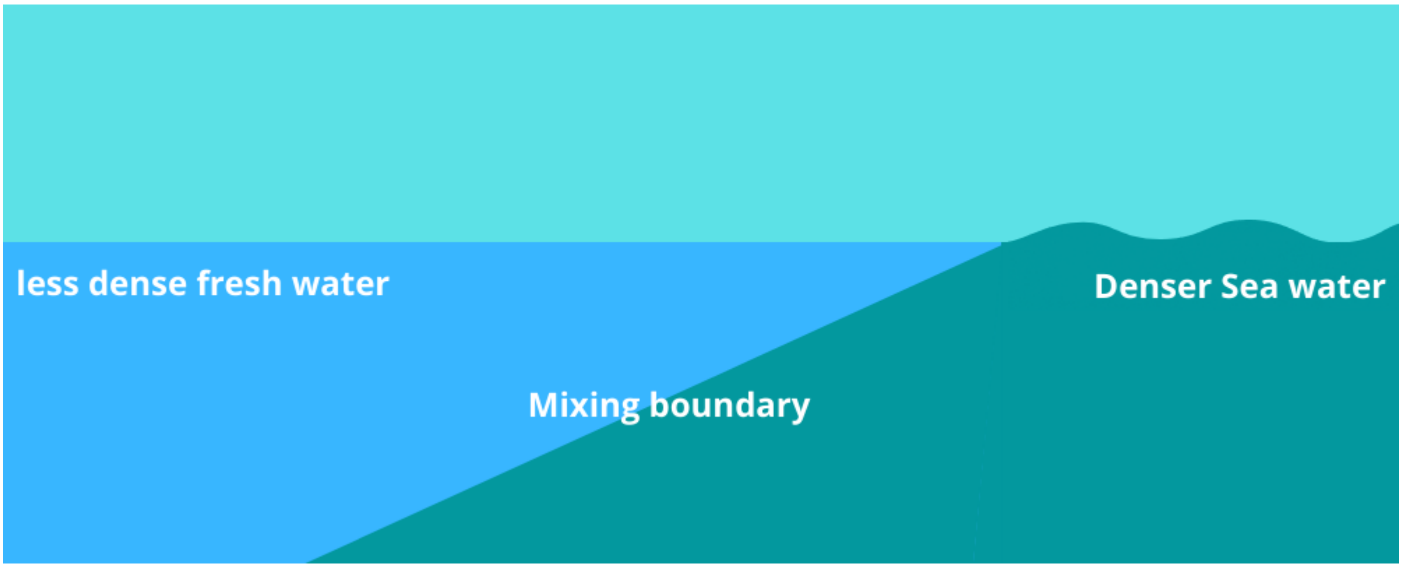


Figure 1. Diagram of the relationship between fresher riverine water mixing with denser seawater creating a mixing boundary. This is often visible on the surface as two areas of different coloured water that converge and mix most likely in an estuary environment where a river meets the sea.

pH

Is used to measure how acidic or basic a substance is and is based on its hydrogen ion (H+) content. The term pH originates from the Latin "potentia hydrogenii" – the power of hydrogen.

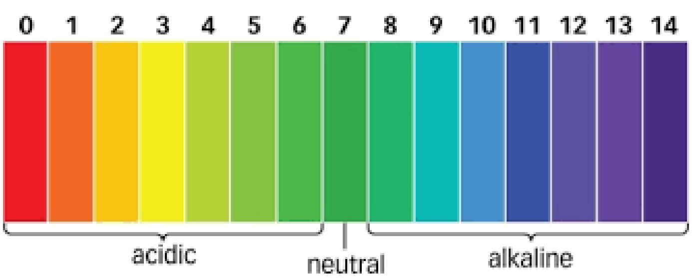


Figure 2. Diagram Illustrating the pH scale.

The pH scale ranges from 1 to 14, anything below 7 is considered acidic and anything above 7 is considered basic.

The pH of seawater is usually around 8.1 pH making it slightly basic, as more carbon is produced in the Earth's atmosphere the acidity of the ocean is increasing (the ocean becomes less basic). This can be detrimental to the health of the environment for many reasons, for example, organisms that use calcium carbonate to form their living structures such as corals and bivalves (e.g., oysters) find it increasingly difficult to survive particularly at larval (early life) stages. The world must reduce its reliance on fossil fuels to prevent ocean acidification.

Turbidity

Turbidity is the measure of water clarity (or cloudiness) and is influenced by suspended particles from multiple sources such as phytoplankton, zooplankton, particles of soil, silt, and clay. These particles can be naturally churned up during rough weather or by construction activity and dredging of material. The turbidity of the water will influence the depth to which light can reach and therefore the growth of phytoplankton, aquatic plants and macroalgae such as seagrass and kelp.

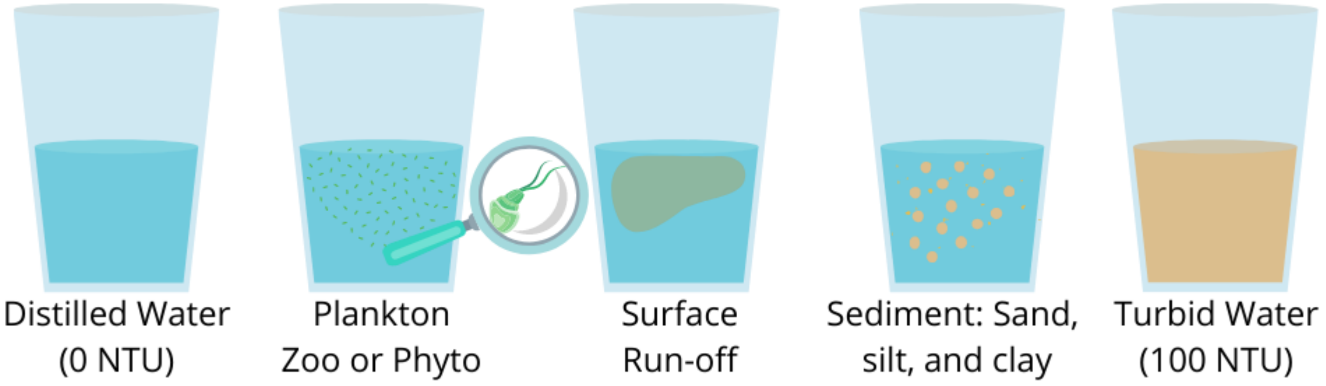


Figure 3. Examples of the different types of environmental water samples that can be encountered in an estuarine and marine environment.

High levels of turbidity can negatively impact fish and their spawning grounds, it is, therefore, an important parameter we measure in the aquatic environment. Turbidity is measured in several different units which includes Nephelometric Turbidity Units (NTU) and Formazin Nephelometric Units (FNU).

Chlorophyll

Chlorophyll is present in photosynthesising algae and is used as an indirect method to quantify phytoplankton activity in the aquatic environment. Measuring chlorophyll can be used to help identify the presence of a Harmful Algal Bloom (HAB), particularly when very high levels are recorded. It can also be used to monitor macronutrients such as Nitrogen and Phosphorous as high levels can cause increased algal biomass.

Figure 4. Phytoplankton are hugely diverse, above are just some of the morphologies that can be found in the marine environment.

Phytoplankton form the base of both the estuarine and marine food web and are essential to a healthy ecosystem, low levels of chlorophyll can be indicative of a lack of food availability for higher trophic levels such as zooplankton, jellyfish, shellfish, fish and marine mammals (seals, dolphins and whales). Low levels of chlorophyll can occur naturally, but can also be caused by human activity e.g., water treatment, pollution, powerplant cooling etc. Chlorophyll is usually reported as mg/l.

fDOM

fDOM (fluorescent Dissolved Organic Matter) or cDOM (Coloured Dissolved Organic Matter) refers to the organic matter in the water column that absorbs strongly in the ultraviolet (UV) spectrum. fDOM can be used as a surrogate for cDOM and is an efficient means of tracking DOM in the aquatic environment. Measuring cDOM/fDOM is important as it affects macroalgae, corals and benthic communities. It can also be used to assess the quality of water at wastewater discharge sites.

Dissolved Oxygen

Oxygen is essential for the survival of aquatic life, dissolved oxygen (DO) measures the amount of Oxygen present as either a % or in mg/L. When oxygen levels reach critically low levels a water body is described as hypoxic and when oxygen is no longer present a water body is described as anoxic, this can result in migration, reduced activity and in extreme cases death of aquatic plants and animals (Figure 4).

Oxygen enters a water body via a variety of pathways, these include:

- diffusion across the water's surface from the surrounding atmosphere
- Introduced via turbulent water e.g., waves, waterfalls, rapids etc.
- Through Photosynthesis of algae as dissolved oxygen.

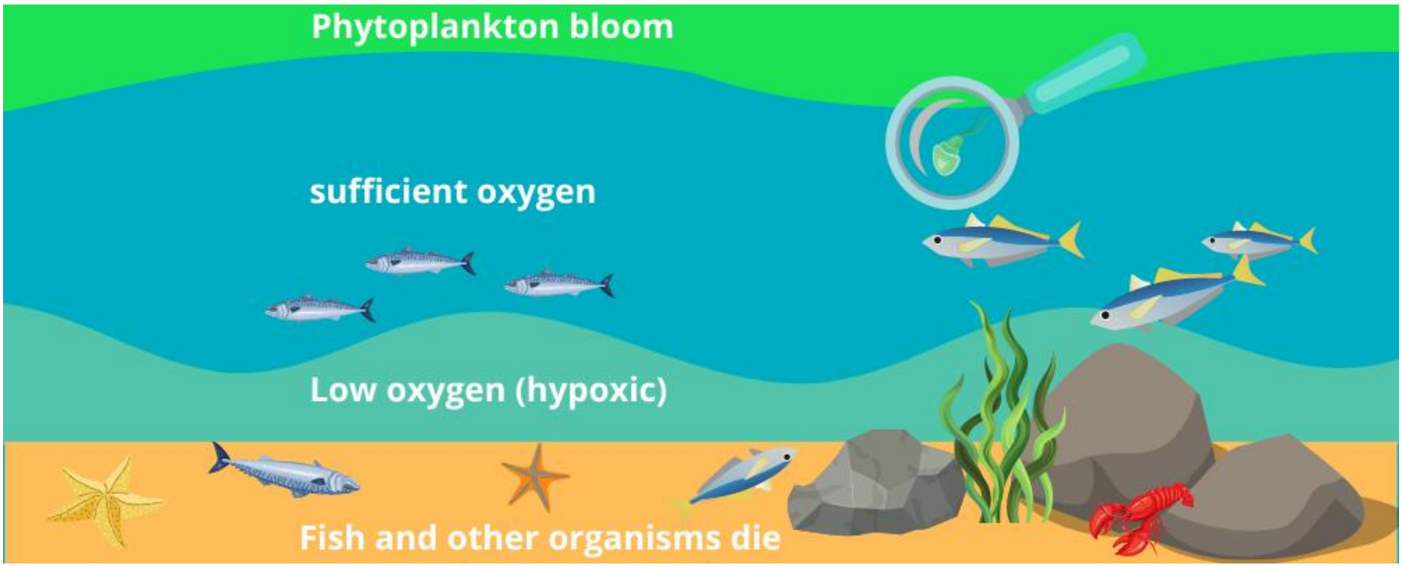


Figure 5. Illustration showing the effects of reduced oxygen in the water column can result in fish and other aquatic organisms' dying.

Increased input of nutrients to an environment via human activity can cause the presence of phytoplankton to increase, this activity will initially increase the DO levels in the water body as photosynthesis increases and more oxygen is produced. However, once the phytoplankton dies off and the microbes that decompose the plant material use up all the available oxygen hypoxic conditions that have negative consequences for the ecosystem can occur. By monitoring the DO in a water body, we can set alarms that indicate when dissolved oxygen drops below a defined threshold, this type of early warning system could reduce the negative impacts of hypoxia/ anoxia on the environment.

Nutrients

Nutrients can enter the estuarine and marine environment from numerous sources including wastewater, sewage and runoff from agriculture. The two main macronutrients that contribute to problems such as eutrophication in the aquatic environment are Nitrogen (N) and Phosphorus (P). Nitrogen is essential for plant growth and is, therefore, an effective fertilizer for crops. This becomes a problem however when excess N is introduced to the aquatic environment and causes the growth of microscopic algae. Excess P is introduced in a similar way to N put usually originates from waste-water discharge. Once the algae die off and fall to the seafloor, they are decomposed by bacteria which reduces the oxygen content of the water resulting in hypoxia.

BOD

Biochemical Oxygen Demand (BOD) is a term used to describe the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at a certain temperature over a specific period. It is used as an indicator of the organic quality of water. It is most commonly expressed in milligrams of oxygen consumed per litre of sample for 5 days (BOD5) of incubation at 20°C and is often used as a robust surrogate of the degree of organic pollution of water. Biological oxygen demand influences the amount of dissolved oxygen in water bodies. It is influenced by temperature, pH, microbial activity, and the type of decomposing material in the water. The higher the BOD value the greater the rate of oxygen depletion in the water body, very high BOD levels can significantly reduce the DO (Dissolved Oxygen) levels and therefore can be detrimental to an ecosystem.

COD

Chemical Oxygen Demand (COD) is a measure of the oxygen which is consumed during oxidation of organic material in the presence of a strong oxidizing agent. It can be used as an indicator to measure the number of pollutants present in a water body.

TOC

Total Organic Carbon (TOC) is a measure of the total amount of carbon in organic compounds in water bodies.

DOC

The Dissolved Organic Carbon (DOC) reservoir in seawater represents a very significant component of the oceanic carbon cycle. The world's oceans have absorbed 31% of all anthropogenic carbon produced between 1994-2007, this has resulted in the increased acidity of the earth's oceans.

SAC 254

SAC 254 is the Spectral Absorption Coefficient (SAC 254 nm). SAC 254 is a total parameter measuring the dissolved organic material that absorbs UV light at a wavelength of 254 nm. It can be used to estimate the influence of organic load on a waterbody.

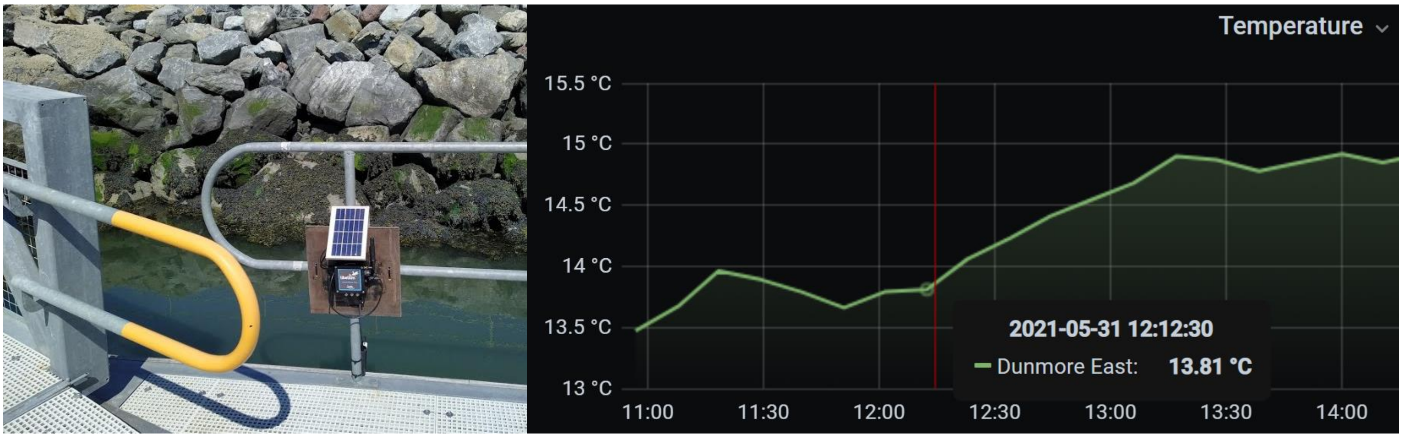


Figure 6. Example of a Sea Surface Temperature (SST) sensor deployed In Dunmore East. County Waterford and the live data that is generated.

Sources:

Herbert, R. A. (1999). Nitrogen cycling in coastal marine ecosystems. https://doi.org/10.1016/S0168-6445(99)00022-4

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