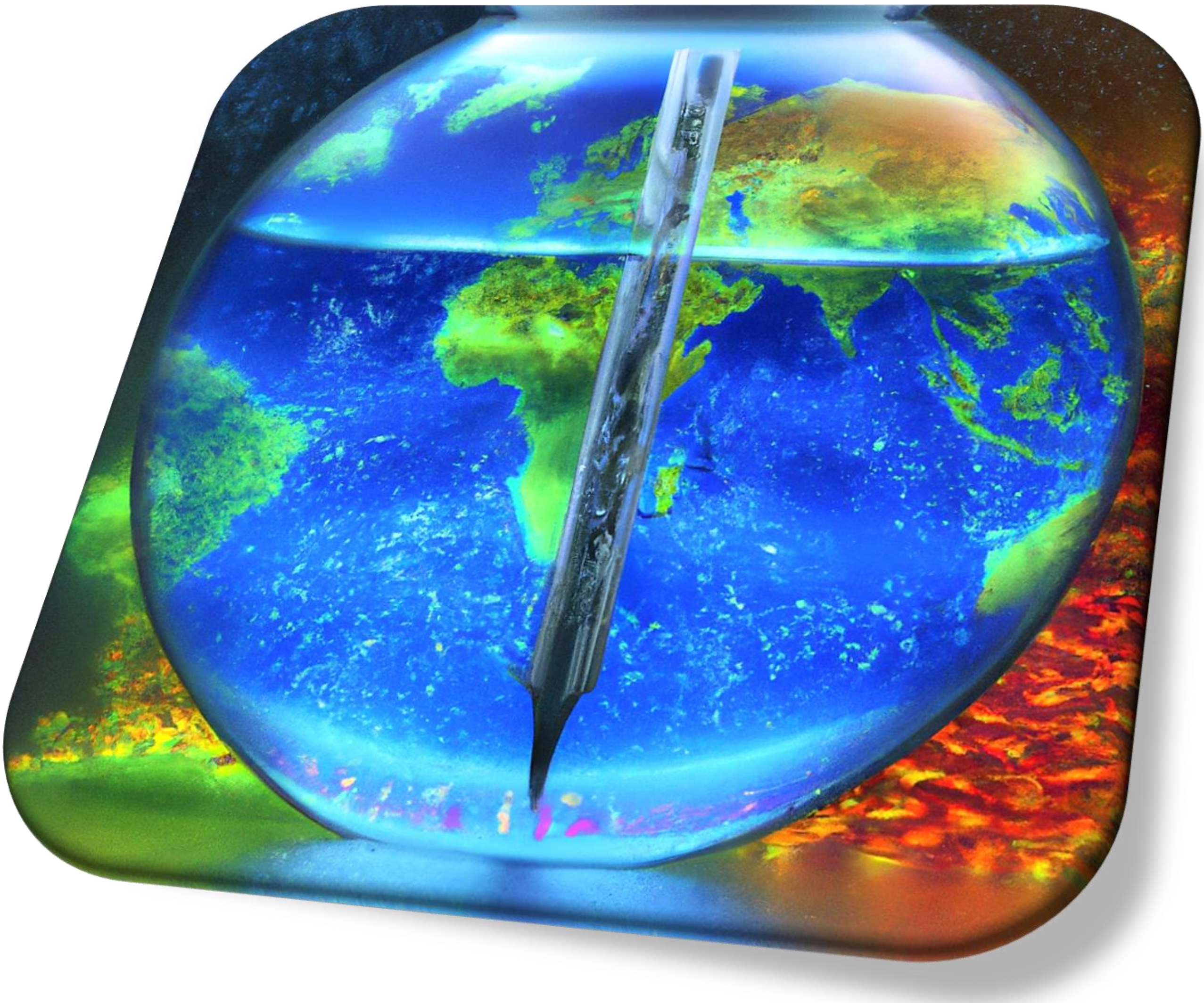
Coastal and Marine Water Quality Physiochemical Parameters and Some Reasons for Monitoring

STREAM Tool Kit

(R. Browne August 2 2023)

STREAM measuring environmental change



STREAM is part funded by the European Regional Development Fund (ERDF)

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STREAM

Sensor Technologies for Remote Environmental Aquatic Monitoring

The STREAM project is part-funded by the European Regional Development Fund (ERDF) through the Ireland-Wales Cooperation programme

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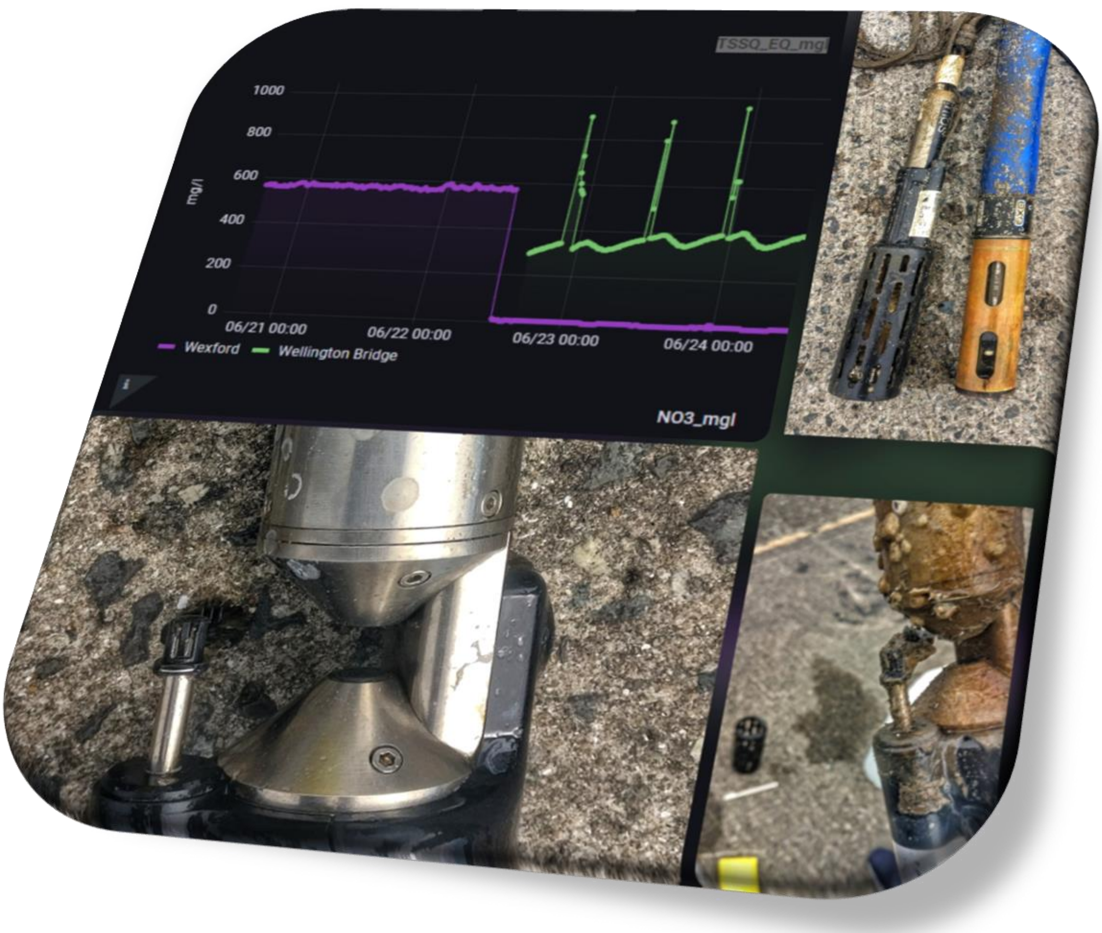

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Introduction and Executive Summary:

The purpose of this Sensor Technologies for Remote Environmental Aquatic Monitoring (STREAM) toolkit is to describe some of the key parameters that the project is measuring. This is an initial report, and it will be updated.

The STREAM project is a joint effort between organizations on both sides of the Irish Sea to enhance our understanding of the effects of climate change, reduce the expenses associated with monitoring estuarine and marine environments, and speed up the process of data collection. The collaborating partners include South East Technological University (SETU), Swansea University, and Munster Technological University (MTU). STREAM is part funded by the European Regional Development Fund (ERDF)

"The Intergovernmental Panel On Climate Change (6th Assessment Report) has found that CO_2 in the atmosphere continues to rise, that surface land and ocean temperatures are warmer, Arctic sea ice has decreased, the upper 700 m of the ocean have warmed, oceans have become more acidic and have seen a decrease in oxygen levels, and that sea levels have risen. Other observed changes in our ocean include a perturbation of nutrient cycles, changes in biogeography of organisms ranging from phytoplankton to marine mammals, ocean warming impacting fisheries catches, increasingly stressed coastal ecosystems and changes in the nature and extent of harmful algal blooms." Irish Ocean Climate and Ecosystem Status Report 2023 (Foras na Mara, Marine Institute 2023). The monitoring of our coastal waters is essential for a variety of reasons, such as:

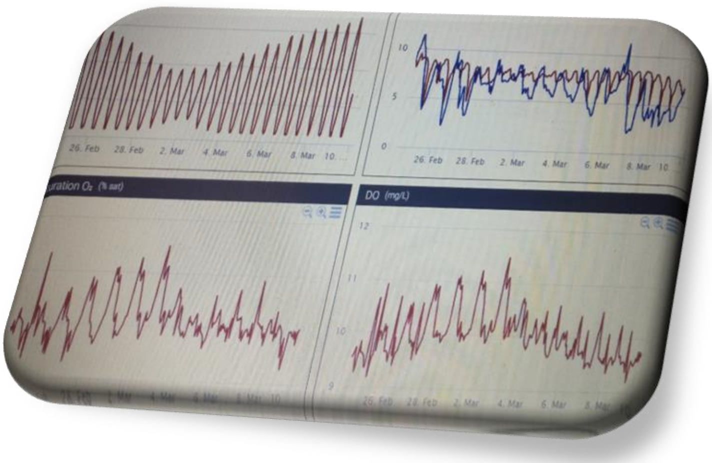
1. It helps assess a marine ecosystems condition and any human activities impact on these environments. By examination we can detect, understand, and potentially introduce localised mitigation plans.
2. The monitoring of seawater quality is crucial for ensuring the safety and sustainability of seafood resources, from things such as contaminated or polluted waters. It also enables the early detection and appropriate responses to events such as harmful algal blooms, oil spills, and other environmental incidents that can have significant consequences.
3. Monitoring also provides valuable data for stakeholders, allowing us to understand better the complex dynamics of ocean ecosystems and climate change impacts.

By monitoring seawater quality, we should be able to make informed decisions and take appropriate measures to protect and conserve our oceans for future generations. The measurements of seawater qualities are vital for various uses, including climate studies, research, and marine and coastal monitoring. The Water Framework Directive and the Marine Water Framework Directive aim to achieve 'good ecological status' and 'good environmental status' of Europe's waters respectively" (European Environment Agency). The EPA, Marine Institute, SFPA and other organisations have implemented an extensive observational program for chemical and microbiological parameters to assess the quality of waters around our coast. As an example the Shellfish Waters Directive, European Communities (quality of shellfish waters) regulations 2006 S.I. no 268 of 2006 has been subsumed into the Water Framework Directive since 2013, but the monitoring program remains in place https://www.marine.ie/site-area/areas-activity/marine-environment/water-framework-directive.

The physiochemical parameters applicable to marine shellfish waters (European Communities S.I. no 268 of 2006) include pH, temperature, coloration, suspended solids, salinity, dissolved oxygen, and the presence or concentration of certain substances such as hydrocarbons, metals, and organohalogenated substances.

Quick Look Up

Physico-chemical seawater quality elements: https://www.marinestream.eu/live_data/



The physicochemical properties of seawater relate to its physical and chemical properties. These can vary considerably such things as freshwater inputs, nutrient load, the proximity of the water to land, depth and other local geological influences. These physicochemical properties of water significantly influence the success of all organisms (plant/ animal) within the sea. What is more, the chemical composition of our atmosphere also affects our coastal waters. For example, marine plants in our oceans release oxygen into the atmosphere (50% of the oxygen we require), significant amounts of carbon dioxide are absorbed by our oceans (25% of manmade emissions), and what's more about 90% of the heat from the emissions is stored in our marine waters (UN 2023, The ocean – the world's greatest ally against climate change).

Historically a lot of the physiochemical parameters apart from temperature needed to be measured in a laboratory but with the advent of electrochemical and optical sensors assessments may be done using sensors or sonde in the field. A sonde being a sensor or set of sensors used to measure a variety of parameters. Typically the seawater parameter measurements at different locations vary. Therefore, it is essential to establish baseline water quality information, assess its significance (as set out below) and monitor it for change. The driver is the maintenance of high-status seawater or improving lower-quality water.

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Table 1: WFD Physico-chemical quality elements

Element	High status	Good status	Moderate status
General conditions	The values of the physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralizing capacity, and temperature do not show signs of anthropogenic disturbance.	Temperature, oxygen balance, pH, acid neutralizing capacity, and salinity remain within the range established for the specific ecosystem and the achievement of biological quality elements' values. Nutrient concentrations do not exceed the levels established for the ecosystem.	Conditions deviate moderately from undisturbed conditions, with moderate signs of distortion resulting from human activity.
General	There are no or only very minor anthropogenic alterations to the physico-chemical and hydromorphological quality elements for the surface water body type.	The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity.	The values of the biological quality elements for the surface water body type deviate moderately from undisturbed conditions and show moderate signs of distortion resulting from human activity.

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Water quality assessment:

The monitoring of water quality relies on routine sampling programs. Such campaigns involve:

- The collection of water samples.
- Transporting them to a laboratory.
- Undertaking analyses.
- Reporting.

This sampling approach can produce high-quality information but has limitations as it may only provide intermittent snapshots of water quality over time. That may not capture the true variations in water quality. Additionally, there are often delays in obtaining feedback from this method because the standard laboratory methods used for water analysis can be time-consuming.

In contrast, online monitoring can continuously measures water quality, allowing real-time water quality measurements and process control. Though it is essential to point out that limitation include how well a sensor is calibrated and maintained, the actual sensors' sensitivity, and how these sensors may drift naturally over time. These sensors also require time and investment in their deployment and retrieval from the field along with an appropriate assessment of the data they produce.

Various water quality sensors are available, each designed to measure specific parameters such as temperature, conductivity, pH, turbidity, chlorophyll and total organic carbon (TOC). Each sensor typically focuses on monitoring a single parameter. Shi et al 2022 provide a description of two main types of sensors, (1) biosensors and (2) optical sensors, which may be used for real time monitoring. Biosensors utilize fluorescence and may be used for detecting microorganisms like bacteria and viruses. On the other hand, optical sensors employ light absorption, light scattering, or fluorescence measurements. An example of an optical sensor commonly used is a turbidity meter. There are also advanced optical sensors, including infrared, fluorescence, and UV-Vis spectrophotometers. Infrared optical sensors can continuously measure organic compounds at wavelengths beyond 760 nm. Fluorescence sensors can assess the dissolved organic matter and indicate microbial water quality by analysing the fluorescence properties of molecules. While UV-Vis sensors can continuously measure various water quality parameters by quantifying the amount of light absorbed by compounds such as TOC, dissolved organic carbon (DOC), colour, nitrate, and specialized parameters.

Sea Level

Rising temperatures are causing the polar ice caps to melt, and the thermal expansion of our oceans results in a rise in sea levels. This increase in sea levels leads to erosion and inundation, which can damage property, infrastructure, water resources, and habitats.

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Temperature:

Water temperature, traditionally measured using a thermometer, is now frequently measured using a thermistor, an electrical resistor whose resistance is dependent on temperature and reported in degrees Celsius. Temperature significantly impacts biological habitat conditions, and chemical and biological processes in water. As marine ecosystems are composed of complex interactions among numerous species, and any temperature changes can disrupt these delicate balances.

Conductivity/Salinity:

Salinity and conductivity are parameters used to assess the chemical composition and properties of seawater. Salinity has been expressed in practical salinity units (PSU) and parts per thousand (ppt). Specific conductance, reported in microsiemens per centimetre, measures seawater's ability to conduct electrical current. It is influenced by the types and amounts of dissolved substances present. In estuaries, variations in specific conductance can be significant due to tidal effects. The highest salinities in coastal waters around Ireland can reach nearly 35 ppt or PSU (pers. obs.). Approximately 3.5 per cent of Oceanic Atlantic seawater is composed of dissolved compounds, while the remaining 96.5 per cent is pure water.

Table 2. Salinity, European Communities (quality of shellfish waters) regulations 2006 S.I. no 268 of 2006

Parameter No.	Parameter	Unit of Measurement	Standard/Value	Reference Method of analysis or inspection	Frequency of sampling
5	Salinity	Practical salinity units (a)	less than 40 practical salinity units	Conductimetry	Monthly
			(b) Discharges affecting shellfish waters must not cause the salinity of the waters to exceed by more than 10 per cent the salinity of waters not so affected.		

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pH:

pH is a measure of the acidity or alkalinity of seawater on a scale of 0 to 14. A pH of 7 represents neutrality, values below 7 indicate acidity, and values above 7 indicate alkalinity. pH is an important indicator of water quality as it affects water treatment, chemical reactions, and the functioning of plants and animals.

Table 3. pH, European Communities (quality of shellfish waters) regulations 2006 S.I. no 268 of 2006

Parameter No.	Parameter	Unit of Measurement	Standard/Value	Reference Method of analysis or inspection	Frequency of sampling
1	pH	pH unit	Not less than 7 nor greater than 9	Electrometry	Quarterly
			Measured in situ at the time of sampling.		

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Dissolved oxygen (DO):

Dissolved oxygen concentration in surface water is essential for chemical reactions and the survival of aquatic organisms. Low dissolved oxygen levels can cause stress or even the death of fish and other organisms. Oxygen concentration is reported in milligrams per litre or as a percentage. Anthropogenic nutrient enrichment and increased water temperatures may lead to reduced oxygen concentrations.

Table 4. Dissolved oxygen %, European Communities (quality of shellfish waters) regulations 2006 S.I. no 268 of 2006

Parameter No.	Parameter	Unit of Measurement	Standard/Value	Reference Method of analysis or inspection	Frequency of sampling
6	Dissolved oxygen	Saturation per cent	(a) Equal to or greater than 70 per cent (average value)	Winkler's method or electrochemical method	Monthly, with a minimum of one sample representative of low oxygen conditions on the day of sampling.
			(b) No individual measurement to indicate a value less than 60 per cent unless it can be established that there are no harmful consequences for the development of shellfish colonies.		However, where major daily variations are suspected, a minimum of two samples in one day must be taken.

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Table 5. Dissolved oxygen mg/L (quality of shellfish waters)

Status	Marine 5% percentile
Good	⩾4.0<5.7 mg/L
Moderate	⩾2.4<4.0 mg/L
Poor	⩾1.6<2.4 mg/L
Bad	<1.6 mg/L

Oxidation-reduction potential (ORP):

Oxidation-reduction potential (ORP) quantifies the redox conditions in seawater. That is "A chemical reaction that takes place between an oxidizing substance and a reducing substance." It is typically measured using an ORP meter and provides valuable insights into the oxidizing or reducing power of the solution. Positive ORP values indicate oxidizing conditions, while negative values suggest reducing conditions. Interpreting ORP values aids in assessing seawater quality, understanding ecological processes, and implementing effective environmental management practices.

Chlorophyll:

Chlorophyll is a pigment/molecule found in plant cells essential for photosynthesis and is used as an indicator of algal biomass in seawater. Chlorophylls absorb light strongest in the blue and red portions of the electromagnetic spectrum. Chlorophyll sensors rely on fluorescence, which is the emission of light by a substance that has absorbed light. Measurement units for chlorophyll include relative fluorescence units (RFU) and micrograms per litre (µg/L). Daily variations in sensor measurements not related to chlorophyll concentrations may occur due to changing light and temperature conditions, affecting algal cells' fluorescence response. According to the European Environment Agency "Nutrient enrichment/eutrophication may give rise to increased phytoplankton biomass, increased frequency and duration of phytoplankton blooms and increased primary production." Detritus, the fragments of large of macro algae and benthic diatoms suspended in a water body may result in elevated recordings of chlorophyll levels in samples analysed in a laboratory or observed by a sensor. Measurements of large surface areas of the sea are being undertaken using satellite radiometers of the radiance of ocean colour. Still, it is necessary to ground truth these readings and assess the species and depths at which they occur. As an example, a sensor reading of 10 ug/L of chlorophyll a in coastal waters could be used as a coarse indicator of an algal bloom (but this is very dependent on species type and their physical size).

Nutrients:

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Traditionally the measurements of nutrients in seawater involves the taking of discrete water samples using a dedicated water sampling device/ bottle and subsequently analysing them in a laboratory. Seawater nutrients are compounds that consist primarily of nitrogen (N) and phosphorous (P). While Silica (Si) is not a nutrient it does support the growth of planktonic species such as diatoms. These nutrients have a controlling role in primary productivity and carbon sequestration seawaters. Nitrogen exists in different forms within the marine environment, with nitrate being the primary form of fixed dissolved inorganic nitrogen that organisms assimilate. However, certain organisms can utilise nitrite, ammonium, or dissolved molecular nitrogen. In seawater, orthophosphate is regarded as the most significant phosphorus species readily accessible for biological processes. Nutrient pollution can occur when excessive nitrogen and phosphorus are introduced into a water body. These nutrients act as fertilizers, enriching a water body, promoting an overgrowth of algae and may then directly impact the health of organisms in the water.

The concentration of nutrients is measured by optical cells and a spectrophotometer tuned to defined wavelengths for nitrogen and phosphorous compounds. ABS210_AU: Light absorption at 210 nm measured in Absorbance Units.* Nitrate can be directly detected by UV absorption spectroscopy in a spectral range between 200 and 350 nm (Kröckel et al 2010). DIN is dissolved inorganic nitrogen: nitrate-N + nitrite-N + ammonium-N, measured on a filtered water sample.

- NNO_3_mgl: Complete Nitrogen – Nitrate in milligrams per litre.
- NNO_2_mgl: Complete Nitrogen – Nitrite in milligrams per litre.

Turbidity:

Turbidity is an optical characteristic of water and a measure of relative clarity of a liquid. It is an optical characteristic of water and is a measurement of the amount of light that is scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Turbidity refers to the cloudiness of the water and may be reported as nephelometric turbidity units (NTUs) or formazin nephelometric units (FNUs). The higher the turbidity figures indicate, the more murky water appears. Turbidity is caused by suspended particles, primarily clay, silt, organic matter, and microscopic organisms. Turbid water is not necessarily harmful; but particles or sediments can cause problems with aquatic organism, carry harmful substances and indicate high levels of sediment in suspension that will settle out. However, turbidity information should always be taken in context as turbid water may not necessarily indicate an issue.

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is a critical parameter for assessing water quality because it measures the organic load/ pollution level in aquatic environments. Biochemical oxygen demand (BOD) depicts the amount of oxygen consumed by bacteria and other microorganisms while decomposing organic matter in water under aerobic (oxygen is present) conditions at a specified temperature. BOD serves as an indicator of the water's ability to sustain aquatic life. High BOD levels indicate increased organic load/ pollution, often caused by anthropogenic activities such as sewage discharge or agricultural runoff. Elevated BOD can lead to oxygen depletion in the water, harming aquatic organisms and disrupting the ecological balance. Monitoring and managing BOD levels are vital for preserving water quality, ensuring aquatic ecosystems' well-being, and safeguarding human health when using water resources for drinking or recreational purposes.

Selected references

Irish Ocean Climate and Ecosystem Status Report 2023.

Shi, Z., K. Chow, C. W., Fabris, R., Liu, J., & Jin, B. (2022). Applications of Online UV-Vis Spectrophotometer for Drinking Water Quality Monitoring and Process Control: A Review. Sensors (Basel, Switzerland), 22(8). https://doi.org/10.3390/s22082987

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More Detail (See marinestream.eu look up Live Data)

https://www.marinestream.eu/live_data/

Please note that even though the sensors' data is monitored, there may be some errors present. Also the STREAM project does not accept any responsibility for any inaccuracies that may occur. Occasionally there can be electronic glitches where inaccurate information is generated and remotely located aquatic sensors face some operational and maintenance challenges. Environmental factors such as fouling, corrosion, and biofouling can negatively impact sensor accuracy and performance. Furthermore, maintenance in hard-to-reach locations can be quite challenging.

Seawater's physical and chemical characteristics can differ depending on factors such as latitude, depth, proximity to land, and the amount of freshwater input. Oceanic seawater comprises around 3.5% dissolved compounds, with the rest being pure water, but estuarine waters composition vary dramatically more. The chemical makeup of seawater at any one point is influenced by various processes such as rock and sediment erosion, anthropogenic inputs, gas exchange with the atmosphere, the metabolism and decay products of organisms, tidal height, weather and in particular rainfall. Nitrogen, phosphorus, and carbon are vital nutrients for living organisms. But, typically they are only found in small quantities in seawater, which can limit the organic cycles of the ocean. Silicon, used in the skeletons of radiolarians and diatoms, and calcium, needed for the shells and bones of organisms like fish and corals, are other essential elements found in seawater.

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Sea level rise

There are two primary mechanisms through which sea levels can rise in response to climate change. The first mechanism involves the warming of the Earth's oceans due to the increasing global temperature. As the oceans absorb more heat, seawater becomes less dense and expands, leading to an increase in volume and consequently a rise in sea level. This process is known as thermal expansion.and therm

The second cause contributing to sea level rise is the melting of ice on land. As the planet's temperature rises, glaciers and ice sheets in Polar Regions and mountainous areas start to melt, releasing vast amounts of water into the oceans. This additional influx of water from melting ice significantly contributes to rising sea levels.

The combination of these two processes, thermal expansion, and the melting of land-based ice, has been identified as the primary drivers of sea level rise observed in recent decades. The impact of rising sea levels is a matter of concern, as it can lead to a range of adverse effects, including coastal erosion, more frequent and severe flooding events, and the potential displacement of millions of people living in low-lying coastal regions.

Addressing the causes and consequences of sea level rise remains a critical challenge for global communities. It necessitates comprehensive efforts to mitigate greenhouse gas emissions, which drive global warming, and the implementation of adaptive measures to protect vulnerable coastal communities from the adverse impacts of rising sea levels. Scientific research and international cooperation are vital to understanding and responding effectively to this pressing issue posed by climate change.

See: National Oceanic and Atmospheric Administration (NOAA)

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Temperature:

Seawater temperature is critical when assessing water quality. In addition to its own influences, temperature impacts other parameters and can modify the physical and chemical properties of water.

Table 6. Some parameters affected by temperature

Conductivity and salinity
Dissolved oxygen and other dissolved gas concentrations
Oxidation reduction potential (ORP)
pH
Water Density
Metabolic rates and photosynthesis production
Compound toxicity

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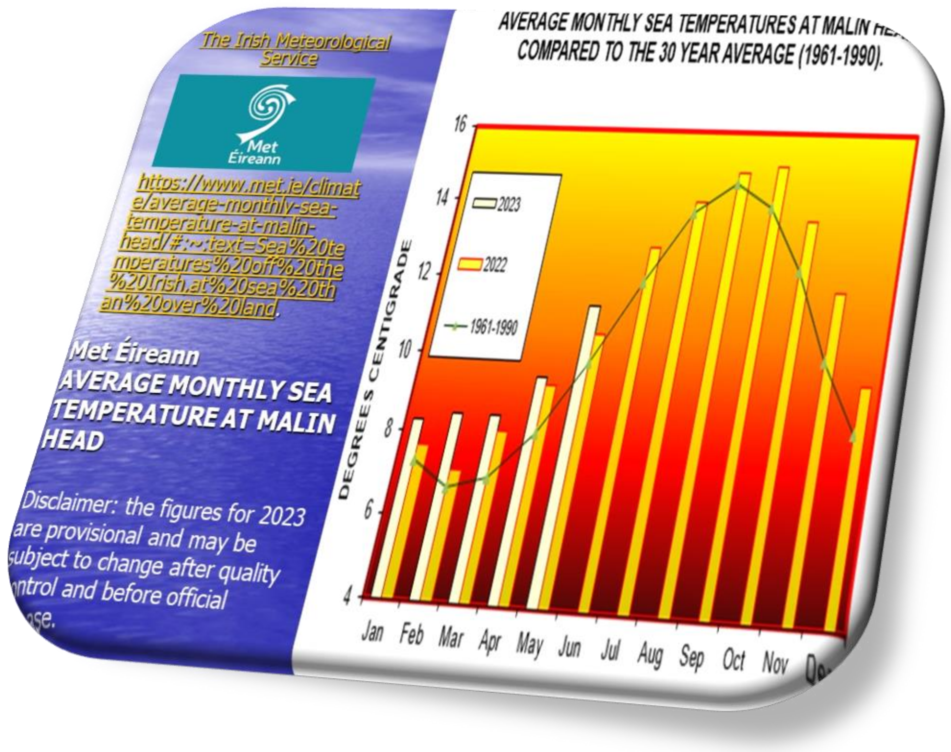
"Irish waters have warmed since the 1980s, with 2007 temperatures over 0.8°C above the 1960–1990 average. Recent years have seen a cooling trend of -0.3°C/decade. Sea surface temperatures remain 0.4°C warmer in the 21st century relative to 1960–1990" (MI 2023). Shifts in ecosystem regimes, invasions, and extinctions are all signs of biological changes that can occur due to a species' physiological response – see papers such as Brierley 2009 and Weiskopf et al. 2020. Tipping points may occur when global warming reaches temperatures beyond critical levels, leading to accelerated irreversible impacts. These events (glacier melt, methane release etc.) can create even more significant uncertainty about future climate, its extremes and, therefore, are best avoided by adopting a cautionary approach to greenhouse emissions.



The impacts of temperature on marine aquatic life, both microscopic and those organisms that are large enough to see with the naked eye, are significant and wide-ranging. Temperature plays a central role in shaping marine species' distribution, their growth and development, their behaviour, physiology, overall health and the timing of events in their lifecycle such as reproduction and spawning. These temperature impacts are thought to be becoming increasingly pronounced and concerning as global temperatures rise due to climate change. Warmer temperatures may benefit some species but can negatively affect others. Temperature effects can also interact with other stressors, potentially weakening an organism's resilience or helping nuisance species flourish, including pathogens and parasites. Mitigating climate change is therefore critical for marine life preservation.

Temperature directly influences the metabolic rates of marine organisms. This is the rate at which an organism makes energy from its foods, leading to higher energy demands and faster growth rates. Warmer temperatures increasing metabolic rates. An increased metabolism can have both positive and negative consequences for marine life. For example, some species may benefit from increased growth rates and reproductive output under warmer conditions. In contrast, others may struggle to meet their energy requirements (finding enough food) and therefore have reduced fitness and survival issues.

One of the most significant impacts of temperature on marine life is its effect on species distribution. Many marine organisms have specific temperature preferences and tolerances, known as their thermal niches. As water temperatures change, species may be forced to migrate to find more suitable habitats. This can lead to shifts in the distribution patterns of marine populations (plants and animals), altering ecosystem dynamics and potentially disrupting food webs.

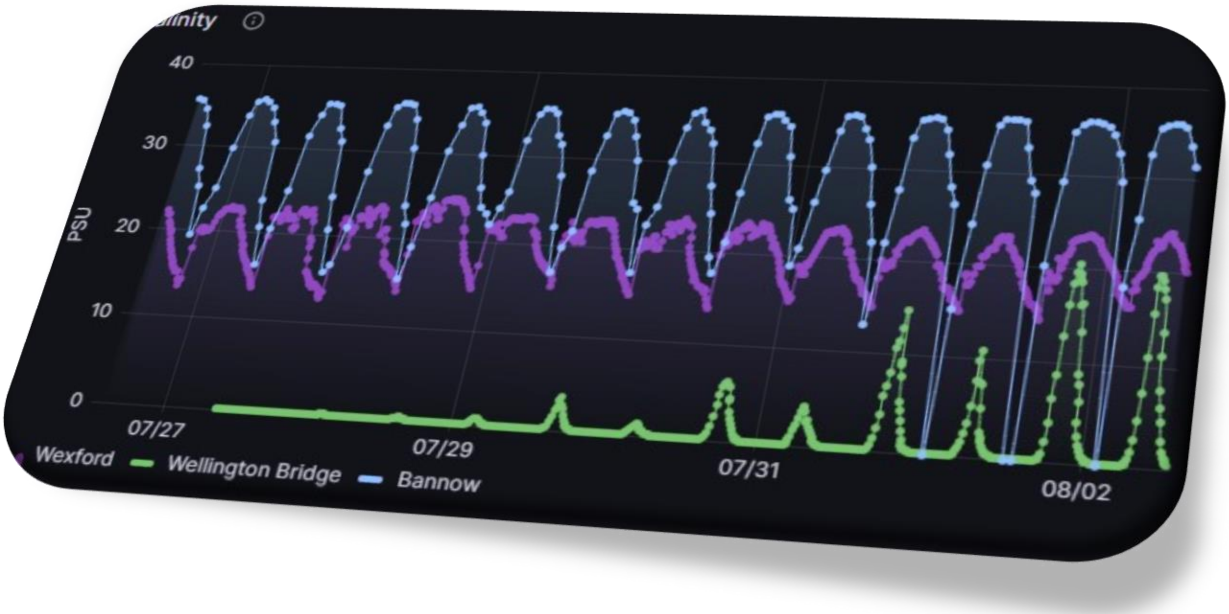
Temperature changes can also impact the timing of biological events (phenology), such as breeding, migration, and blooms of microorganisms, such as phytoplankton and zooplankton. For example, warmer temperatures can trigger earlier spawning in some fish species, which may mean their offspring miss the opportunity to feed on the microscopic plants (phytoplankton), causing missed opportunities throughout the food chain. This mismatched timing between species interactions can disrupt predator-prey relationships and reduce reproductive success. Microorganisms, such as phytoplankton, are also greatly affected by temperature changes. Phytoplankton are the primary producers in marine food webs, and their growth and productivity are strongly influenced by temperature. Higher water temperatures can lead to increased phytoplankton blooms in some regions, altering the dynamics of marine ecosystems. However, excessive temperatures can also limit the growth of certain phytoplankton species, affecting the entire food chain. The impact of temperature on photosynthesis in algae and cyanobacteria varies depending on the species. Overall, photosynthetic production tends to rise with increasing temperature for all phytoplankton, although each organism has its own optimal temperature range. If this optimal range is surpassed, photosynthetic activity decreases as excessive heat can denature the enzymes involved in the process, slowing down photosynthesis instead of enhancing it.

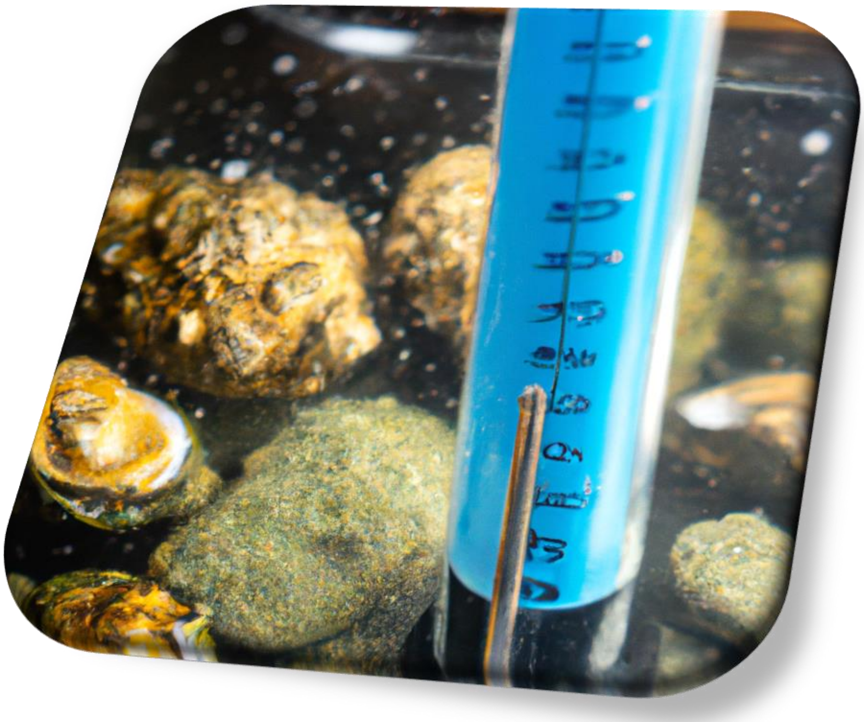
In addition to these direct effects, temperature changes can interact with other stressors, such as ocean acidification and pollution, exacerbating their impacts on marine life. Combined stressors can weaken the resilience of marine organisms and make them more vulnerable to disease outbreaks, predation, and other threats. For example, warming ocean temperatures have been associated with kelp forest declines worldwide, and elevated temperatures can act synergistically with other local stressors to exacerbate kelp loss, according to Weigel et al. 2023 in the Journal of Phycology.

It is critical to address climate change and reduce greenhouse gas emissions to mitigate the negative impacts of temperature on marine aquatic life. Efforts to limit global warming and protect marine habitats, such as establishing marine protected areas and implementing sustainable fishing practices, are vital for safeguarding the health and biodiversity of our oceans.

In conclusion, seawater temperature profoundly affects marine aquatic life, influencing macro and microorganisms' distribution, behaviour, physiology, and overall functioning. These plants and animals have evolved and developed over a long period of time to adapt to their optimal temperature regimes. Unfortunately rapidly rising temperatures associated with climate change pose significant challenges for marine ecosystems, including shifts in species distributions, altered timing of biological events, and changes in productivity. By understanding these impacts and taking proactive measures to address climate change, we can work towards preserving our oceans' invaluable biodiversity and functioning.

Salinity and Conductivity Measurements in Seawater:





Salinity and conductivity are fundamental parameters used to assess the composition and properties of seawater. Seawater is a complex mixture of dissolved salts, gases, and suspended particles. Salinity refers to the concentration of dissolved salts, while conductivity measures the water's ability to conduct electrical current. Accurate and precise measurements of salinity and conductivity in seawater are significant for various applications,

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including climate studies, water quality monitoring (change) and marine research. Traditionally, salinity has been expressed in practical salinity units (PSU) and parts per thousand (ppt). PSU is defined based on the electrical conductivity ratio of a seawater sample to a standard reference solution. It provides a standardized scale for salinity measurements. While ppt represents the ratio of dissolved salts' mass to the seawater sample's mass, expressed in parts per thousand.

Electrical conductivity measures the seawater's capacity to conduct electrical current, which is directly related to the presence of dissolved ions. Conductivity is typically expressed in Siemens per meter (S/m) or mS/cm (millisiemens per centimetre). It is an indirect measure of salinity, and higher salinity levels correspond to increased conductivity due to the presence of more dissolved ions. Conductivity measurements in seawater are commonly performed using conductivity cells or sensors. These instruments consist of electrodes immersed in the water and an electric field applied between them. The resulting current is measured and used to determine the conductivity of the sample. This value can then be converted to salinity using calibration equations or algorithms. The Practical Salinity Scale (PSS) is a widely accepted international standard for measuring salinity. It is based on the relationship between electrical conductivity and salinity and provides a consistent method for comparing salinity data worldwide. The PSS scale is closely related to PSU and is used interchangeably in many applications. From a practical standpoint it is important to know that the actual numeric difference between PSU and PPT is relatively small.

Accurate salinity and conductivity measurements are essential for understanding seawater density, thermodynamics, circulation patterns, and ecological health. These measurements contribute to climate studies, oceanographic research, and the assessment of marine ecosystems. Salinity have direct physiological effects on marine organisms as this parameter affects the osmoregulatory capabilities of organisms. Osmoregulation is how organisms balance water and salt concentrations within their bodies. Marine species have evolved specific adaptations to cope with variations in salinity. For example, some fish species have specialised kidneys that enable them to excrete excess salt in high-salinity environments. In contrast, other organisms have mechanisms to retain water and prevent dehydration in low-salinity conditions.

The availability of food and nutrients can also be influenced by salinity levels. As changes in salinity can affect the distribution and abundance of phytoplankton and zooplankton, which are essential food sources for many marine organisms. Alterations in salinity can also result in shifts, or changes in the composition of these planktonic communities, potentially impacting the food web and overall productivity of marine ecosystems.

Salinity levels also effect the distribution and behaviour of marine species. Changes in salinity can disrupt the balance and diversity of these ecosystems, affecting the associated fauna and flora. Some organisms have specific salinity requirements and are adapted to thrive within particular ranges. Variations in salinity can limit the distribution of certain species, as they may be unable to tolerate conditions outside their preferred scope. As a result, salinity gradients in temperate waters around Ireland can act as barriers or facilitators for the dispersal and colonization of marine organisms.

The interplay between salinity and other environmental factors further influences the ecology of marine organisms. For example, salinity can interact with temperature, nutrient availability, and light conditions to shape the growth and distribution of macro algae, which are important habitat-forming species.

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Human activities, such as freshwater abstraction, coastal development, and climate change, have the ability to alter salinity patterns in marine environments. These alterations can have cascading effects on the health and functioning of ecosystems, potentially leading to changes in species composition, reduced biodiversity, and altered ecosystem dynamics.

Vibrio bacteria are marine heterotrophic bacteria and can exhibit rapid growth with short generation times. Moreover, many Vibrio spp. are pathogens, causing diseases in marine animals and humans. Vibrio’s are widely found in estuarine and marine environments worldwide, particularly in coastal regions. Additionally, vibrio’s can swiftly respond to sudden nutrient increases, leading to their logarithmic growth in these modified microcosms, such as during phytoplankton blooms or high levels of nutrients. Suggesting that the short-lived Vibrio blooms should be considered when assessing their contribution to the breakdown of organic macromolecules.

Understanding the impacts of salinity on marine organisms is key for conserving and managing marine environments in temperate waters around Ireland. Monitoring salinity levels, particularly in areas susceptible to human activities, can help identify potential impacts and inform sustainable management practices. By protecting and preserving the delicate balance of salinity in marine ecosystems, we can contribute to Ireland's temperate waters' long-term health and biodiversity. In conclusion, salinity is an important environmental factor influencing marine organisms' distribution, physiology, and ecology in temperate waters around Ireland. Variations in salinity levels can have direct physiological effects, affect osmoregulation, impact food availability, influence species distribution and behaviour, and interact with other environmental factors. Recognizing the importance of salinity and its potential impacts is vital for the conservation and sustainable management of marine ecosystems in Ireland's temperate waters.

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Oxygen:

Unlike land animals, marine organisms encounter a significantly more formidable task when extracting oxygen from their environment to sustain their metabolism. As depending on its temperature and salinity, seawater can contain 20-40 times less oxygen by volume than air (with saltwater holding slightly less oxygen than freshwater). Moreover, the oxygen diffusion rate through water is approximately 10,000 times slower than in air. Consequently, even minor reductions in dissolved oxygen levels can substantially impact marine animals.

The concentration of dissolved oxygen in ocean water usually ranges from 7 to 8 milligrams per litre (mg/L). When the concentration drops below 4 mg/L, organisms start to react, and mobile species either migrate out of or avoid the area. Water with less than 0.2 mg/L of dissolved oxygen is anoxic and cannot sustain most life forms. Hypoxic water is water that has little detectable dissolved oxygen.

- Globally there has been a decrease of oxygen concentrations from the sea surface to 1000 m depth over the last 60 years.

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- The levels of oxygen seen in McSwyne´s Bay, Co Donegal, in 2005 and 2012 are associated with summer phytoplankton blooms which caused major mortalities of marine organisms.
- See: https://climateireland.ie/statusTool/_3_7_DissolvedOxygen

Oxygen is essential for marine life in coastal waters, supporting respiration and metabolic processes. Low oxygen levels can lead to stress in marine organisms, impaired growth, poor health and altered ecological interactions. Oxygen dynamics are influenced by organic matter inputs and physical processes. Monitoring and managing oxygen levels are vital for ecosystem health and understanding in coastal waters.

Oxygen is indispensable for the respiration of marine organisms, allowing them to convert nutrients into energy. Fish, invertebrates, and other marine animals extract oxygen from the water through their gills, while microscopic organisms such as phytoplankton and bacteria rely on dissolved oxygen for their metabolic processes. Adequate oxygen levels are necessary to meet the energy demands of marine life and maintain their physiological functions.

Coastal and transitional waters in Ireland can be subject to varying oxygen conditions due to a variety of factors. Important influences for example are the collapse of significant algal blooms, or the input of organic matter from land, such as runoff from agricultural activities or wastewater discharges. When excess organic matter enters the water, it decomposes through bacterial action, consuming oxygen in the process. This can lead to a depletion of oxygen and the formation of anoxic or dead zones where oxygen levels may be critically low or even absent. These dead zones can have severe consequences for marine organisms, as they may be unable to survive in such oxygen-poor environments.

Oxygen levels in seawater are also influenced by physical processes such as water circulation and mixing. Tidal currents, wind patterns, and temperature gradients can affect the distribution and availability of oxygen in these ecosystems. For example, strong tidal currents can promote mixing of oxygenated surface waters with deeper layers, ensuring a more uniform distribution of oxygen throughout the water column. Conversely, stagnant or stratified conditions can impede oxygen exchange and lead to oxygen-depleted zones. Elevated seawater temperatures may also result in lower dissolved oxygen levels.

Low oxygen levels, commonly referred to as hypoxia, can have detrimental effects on marine organisms. Oxygen-deprived conditions leading to physiological stress, impaired growth, and reduced reproductive success in fish and invertebrates. Some species may exhibit behavioural adaptations to cope with low oxygen levels, such as seeking out oxygen-rich areas or altering their feeding patterns. However, chronic exposure to hypoxia can still have long-term impacts on population dynamics and biodiversity. Furthermore, low oxygen conditions can trigger changes in the composition and functioning of marine ecosystems.

Regular monitoring programs can provide valuable information on oxygen dynamics, allowing for early detection of hypoxic events and the implementation of appropriate measures. Reductions in nutrient inputs, improved wastewater treatment, and promoting sustainable land management practices can help mitigate excessive organic matter inputs and decrease the likelihood of oxygen depletion. In conclusion, oxygen is of vital importance to marine aquatic life in coastal and transitional waters around Ireland.

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O'Boyle et al. (2009) discuss the summer oxygen conditions in estuarine and coastal waters around Ireland from 2003 to 2007. Out of the 95 water bodies surveyed, 85 had sufficient oxygen levels to support aquatic life, covering 3125 $km^{2,}$ or 99.4% of the total area assessed. Ten water bodies, totalling 20.2 km2, had lower oxygen but could still support most aquatic life. No hypoxia or anoxia was detected (<2.0 mg/l O2 and <0.2 mg/l O2, respectively). Some estuaries showed improving dissolved oxygen conditions, likely due to enhanced municipal wastewater treatment. Implementing measures from the Nitrates, Urban Waste Water Treatment, and Water Framework Directives is expected to eliminate areas of oxygen deficiency in Irish waters.

Oxidation-reduction potential (ORP):

Oxidation-reduction potential (ORP), also called redox potential, plays a vital role in understanding seawater's chemical and biological processes. ORP is a measure of the tendency of a solution to either gain or lose electrons in a redox reaction. In seawater, it provides valuable information about the oxidative or reducing conditions present, significantly influencing marine organisms' behaviour and survival.

ORP is typically measured using an ORP meter consisting of a reference electrode and a measurement electrode. The ORP value is then displayed as millivolts (mV), representing the solution's relative oxidizing or reducing power. Positive ORP values indicate oxidizing conditions, where there is a tendency for the solution to gain electrons and undergo oxidation reactions. A positive value can be attributed to oxidizing agents such as dissolved oxygen or other reactive oxygen species. In seawater, positive ORP values are generally associated with well-oxygenated and relatively stable environments. However, negative ORP values suggest reducing conditions, indicating the presence of reducing agents or the absence of oxidizing agents. In seawater, negative ORP values may be observed in areas with high organic matter content, such as estuaries, where decomposition processes occur. These reducing conditions can impact the solubility of various elements and influence the microbial community composition.

By monitoring ORP values over time, it is possible to assess changes in seawater quality and identify potential risks or imbalances in marine ecosystems. This knowledge helps develop appropriate management strategies and conservation efforts to protect the delicate balance of marine life. It provides insights into the health of aquatic habitats, nutrient cycling, and harmful algal blooms. An understanding the ORP of seawater is important for various applications, including aquaculture, water treatment, and monitoring of coastal zones.

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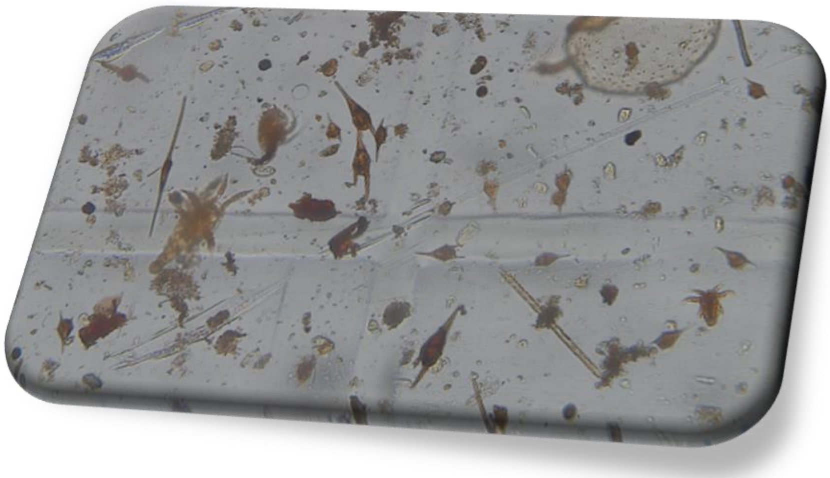
Phytoplankton and chlorophyll:



Phytoplankton are microscopic organisms that photosynthesize and form the basis of the marine food web and "can be thought of as sensitive indicators of climate change" (MI 2023). They are responsible for the majority of primary production in coastal and transitional waters, converting sunlight, nutrients, and carbon dioxide into organic matter through photosynthesis. Primary production is the process of assimilation and fixing inorganic carbon and other inorganic nutrients into organic matter. The abundance and diversity of phytoplankton have direct implications for the productivity and functioning of an ecosystems. These characterizations/ quantifications can be used to indirectly monitor and detect indicator pollutants, including phosphorus and nitrogen.

Chlorophyll, a pigment found in phytoplankton, is used to capture light energy for photosynthesis. Therefore, chlorophyll levels are often used as a proxy for phytoplankton biomass and primary production. The levels of phytoplankton and chlorophyll varies seasonally and spatially due to a range of factors. Light availability, nutrient availability, temperature, and water circulation patterns all influence the growth and distribution of phytoplankton. According to NASA 2023 "at least 1/2 of the oxygen we breathe comes from the photosynthesis of marine plants."

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Photosynthetic reaction

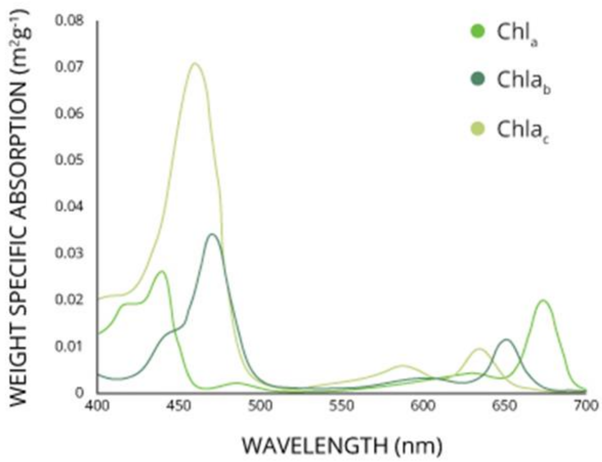
Sunlight

$$6\ CO_2 + 6H_2O\ -\ C_6H_{12}O_6 + 6O_2$$

Chlorophyll

Phytoplankton and chlorophyll levels are vital in an assessment of primary productivity and ecosystem health. They form the foundation of the food web and help mitigate climate change through carbon absorption. Monitoring their levels is important for assessing ecosystem health and detecting harmful algal blooms. The MI 2023 report that there has been "an expansion of the phytoplankton growth season has been observed for some species in Irish waters. Diatom cell abundance has increased nationally while many dinoflagellates have declined in terms of monthly cell abundance". But "Harmful algal species have expanded their growth season since 1990 and are now present throughout the year in Irish waters". Harmful algae can be categorized into two main groups: toxin-producing and non-toxin-producing species. These algae can damage marine ecosystems and/or pose risks to seafood safety.

Chlorophyll is a pigment found in plants, algae, and phytoplankton, essential for photosynthesis, which converts sunlight into energy. It comes in six different forms (A, B, C, D, E, and F), with chlorophyll A being the primary molecule responsible for photosynthesis in all photosynthesizing organisms. The other chlorophyll forms are accessory pigments that assist in photosynthesis by absorbing sunlight and transferring the energy to chlorophyll A. For example, chlorophyll B is mainly found in land plants, aquatic plants, and green algae, while chlorophyll C is found in red algae, brown algae, and dinoflagellates. The presence of these accessory pigments makes photosynthesis more efficient in different organisms.



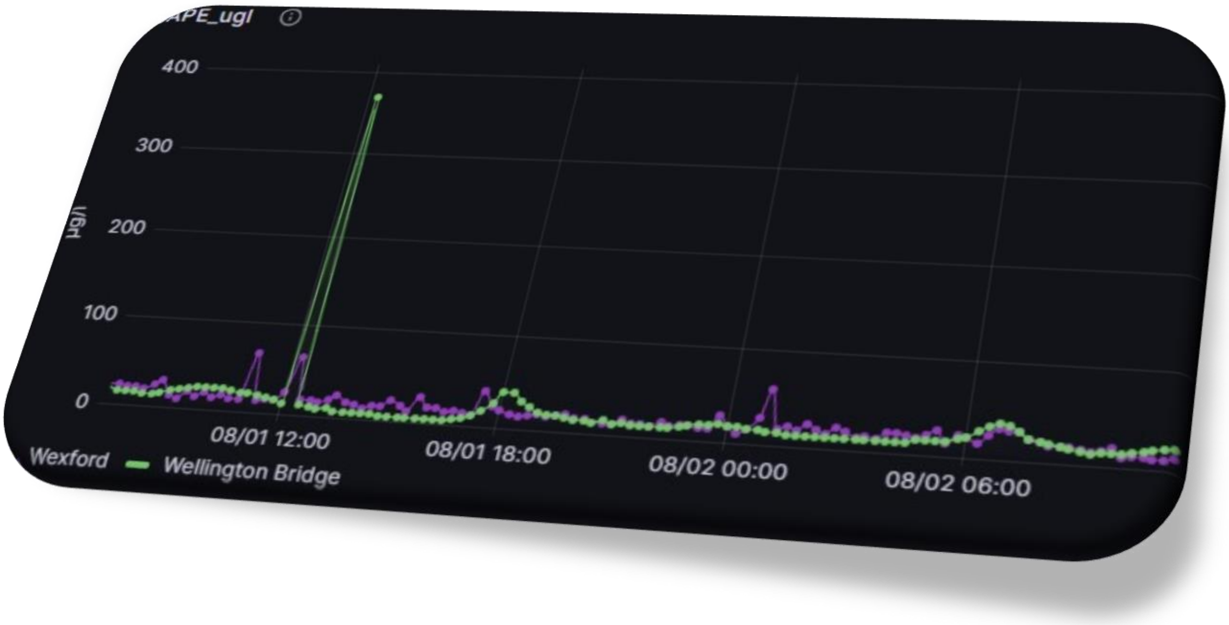
See Fondriest Environmental, Inc. "Algae, Phytoplankton and Chlorophyll." Fundamentals of Environmental Measurements. 22 Oct. 2014. Web. < https://www.fondriest.com /environmental-

During spring and summer, increased light levels and nutrient availability promote phytoplankton growth, and can result in blooms. These blooms may sometimes be observed as patches or discolorations in the water and are often dominated by specific phytoplankton species. Diatoms, dinoflagellates, and coccolithophores are some of the common groups found in the coastal and transitional waters around Ireland. They provide a vital food source for zooplankton, which are in turn consumed by fish and other higher trophic level organisms. Phytoplankton also play a central role in the global carbon cycle, as they absorb carbon dioxide from the atmosphere and incorporate it into their biomass. This process helps mitigate the impacts of greenhouse gases on climate change. However, excessive phytoplankton growth can lead to eutrophication, a phenomenon characterized by an overabundance of nutrients in the water. Excess nutrients, particularly nitrogen and phosphorus from sources like agricultural runoff or sewage discharge, can fuel the growth of harmful algal blooms (HABs) and negatively impact water quality. Some HAB species produce toxins that can harm marine organisms and pose risks to human health through the consumption of contaminated seafood.

Monitoring phytoplankton and chlorophyll levels in coastal and transitional waters is essential for assessing ecosystem health and identifying potential environmental concerns. Regular monitoring programs help detect changes in phytoplankton community composition, track the occurrence of harmful algal blooms, and provide insights into nutrient dynamics and ecosystem functioning. Around Ireland, initiatives such as the Marine Institute's Phytoplankton Monitoring Programme provide valuable data on phytoplankton abundance, composition, and chlorophyll concentrations in coastal and transitional waters. This information contributes to the understanding of ecological trends, assists in the management of coastal resources, and aids in the development of policies and strategies to safeguard marine ecosystems.

Phytoplankton and chlorophyll levels are key indicators of primary productivity and ecosystem health in coastal and transitional waters around Ireland. Monitoring these parameters helps assess the abundance, diversity, and dynamics of phytoplankton communities, as well as identify potential risks associated with harmful algal blooms and eutrophication.

BGAPE μg/L:



Blue Green Algae Sensor: Phycoerythrin (BGA-PE) measure phycoerythrin in cyanobacteria (bacteria capable of photosynthesis) in marine environments. It is a pink/red coloured light-harvesting pigment of red algae and cyanobacteria that play and important role in nutrient and energy supply in the marine environment.

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pH:

	pH (illustrative purposes only)	
14		Caustic Soda and Drain Cleaners
13		Bleaches
12		Soapy Water
11		House Hold Ammonia
10		Milk of Magnesia
9		Tooth Paste
8		Seawater and Baking Soda
7		Distilled Water and Human Blood
6		Milk, Saliva and Urine
5		Acid Rain and Black Coffee
4		Tomatoes
3		Orange Juice and Soft Drinks
2		Lemon Juice and Vinegar
1		Stomach Acid and HCl

The pH level or hydrogen ion content of seawater helps shape marine ecosystems (where all the plants, animals and the physical environment interact). The pH of seawater is measured using a logarithmic scale. The coastal areas of Ireland can exhibit significant variations in pH due to environmental factors, local catchment geology, and human activities. The ocean's average pH is reportedly around 8.1, which is basic (or alkaline). However, as the seas absorb more anthropogenic atmospheric carbon dioxide (CO_2), the pH is projected to decrease (less than pH 8.1), and the oceans will become more acidic. ""Ocean Acidification, Irish offshore waters have become more acidic with an overall reduction in pH of 0.02 units per decade" (MI 2023).

On a localised basis a significant algal bloom can alter the pH of a waterbody as when phytoplankton photosynthesize, they convert carbon dioxide (CO_2) from the sea to carbohydrates (sugars) and

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oxygen. This process reduces the amount of CO_2 in the seawater, lowering the acidity. The more intense a bloom of phytoplankton is, and the longer the daylight hours, the lower the alkalinity (a higher pH). As the bloom ends, much of the phytoplankton die and decompose. The decomposition process releases CO_2 into the water, and pH levels go down (more acidic water).

An increased acidification of seawater may pose serious challenges to calcifying organisms like molluscs and shellfish. Decreased pH inhibits the formation and growth of calcium carbonate structures, affecting their ability to build shells or protective exoskeletons.

Algae and seaweeds are also sensitive to pH variations. Acidic conditions can alter their metabolic processes, growth rates, and reproduction, impacting their overall abundance and diversity. Climate change-induced factors, such as increased carbon dioxide (CO_2) levels and rising sea surface temperatures, exacerbate pH fluctuations. CO_2 dissolves in seawater, leading to ocean acidification and a decrease in pH. Moreover, higher temperatures have the potential to intensify the effects of acidification on marine organisms.

Human activities, such as coastal pollution and nutrient runoff, can also contribute to pH variations. Chemical pollutants and excessive nutrient inputs can alter the pH levels in coastal waters, further stressing intertidal organisms. Reducing pollution and adopting sustainable practices are decisive for maintaining a healthy coastal ecosystems.

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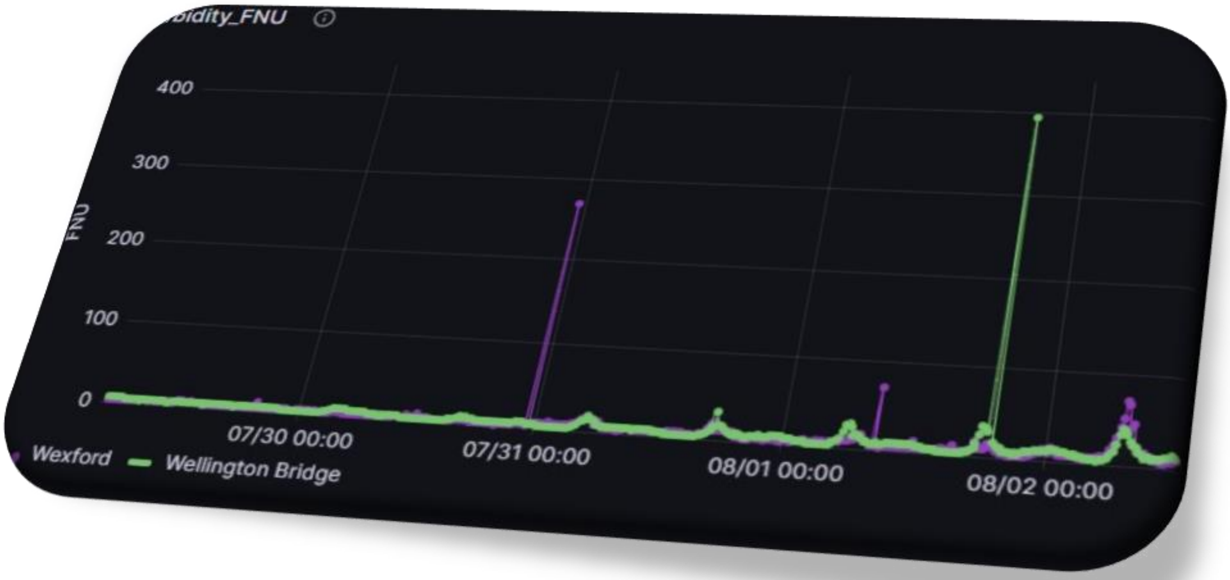
Turbidity:



Turbidity refers to the opacity or cloudiness of seawater and is quantified in nephelometric turbidity units (NTUs) or formazin nephelometric units (FNUs). The higher the turbidity reading, the murkier the water appears. Suspended particles, including clay, silt, organic matter, and microscopic organisms, are responsible for turbidity. While turbid water is not necessarily harmful, particles and sediments can cause issues. Sediment can negatively impact aquatic life by clogging fish gills, while particulates and organic matter can contribute to low dissolved oxygen levels. Additionally, these particles may adsorb metals, bacteria, and toxic organic substances, and metal oxy-hydroxides can coat the particles.

Turbidity significantly affects the availability and quality of light in a water column, directly influencing photosynthetic organisms such as phytoplankton, macroalgae, and seagrasses. High turbidity reduces light penetration, hindering photosynthesis and limiting primary productivity. Consequently, the growth and abundance of these primary producers are affected, which can have cascading effects on the entire food chain.

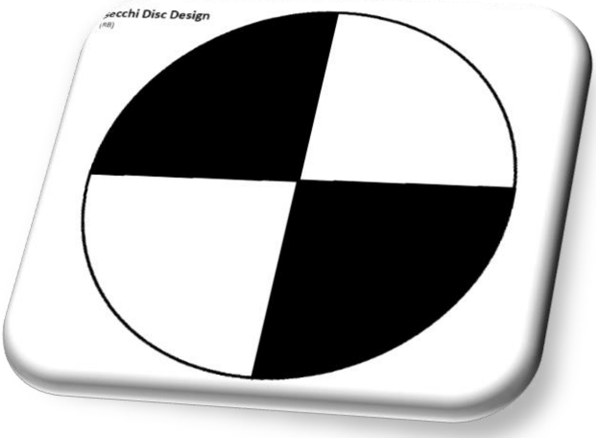
Coastal organisms, including filter-feeding species like bivalves and sponges, are particularly susceptible to turbidity-induced changes. Elevated turbidity levels can clog their feeding structures and interfere with their ability to capture food particles effectively. Leading to reduced feeding efficiency, compromised nutrition, and overall decreased well-being of these organisms.

Turbidity also influences the behaviour and distribution of marine organisms. Many fish species rely on visual cues to find prey, mates, and suitable habitats. Increased turbidity disrupts optical detection, making it harder for these organisms to perform essential tasks such as foraging and reproduction.

Anthropogenic activities, such as construction, dredging, and coastal development, can contribute to elevated turbidity levels in coastal waters as they cause sediment runoff, nutrient pollution, and the disturbance of seabed habitats. Implementing proper sediment and pollution control measures is essential to mitigate these impacts.

The effects of turbidity on coastal organisms are context-dependent, with some species displaying adaptability and tolerance to higher turbidity conditions. However, chronic or extreme turbidity can overcome the resilience of many species, leading to reduced biodiversity, altered community structures, and ecological imbalances in coastal ecosystems.

To measure turbidity or water clarity a Secchi disc was devised by Angelo Secchi in 1865. It consists of a simple, white, circular disc, coloured black and white to improve contrast, with a 30 cm diameter that measures water transparency and turbidity in various water bodies. The disc is affixed to a pole or line and gradually lowered into the water. The point at which the disc becomes invisible determines the water's transparency, termed the Secchi depth, and indicates its turbidity. Over time, this tool has also been adapted with a smaller 20 cm diameter and a black-and-white design to assess freshwater transparency. For consistency of results, where practical, deploy it from the shady side of a boat and dock between mid-morning and mid-afternoon (do not wear sunglasses). Using a measured line (marked intervals of at least 10 cm on the cord, or better yet, use a flexible measuring tape attached to the line).



To measure the transparency of the water with a secchi disc, carefully lower the disc into the water while holding it steady with one hand and feeding a slack measured line with the other hand. Keep lowering the disc until the contrast (black and white) is no longer visible. Then, slightly raise the disc to see it again, and drop it slightly until it disappears again. Record the distance between the surface of the water and the disc.

TSSQ-Eq mg/L:

Turbidity is primarily attributed to total suspended solids (TSS), and the estimation of TSS levels using sensors has been calculated using linear regression modelling based on turbidity measurements. Parameters with the eq prefix are associated with the TriOS OPUS spectrometer, the company has developed a library of absorption spectra associated with the parameter.

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Nutrients:

Nutrients such as dissolved inorganic nitrogen, phosphate, and silicate are vital for primary productivity in plants. But when depleted can limit plant growth. Around Ireland's coast, nutrient concentrations are influenced by various factors, including their concentrations in shelf waters, nutrient loads from freshwater input and land-based discharges, atmospheric inputs, and biogeochemical processes such as recycling, biological assimilation, or denitrification. Excessive nutrients can lead to eutrophication, primarily confined to specific nearshore areas and embayments.

Around the Republic of Ireland according to the EPA's Water Quality Monitoring Report on Nitrogen and Phosphorus Concentrations in Irish Waters (2020), nutrient losses from agriculture significantly affect water quality and hinder the achievement of environmental objectives under the WFD. The EPA's assessment (2013–18) reveals that just over half of rivers and lakes and only 38% of estuaries were ecologically healthy, with declining overall water quality. The main issue is an excess of phosphorus and nitrogen in the water.

Nitrogen concentrations in rivers, groundwater, and estuaries in Ireland's south, southeast, and east have risen since 2013. Around 32% of rivers have concentrations higher than 11.5 mg/l NO3, which might contribute to breaching the environmental quality standard in marine waters. Nitrate concentrations in the southeast are double those found elsewhere in the country (EPA 2020).

Over 35% of all river and 25% of groundwater sites have increased by more than 1.5 mg/l NO3 in the annual mean concentration since 2013. The most significant increases in nitrate concentration are observed in the southeast and south, with 10 out of 16 monitored estuaries and coastal waters in this region having nitrogen concentrations above the marine water standard, and a quarter of these water bodies showing an upward trend of more than 1.5 mg/l NO3 since 2013 (EPA 2020).

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Nitrate after carbon is quantitatively the most important element for nutrition of microalgae, since it plays an important role on their lipid profile. A methodology named the Dual-wavelength correction scheme has been adopted by STREAM (Benyuan Yu 2022 pers. Comm.) and evaluated for the correction of absorbance organic matters might contribute. Using this method, UV absorption is measured at 220nm and calibrated to a nitrate concentration. A second absorbance measurement is then made at 275nm. The value recorded is then multiplied by two and subtracted from the 220nm absorbance value. Absorbance of a sample can be calculated with the weakening of the light caused by passing through the measurement sample liquid compared with that of the light passing through the de-ionised pure water.

$$A = 2 - \log_{10}\left(100 \times \frac{I}{I_0}\right)$$

Where A is absorbance of samples, *I* is intensity of light caused by passing through the sample, and I_0 is the intensity of light caused by passing through the reference de-ionised pure water (Benyuan Yu 2022 unpublished document).

- NO_3_mgl: measures the Nitrate in the water in milligrams per litre.

According to the Intergovernmental Panel on Climate Change (IPCC), the nutrient cycles in the open ocean are being disrupted due to ocean warming and increased stratification. This disturbance is causing regionally variable impacts on primary producers. Climate models predict a decline in nitrate concentrations within the upper 100 meters of the ocean by 2081-2100, compared to 2006-2015, due to increased stratification.

Climate change will likely influence the concentration and distribution of nutrients in Irish coastal waters. Factors such as prolonged stratification and changing rainfall patterns can impact nutrient levels. By the end of the century, climate projections indicate a very likely increase in the annual mean stratification of the top 200 meters within the range of 1-9% for RCP2.6 and 12-30% for RCP8.5, relative to the 1986-2005 period. Additionally, climate change is expected to result in more rain and increased flooding during winter months, leading to higher nutrient enrichment through increased freshwater input and land runoff. Climate models also suggest that areas with already high precipitation, particularly in the Northern Hemisphere, will become even wetter.

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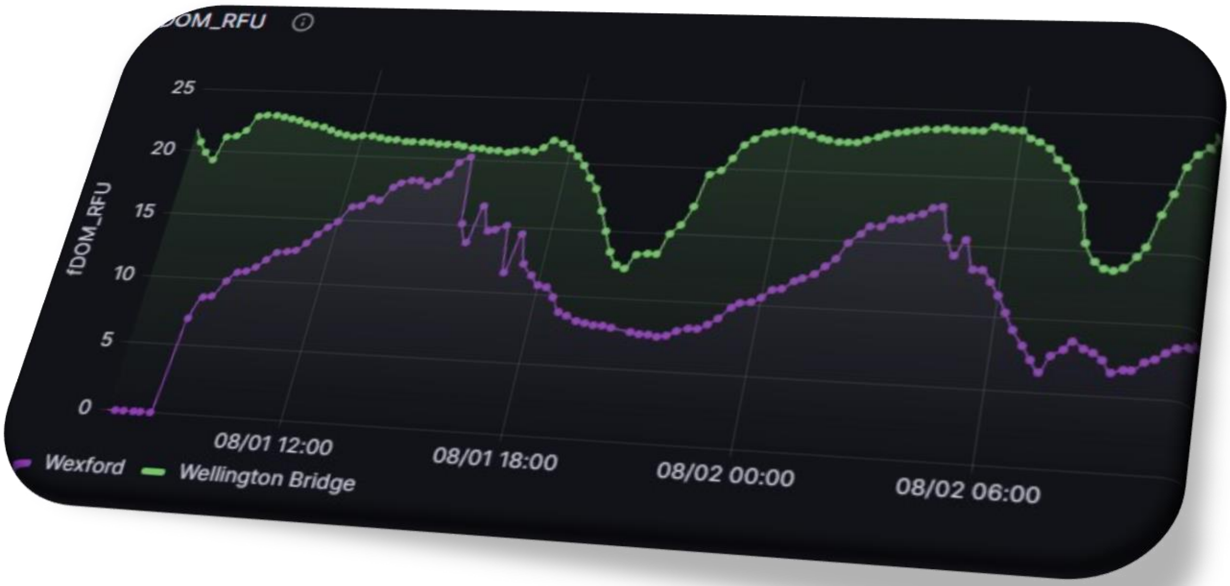
FDOM and CDOM:



Fluorescent Dissolved Organic Matter (fDOM) denotes the portion of Coloured Dissolved Organic Matter (CDOM) that fluoresces. Both indicate organic matter in water which absorbs in the ultraviolet (UV) spectrum. As a surrogate for CDOM, fDOM detection provides a useful method for monitoring Dissolved Organic Matter (DOM) in natural water environments. The measurement of CDOM/fDOM is important because concentrations of CDOM can affect marine benthic plant and animal communities. The measurement of fDOM/CDOM is also suitable for monitoring a wastewater discharge, as the fluorescence of fluorescent dissolved organic matter (fDOM) indicates the total organic carbon (TOC) content. The concentration of fDOM in water can also provide insights into a water body's dispersion, transport, and mixing.

The measurement units for fDOM and CDOM are fluorescence units (RFU). fDOM_QSU: Fluorescent Dissolved Organic Matter that has been measured in Quinine Sulphate Units. CDOM mg/L (note Exo2 fDOM, is a proxy for RS-Hydro CDOM). Fluorescent Dissolved Organic Matter (fDOM) refers to the fraction of CDOM (Coloured Dissolved Organic Matter) that fluoresces.

- ABS254_AU: Light absorption at 254 nm measured in Absorbance Units.* (DOC) at 254nm
- SAC254_lm: Spectral Absorption Coefficient at 254 nano metres, measures the dissolved organic material that absorbs UV light at a wavelength of 254 nm. It is usually used to monitor diffuse and point source pollution in water bodies. (DOC) at 254nm

SAC254:

Utilising the Spectral Absorption Coefficient (SAC) of seawater at 254 nm is a valuable measure of UV absorption (a surrogate parameter correlated to carbon-based parameters such as DOC and TOC) at a wavelength of 254nm. The DOC content of seawater is the concentration of carbon remaining in a seawater sample after removing particulate and inorganic carbon. Total Organic Carbon (TOC) is the total of the particulate and DOC when existing inorganic carbon is removed in a laboratory analysis by acidification.

Dissolved organic carbon (DOC) is an essential nutrient for marine microorganisms, an indicator of organic matter, and is a significant component of the worldwide carbon cycle. “The ocean plays a vital dominant role in the Earth's carbon cycle. The total amount of carbon in the ocean is about 50 times greater than the amount in the atmosphere, and is exchanged with the atmosphere on a time-scale of several hundred years” NASA 2023. Currently, nearly half of the carbon released by burning fossil fuels is stored in the ocean. However, there are significant concerns about how this carbon sink will function in the future due to the potential impacts of climate change on ocean circulation, biogeochemical cycling, and ecosystem dynamics.

SAC254_lm: Spectral Absorption Coefficient at 254 nano metres, measures the dissolved organic material that absorbs UV light at a wavelength of 254 nm. It is usually used to monitor diffuse and point source pollution in water bodies (DOC) at 254nm.

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Selected References

MASA 2023 see - https://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-carbon cycle#:~:text=The%20ocean%20plays%20a%20vital,scale%20of%20several%20hundred%20years.

STREAM

Sensor Technologies for Remote Environmental Aquatic Monitoring

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See: marinestream.eu

Download and usage of any of the data on the website implies acceptance that although the data is regularly monitored, errors may be present and the STREAM project accepts no responsibility for any inaccuracies

https://www.marinestream.eu/live_data/

RB 2nd August 2023