Toolkit 5. STREAM Guidelines for Calibrating and Managing Water Quality Sensors to assess the qualities of saline waters

A well-designed program for calibrating and managing water quality sensors is essential to ensure accurate and reliable data collection. Regular calibration and maintenance help maintain the integrity of the collected data, which is crucial for making informed decisions about water quality issues.

This report card examines some of the considerations when choosing sensors. It outlines a strategy for using a sonde (a sonde is a general term for a device that can test physical conditions, such as water quality). A multiparameter sonde is an instrument with multiple sensors. Typically, a sensor measures one parameter, but some sensors may be used for more. For example, temperature and conductivity (salinity) readings as there is an interrelationship between these measures.

Monitoring the water quality of a water body

The International Organization for Standardization (ISO) defined monitoring as: “the programmed process of sampling, measurement and subsequent recording or signalling, or both, of various water characteristics, often with the aim of assessing conformity to specified objectives”.

“Since 2000, the WFD has been the main law for water protection in Europe. It applies to inland, transitional and coastal surface waters as well as groundwater’s. It ensures an integrated approach to water management, respecting the integrity of whole ecosystems, including by regulating individual pollutants and setting corresponding regulatory standards.

Legislation

The European Water Framework Directive (WFD) provides some of the primary legislation in relation to coastal and transitional water quality around Ireland. It is supported by two so-called daughter directives on the quality and quantity of groundwater and on the quality of surface water.

https://environment.ec.europa.eu/topics/water/surface-water_en

Characteristics of surface marine waters

Transitional waters refer to the bodies of water located at the boundary between land and sea. They consist of estuaries, fjords, lagoons, deltas, and rias, and are frequently found at the mouths of rivers, marking the shift from freshwater to saltwater environments.

Coastal waters are defined as "The waters outside the low-water line or the outer limit of an estuary". "Surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters."

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Some indicators for water quality

Some important water quality parameters are temperature, salinity (specific conductance), dissolved oxygen, nitrogen, phosphorus, chlorophyll a, transparency, biochemical oxygen demand (BOD).

Nutrients and water quality

Nitrogen and phosphorus are nutrients found in rivers, lakes, and marine waters that can encourage the growth of algae (macro algae and microalgae or phytoplankton). These algae can provide food and habitat for aquatic creatures, such as fish, molluscs, and crustaceans, at moderate levels. However, if the concentration of nutrients in a water body becomes too high, it can lead to an overgrowth of algae and eutrophication.

See: Nitrates directive

https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1561542776070&uri=CELEX:01991L0676-20081211

EPA Assessment of Coastal and Transitional Waters

According to the EPA's evaluation of transitional and coastal waters' ecological condition, 81% of observed coastal water bodies and 36% of observed transitional waters have a 'good' or 'high' ecological status. However, there has been a decrease in the quality of our estuaries and coastal waters, mainly in the southern and south-eastern regions of Ireland, where high nutrient levels in the water are harming their ecology.

See: https://www.epa.ie/our-services/monitoring--assessment/freshwater--marine/estuaries-and-coastal/

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STREAM Sonde and sensor management outline:

1. Goal and Objectives:

- Ensuring accurate and reliable data collection.

- Detecting anomalies or sensor malfunctions promptly.

- Enhancing the quality of water monitoring efforts (calibration and Intercalibration exercises).

2. Sensor Inventory:

From the experience of the STREAM project, it is recommended that Depth, Temperature, Salinity (Conductivity), and Dissolved Oxygen be considered for the primary assessments of water quality in an area. Ideally, these parameters should be broadcast live along with power source information if the sensors are operated with battery power. The information being gathered should also be stored so that it can be analysed later in the event of an issue to more fully understand its impact. Of the hierarchy of the parameters outlined below for an independent operator, their preference for knowing the pH or Oxygen levels should take priority.

Suggested Priority List of Parameters for Consideration

1)	Depth (if variable)
2)	Temperature
3)	Salinity (Conductivity)
4)	Oxygen
5)	pH
6)	Turbidity
7)	Chlorophyll
8)	Nutrients

In the authors opinion the more parameters to be measured, the greater the cost of sensors and potentially more costly and time-consuming calibration processes. Also, there is a greater probability of sensor failure and the need to remove the sonde from the water for repair.

Maintain an updated inventory of all water quality sensors, including details such as sensor type, location, installation date, and last calibration date.

When monitoring any water body of a significant size, it is ideally recommended that there are at least two locations where sensors are deployed (where practical to install). For example, a representative site of the inner (more freshwater) and outer estuary (more oceanic). Having more than one sensor deployed at all times should ensure that at least one sonde is always operational and allows for comparison of results in the event of a significant change from the norm. If finance permits in an ideal scenario, at least three sondes should be available for monitoring a bay or waterbody to allow for the

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deployment of two units and the calibration or maintenance of a third. Also, by having a third sonde, there is less time pressure to return a sonde that is being calibrated to the water.

3. Monthly Calibration Schedule:

Establish a monthly schedule for sensor (sonde) calibration following the manufacturer's guidelines. This consistency minimizes data discrepancies and allows for trend analysis over time.

Sensors are only as good as their specification, drift and last calibration.

When calibrating ensure that you have enough in date standards for one, two or three point calibration procedures according to the manufacturers specification.

Also, when calibrating check that the standards you use are appropriate for the waters you are testing. For example – it is important that the conductivity/ salinity standard is of a comparable reading to the waters being tested.

4. Calibration Procedures:

For each sensor type (e.g., temperature, dissolved oxygen, pH, and turbidity), outline detailed calibration procedures – such as cleaning, rinsing (potential use of solution for initial rinses):

- Provide step-by-step instructions for calibrating the sensors using appropriate standards and calibration solutions (see manufacturer's instruction as there are too many types to cover here).

- Specify calibration frequency, factors affecting calibration (e.g., temperature, salinity, oxygen), and acceptable calibration tolerances.

- If practical and your sonde is portable undertake spot sampling around the water body of interest and assess the samples over the geographical range for anomalies.

5. Data Recording:

Develop a standardized data recording format for each sensor's calibration results. Include fields for:

- Sensor serial number/identifier.

- Calibration date and time.

- Calibration solutions used (batch, standard type, solution open date ad solution expiry date).

- Pre-calibration and post-calibration readings (for sensor – issues).

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- Deviation from expected water quality parameter values (if any).

6. Quality Control Checks:

Incorporate periodic quality control checks to ensure sensors remain accurate between monthly calibrations:

- When practical conduct daily or weekly spot checks against known standards.
- If discrepancies are identified, take corrective action and document the process.
- Ideally, samples should be regularly taken for analysis by a laboratory accredited for saline water analysis. If this is too costly, samples should be taken periodically, at all times, taking care to take representative samples, avoiding contamination and ensuring they are delivered appropriately and on time.
- Compare your water quality data results with those provided by statutory bodies and, where practical, ascertain where their samples are collected.
- Examine meteorological data for things like wind and rain, as these can significantly affect water quality within a water body.
- Study the impacts of the tides on water quality within your area.

7. Sensor Maintenance:

Regular maintenance enhances sensor longevity and data accuracy:

- Provide guidelines for cleaning sensors to prevent fouling (such as a more frequent cleaning process during times of high biofouling or when there is a high sediment load in the water column).
- Check for physical damage, fouling, or corrosion during monthly maintenance.
- Check the power supply and that any O rings are not perished and adequately greased, if required, according to the manufacturer's instructions.

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8. Sensor Replacement and Repairs:

Outline the process for sensor replacement or repair in case of malfunction or damage (can your sonde operate in the absence of a sensor):

- Specify the procedure for identifying malfunctioning sensors.

- Detail the steps for requesting (supplier) replacements or repairs and recording the process.

9. Training:

Ensure all personnel involved are well-trained in calibration procedures, data recording, maintenance, and troubleshooting. Also,

10. Documentation and Reporting:

Maintain a centralized database or record-keeping system to store all calibration records and maintenance activities.

11. Data Analysis:

Periodically review calibration and sensor data to identify trends or issues that may require further investigation or adjustments.

12. Continuous Improvement:

Regularly review and update the program based on feedback and lessons learned. Consider technological advancements or changes in best practices.

Conclusion and benefits of a sensor (Sonde) management strategy:

- Ensures data accuracy and reliability, which is crucial for informed decision-making.

- Reduces data gaps and inconsistencies that can arise from irregular or improper calibration.

- Facilitates early detection and resolution of sensor malfunctions or anomalies.

- Enhances transparency and accountability in water quality monitoring efforts.

- Supports data-driven environmental management and policy decisions.

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Implementing a robust program for calibrating and managing water quality sensors every month is a proactive approach to maintaining accurate and reliable data for informed environmental stewardship and management.

Selected literature sources

Environmental Protection Agency (EPA), National Marine Monitoring Programme. https://www.epa.ie/our-services/monitoring--assessment/freshwater--marine/estuaries-and-coastal/

European Environment Agency - https://www.eea.europa.eu/help/glossary/eea-glossary/coastal-waters

World Health Organisation - https://www.who.int/publications/i/item/0419217304

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Report

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