



# An Exploration of the Stratification of Irish Coastal and Estuarine Waters

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## Introduction

The estuarine and coastal water bodies around Ireland are rich in biodiversity. The success of their ecosystems depend on a balance of physical properties, including temperature, salinity and dissolved oxygen.

Stratification, which is the occurrence of non-mixing layers with different physical properties, can occur naturally. Changes to this stratification can be detrimental to the ecosystems of the sea. These changes may be caused by anthropogenic factors including industry, agriculture and climate change.

The EPA continually monitor Irish coastlines as part of the EU Water Framework Directive and it is part of their data that is the focus of this data science research. A fuller understanding of the patterns of stratification around Ireland would assist in their commitment to maintaining the health of our coasts.

## Research Objectives

**This research will examine if there are any identifiable trends in the physical properties of Irish coastal and estuarine waters with particular focus on identifying areas of stratification.**

## Literature Findings

There exist many challenges in understanding the patterns of occurrence of stratification. Influences include:

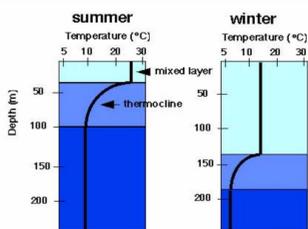


Fig. 1 Illustration of seasonal thermoclines<sup>1</sup>

- Seasonality
- Weather
- Anthropogenic impact
- Additional influences at estuarine water bodies of their environs of both tidal and river waters.

- Understanding stratification is integral to the understanding the ecosystems of the sea.
- Organisms at the bottom of the food chain, such as phytoplankton, are dependent on physical properties including oxygen concentration and temperature, which are essential for the flow of nutrients to support the food chain.
- The EU Water Framework Directive (WFD) commits member states to achieve and maintain "good ecological status" of the waters.<sup>2</sup>
- The EPA continually gather data, and research how best to utilise this data to meet WFD status.<sup>3</sup>
- There is research focus on developing metrics for the field data to effectively monitor and maintain the health of our waters.<sup>4,5</sup>
- The data science challenge is to find meaningful trends within the empirical data collected.

## The Data

- Over 250,000 observations have been made over the last 16 years at 850 locations by the EPA, as part of the Water Framework Directive.
- The data is taken from water column profiles at water bodies all around the Irish coast up to 4 times a year.
- At each sampling point parameters are measured from the surface of the water and at different depths to the seafloor.
- Measurements of interest include:
  - **Depth**
  - **Temperature**
  - **Salinity**
  - **Date/Time**
  - **Dissolved Oxygen**
  - **pH**

## Methodology

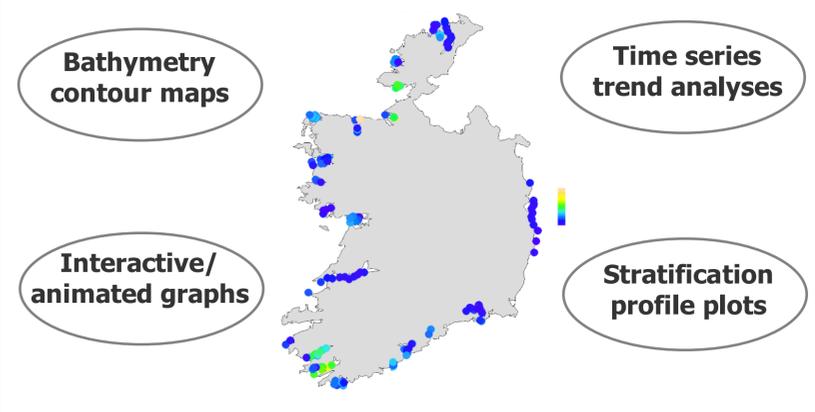
The objective is to identify and visualise trends in stratification both overall and in clusters of sampling locations (water bodies) using **RStudio**.

The data has been cleaned and manipulated using a range of packages including **dplyr** and **tidyverse**.

Data exploration through visualisation has been carried out using packages such as **ggplot**, **plotly** and **Shiny**.

It is proposed to use **flexdashboard** to develop an interactive tool to navigate the many variables. This would show a range of features, for example:

**A landing page identifying testing zones (lighter shows more stratification). From here particular areas can be examined by a range of criteria.**



Depending on the trends identified other data may be used in conjunction to find correlations and to seek to rationalise the research significance.

## Technologies



## Early Indications and Next Steps

### Early indications:

- Specific water bodies have been identified where stratification is more prevalent.
- Seasonal trends in stratification have been identified at these locations.
- Changes in trends over the time span of the data are harder to determine due to the intermittent nature of the time series data.

### Next steps include:

- Further time series trend analysis.
- Developing functions to classify and plot thermoclines and haloclines.
- Development of contour maps for specific water bodies.
- Determine research significance of findings through correlation with appropriate data.

## References

1. College of Exploration (2016). Thermocline Graph [online]. Available from: [http://www.coexploration.org/bermuda/html/thermocline\\_graph.html](http://www.coexploration.org/bermuda/html/thermocline_graph.html) [accessed 13 April 2020].
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4. O'Boyle, S. and Nolan, G. (2010). The influence of water column stratification on dissolved oxygen levels in coastal and shelf waters around Ireland. In: Biology and Environment: Proceedings of the Royal Irish Academy. JSTOR, pp.195–209.
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