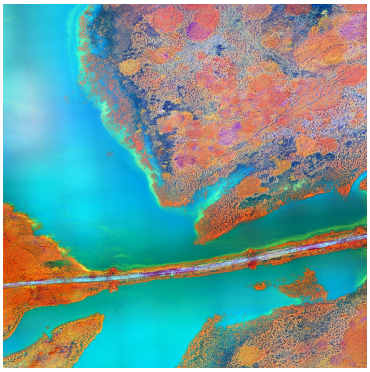
EuroMCM Sample Problem α : The Toxic Bloom



1 Background

Fjords are deep, narrow sea inlets shaped by glaciers, and they are not just spectacular landscapes. They also sit at the centre of a multi-billion-euro aquaculture industry. Scandinavia supplies a large share of the world's Atlantic salmon. Today, however, this industry is under serious threat from a microscopic problem: harmful algal blooms (HABs). These events happen when algae, tiny plant-like organisms in the sea, multiply rapidly and spiral out of control. Although each organism is microscopic, dense blooms can be devastating. Some release toxins, while others clog fish gills, causing suffocation. Entire stocks can be wiped out in a matter of hours. In 2019, a single bloom in northern Norway killed more than eight million farmed salmon, with direct industry costs around 2.2 billion NOK.

Algal blooms are driven by a combination of factors. They thrive on high nutrient levels, which can be intensified by agricultural runoff or waste from fish farms themselves. Long hours of sunlight and rising water temperatures, especially during the Nordic midnight sun, also play a major role. Fjords are particularly vulnerable because of their unique water dynamics. They are semi-enclosed, often layered by temperature and salinity, and have limited exchange with the open ocean, creating ideal conditions for algae to flourish.

2 Requirements

- Develop a mathematical model that describes the temporal evolution of the harmful algal bloom. Your model must capture the feedback loop between the aquaculture site and the algae:
  1. Does the nutrient load from farmed salmon act as the primary driver for the bloom's initiation, or does it merely prolong the duration of an environmentally driven event?
  2. How does increasing algal density drive fish mortality?
  3. How do water temperature changes and the extended Nordic summer photoperiod affect the model outcomes?
- Unlike the open ocean, a fjord is a physically constrained system. Extend your model to investigate how an algal bloom propagates spatially within a fjord, taking into account salinity stratification and the dominant circulation mechanisms, such as freshwater inflow at the head and tidal exchange at the mouth.

- Once a bloom is detected, farm operators have limited options, each with high costs and risks. Use your model to guide management choices, based on factors including bloom size, proximity to farms, and fish market value. Possible actions may include:
  1. Early harvesting;
  2. Physical or operational barriers to bloom exposure;
  3. Adjustments to feeding practices.

3 Share Your Insights

Write a one-page, accessible article for the Institute of Marine Research (IMR), aimed at a general audience, explaining your findings and how your model can help limit future damage.

4 Submission

Your PDF solution (≤25 pages) should include:

- One-page Summary Sheet
- Table of Contents
- Complete Solution
- One-page Article
- References
- Report on Use of AI Tools (if applicable; excluded from the 25-page limit)

There is no mandatory minimum length. Teams may submit incomplete solutions. The use of AI tools is allowed but optional; compliance with EuroMCM AI usage policy is required.

5 Links

Algal bloom causes significant salmon mortality in Norway

Aquaculture didn't cause the algal bloom

Millions of Salmon in Norway Killed by Algae Bloom

6 Glossary

Aquaculture: The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants.

Photoperiod: The period of time each day during which an organism receives illumination; day length.