High-Resolution Satellite Remote Sensing and Machine Learning for Harmful Algal Bloom Detection in Coastal Aquaculture

Harmful algal blooms (HABs) represent a persistent ecological and economic risk for aquaculture systems. The increasing availability of high-resolution Earth observation imagery (3–5 m) offers unprecedented opportunities for HAB monitoring, but also introduces significant technical challenges. High-frequency variability in coastal waters, adjacency effects, and sensor-specific noise complicate the extraction of biologically relevant signals.

This presentation outlines a machine learning–based framework developed at WaterMind for detecting and characterizing HABs in salmon aquaculture regions. The approach integrates:

- **Preprocessing of high-resolution imagery**, including atmospheric correction and water-specific masking strategies to minimize noise.

- A **specialized labeling mechanism** that fuses expert biological knowledge, in-situ observations, and remote sensing indices (e.g., NDCI, FAN composites, chlorophyll-sensitive band ratios).

- A **model training pipeline** designed to address limited ground-truth data, employing semi-automated labeling to enhance robustness.

- **Operational outputs,** including daily probability maps of high microalgal concentrations, classification of bloom types, and temporal change detection to support early detection and risk assessment.

Results demonstrate how machine learning applied to high-resolution satellite data can improve early detection of algal blooms, enabling aquaculture operators to anticipate bloom development and implement timely mitigation strategies. This integration of remote sensing and AI provides a scalable pathway toward proactive HAB risk management in coastal environments.