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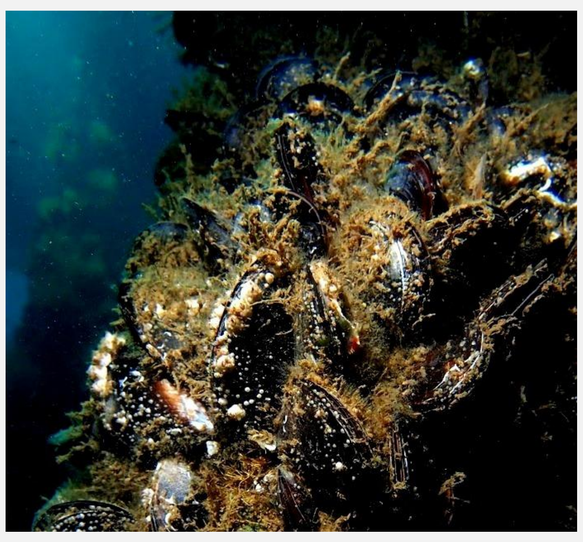

Real Time Monitoring and Alert System to forecast Harmful Algal Blooms (HAB) based on Cyberinfrastructure Technologies.

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Introduction

There has been a geographic expansion of episodes of HAB (Harmful Algal Bloom) in recent decades. This phenomenon is of particular concern in Spain which is the 1st aquaculture producer in the EU. The HAP phenomenon has a wide socio-economic impact at Galicia specially.

The financial losses caused in the Galician mussel sector by the last HAB phenomenon are estimated to be 40 M€ at the end of 2010 (Regulatory Council of the Origin Denomination of Galician Mussel). The Galician Association of Scrubbers Mollusks estimated that the sales decreased by 50% due to red tide events.

Goal

The goal is to provide an EARLY WARNING SYSTEM to monitor in real time and predict in the short term harmful algae blooms (HABs) in the areas of interest for the marine aquaculture sector.

This system can contribute to reduce the large financial losses that are affecting to the competitiveness of the aquaculture producer sector in recent years.

Challenges

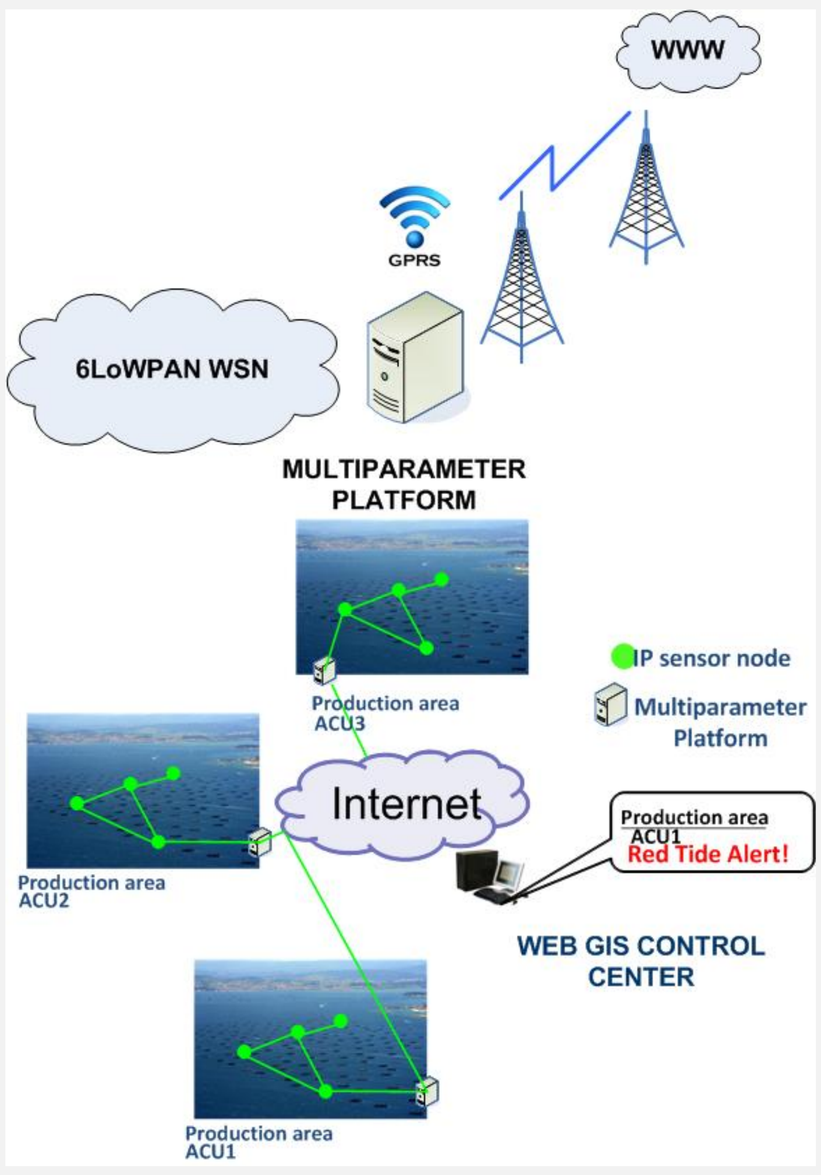
Taking into account the environmental variability in each production area, the forecasting difficulties are high and very dependent on local variables. The current analytical procedures applied in the HAB surveillance and management, mainly based on periodic sampling are not enough. Although these methods are in compliance with the current legislation and ensure the protection of the consumer, can not predict and anticipate the HABs. This may be causing false positives, with consequent economic losses.

The variables involved in the generation and surveillance of HABs are diverse: weather and season, physical variables of the water (temperature, pH, salinity, oxygen, etc.), optical properties of the water (turbidity, suspended matter and matter dissolved organic), nutrients and other phytoplankton species.

Materials and methods

We used a combination of the last generation technologies on remote sensing (multispectral sensors and satellite high resolution sensors), wireless sensor networks, GIS-Web and Artificial Intelligence:

- Multiparameter platforms to measure a wide range of environmental parameters and optical properties of the water. The sensors must allow the highest temporal and spectral resolution and further adding the vertical dimension in the water column.
- Information and Communications Architecture converged with the Future Internet and the next generation networks. The architecture provides IP connectivity at sensor node (IPv6 / 6LoWPAN).
- WOA (Web Oriented Architecture) approach in combination with Geographic Information Systems (GIS).
- The platform can also acquire information from various sources (others external sensors and external databases) to be processed in real time and remotely via Internet.
- Integration of data and parameters from other sources of environmental variables.
- Advanced Techniques of Artificial Intelligence (GAMS, neural networks and fuzzy logic) to enable working with a large number of variables and data from various sources in real-time.



Validation

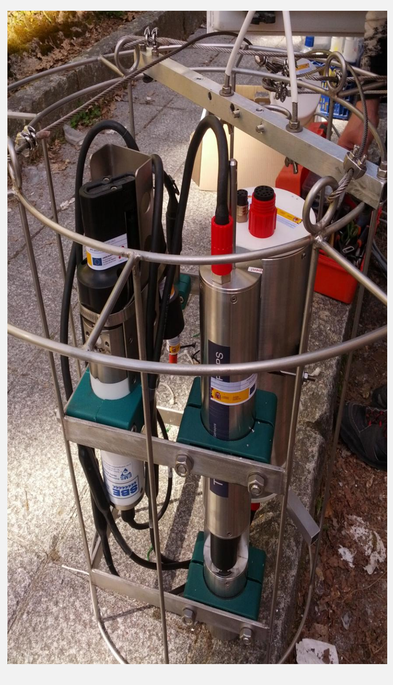
The Predictive System for HABs, based on remote devices with environmental sensors (buoys), models of atmospheric circulation and satellite data, has been implemented and validated in two scenarios with specific types of HAB generating algae:

- Galician Estuaries (Rías Baixas): dinoflagellate phytoplankton group. The analysis was focused especially on *Catenatum Gymnodinium* and *Gonyaulax (Alexandrium)* which causes most of the toxic episodes at Galicia.
- Catalan Estuaries (Ebro river estuaries): The micro algae of the kind of the dinoflagelate *Karlodinium veneficum* which has a wide geographic distribution. It produces harmful blooms in the bays of Ebro, and also on the east coast of the United States, South Africa and Australia.

Results

The results of this project provide a **surveillance, early warning and prediction system for HAB management which increases the resolution of the existing control network and analytical methods (laboratory)**, through the following key features:

- Early prediction of HAB events at least one week in advance (with an accuracy rate above 83%).
- Data on the algae biomass available at real time.
- Wide range of environmental parameters and properties of the water at quasi-real time.
- Scalability and modularity; ease of adding new variables and new sources of information and external databases. Direct applicability to other geographical areas.
- Ease installation, management and maintenance of the instrumentation and the end-user application.
- Remote and ubiquitous access at real time via Internet.
- GIS systems to geospatial information.
- These results are achieved by a design based on standards and converged with the internet of the future:
  - Wireless sensor networks with ipv6 connectivity at node level. The solution facilitates the interconnection with all types of networks to IP level and the development and implementation of the web services at each node. These features provide more simplicity to the network and services management, and a flexible, transparent and independent hardware.
  - A data acquisition system to facilitate the integration of new sensors. This data acquisition system is based on standard technologies for data communication in wireless sensors.
  - Algorithms and predictive models open to new environmental conditions.



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