SIMOC, a versatile tool for continuous monitoring of water quality

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Abstract. *SIMOC is a computational system developed by Taxon. It helps with decision-making on the design and management of discharges. This system is mainly based on continuous monitoring of physical-chemical parameters, through submerged networks of sensors which are distributed and are tailored specifically to the needs of each project. Data registered are stored in a database, updated every few minutes. This historical database is useful for the planning and the design of a more efficient infrastructure, including the control system to prevent unfavorable pollution situations on any natural community of ecological importance or bathing water quality. There is also the possibility of extending the control capacity on the discharge coupling the data from SIMOC to an operational hydrodynamic model that simulates the flow of pollution and its dispersion in the receiving environment. This system allow us to forecast the extent and duration of episodes of contamination, making it an effective predictive system alerts.*

Keywords: *Water quality, continuous, remote, monitoring*

I. INTRODUCTION

The recent development of seawater desalination, as a palliative to the water deficit of the driest Spanish regions, implies the need to control the brine effluent intensively in order to protect sensitive marine benthic communities (mainly protected communities, such as seagrass (*Posidonia oceanica*) of this industrial activity.

Since 2006, one of the lines of work in TAXON has been the development of several continuous monitoring systems (SIMOC). Our developments are adapted to the needs and environmental authorizations for each project, so that, although currently the sector in which it is applied mainly is desalination, recorded parameters, distribution of sensors and statistical treatment of the data can be adapted to every industrial activity and its effects on relevant communities in each area.

SIMOC is tool created in response to this need and has two main objectives that meet the requirements proposed by the EU Water Framework Directive (WFD). This directive on water policy established a new comprehensive framework for the protection of inland waters, transitional, coastal waters and groundwater, which tries to prevent further deterioration, protect and enhance the status of aquatic ecosystems. The objectives mentioned above are:

- Development of custom-made systems for planning and integrated management of discharges to the aquatic environment.
- Development of a system for continuous monitoring, forecasting and warning the pollution.

The "feedback" of environmental physic-chemical parameters in real time offered by SIMOC allows modulation of the characteristics of the effluent for good adjustment to the limits imposed by discharge authorizations. When industrial processes need of water intake, SIMOC allows to anticipate sudden environmental changes in the sea water, thereby lowering production costs.

The SIMOC is a tool used to support the planning of facilities. This is a system that stores and provides historical data. As it is an open system that can be customized, when data are recorded prior to the start of the activity, the analysis of them allows the characterization of the preoperational state of the study area; and the physic-chemical conditions of potential points of discharge and / or water intake. This characterization allows to point out the influence of these points on other discharges (spills, natural waterways) and / or local phenomena related both with hydrodynamism or with oceanography (exposure to strong currents, thermocline, …). This system is a planning and decision making tool that allow us to assess cost-benefit of various investment alternatives in hydraulic and marine infrastructure and choose those that obtain the best solution for both the environment and for the efficiency of the industrial process.

It is also possible to couple the Continuous Monitoring System to an Operational hydrodynamic model in order to display the short-term prediction of the spill evolution. So, the system would allow forecasting the evolution of the discharge. SIMOC can be programed to inform via the Internet, if a disturbing episode is detected or forecasted, to the managers, so that necessary measures can be taken to avoid and correct the effects of pollution.

II. TECHNICAL DESCRIPTION

A. SIMOC architecture

The SIMOC are based on a network of underwater sensors, with measure points located on benthic communities to be protected. The data recorded by the instruments are received in a data server. The connection between instruments and between the instruments and the server usually done via cable, but sometimes it resorts to other communication between different parts of the system, depending on the infraestructures and the needs of the project. The server automates the statistics and graphs reports, allow a remote query, and triggers an alert on any situation outside the limits set. All developments are based on different systems and tools of free software (GNU / Linux, Perl, PHP, mySQL, Apache, R, ...).

B. Installing Instruments

The installation tasks of a network of underwater sensors for a continuous monitoring system of water quality largely depends on the infrastructure of each particular activity or project, on the needs of the sensors, as well as on the characteristics of the seabed on which it will be installed.

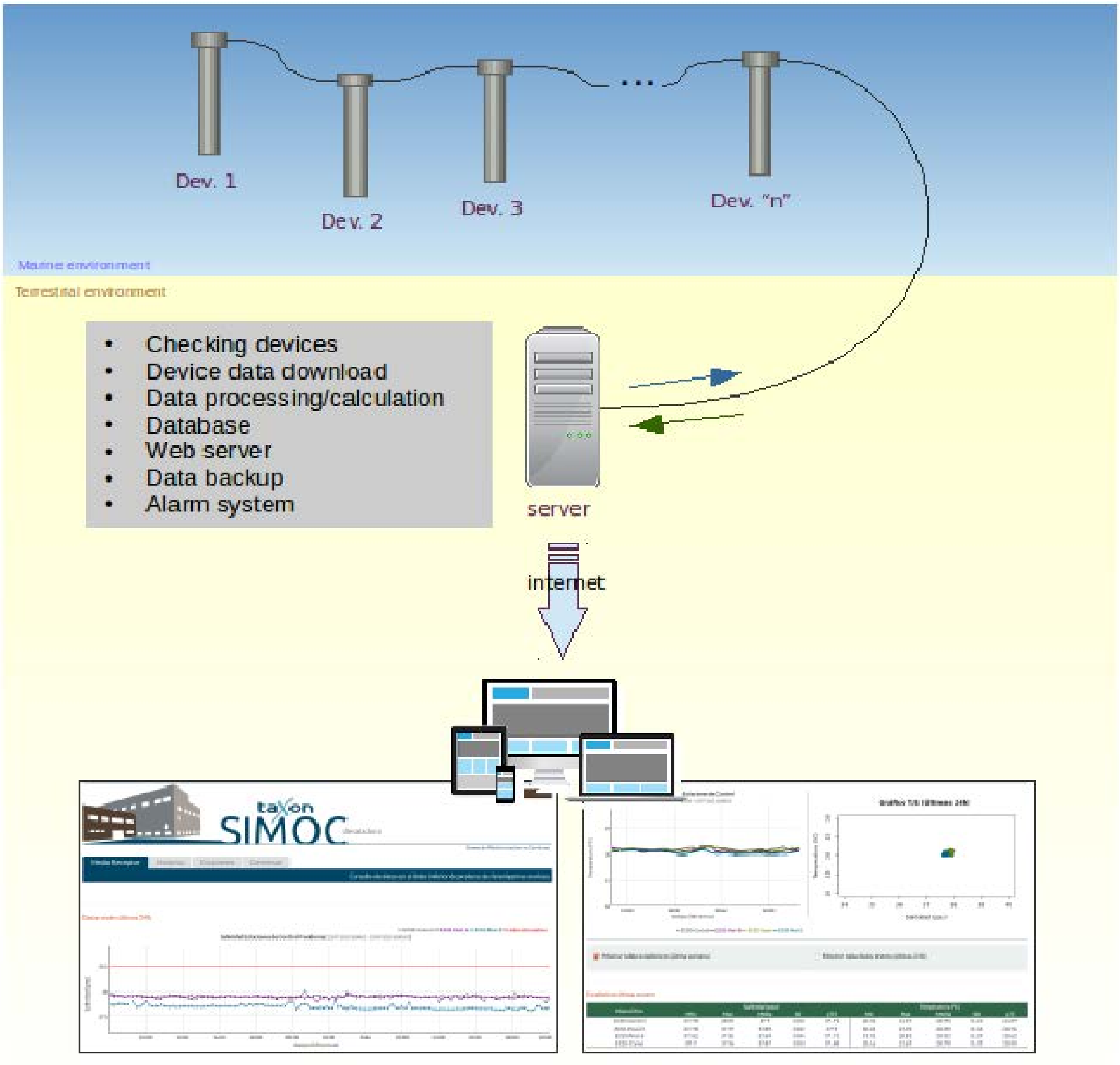

Fig. 1. Integral diagram of the Continuous Monitoring System (SIMOC): sensor network, data service, etc.

We used protections manufactured in high density polyethylene plastics to ensure safety of instruments. The sensors and its protections are fixed to a concrete ballast. Eventually these structures are buried in the seabed and locations of the instruments become fixed.

The alternative chosen for communication with land is an inductive wire connected to each of the instruments which may finish in land or in a communication buoy, depending on the characteristics of the infrastructure where the data server and modems for communication are located.

C. Data Integration and Service

The submarine network is connected in real time to a data server that allows the user develop various tasks (Fig. 1):

- Checking the status of devices: the server makes daily consultation to identify malfunctions, check the batteries life level and the presence of "outliers" in the records.
- Consultation oceanographic data from devices: The server queries the data collected by the network of underwater sensors and updates the data base every 10 or 30 minutes. The frequency of this task is programmable and will depend on the needs of each work.
- Compute of dependent variables: the server makes calculations of derived variables (density of water, salinity absolute and practical ...) from the data using various algorithms.
- Inserting data into the database: All data obtained from sensors or calculated from them are included in a database "endless". The data base architecture allows quick

access to current and historical data.

- Backup: much of the robustness of the system is due to a triple backup. Each instrument keeps its own records, also the server in land maintains a backup in an external drive and finally a remote backup is stored in the server of our offices.
- Web Application Server for on-line data representation: the web server provides secure connection restricted by user name and password to a web environment, designed and programmed *ad hoc*, adaptable to the screen of the device you connect. Shows oceanographic parameters measured by the instruments connected in the past 24 hours. With these registers the basic and descriptive statistics (average, maximum and minimum values, percentiles, standard deviation) and derived variables (absolute and practical salinity) are automatically calculated. This information is presented in tables and graphs. In order to favor the query the user has some capacity to interact with the system. The user can check real time data and historical records framed to a sampling period, likewise can select the variables which is interested on.
- Warning System: the web environment is programmed to highlight those data that exceed certain values either administrative limits or performance requirements. There is also the possibility that the system send an alert message to the costumer by email and / or SMS.

D. System Maintenance

The main feature of the instruments chosen to join networks are measuring accuracy, durability and low maintenance. So the invest on equipment is quickly amortized by the savings in maintenance, calibrations and repairs. This system eliminates the need for weekly dives for data download and maintenance. The frequency of maintenance visits is subject to environmental conditions in every measuring point and the parameter to be measured. As an average, with this system, the maintenance visits required for the equipment used (for example salinometers) is reduced to:

- checking, cleaning and preventive calibration site every four months;

overhaul with change of expendable materials annually;

III. CONCLUSIONS

The SIMOC systems of TAXON have been tested with excellent results in various desalination plants, with different sizes and various environmental situations.

This is a potentially open system; can be enlarged or reduced to fit project needs, both in number of sensors, and its distance from the spill. For example, they can add to the system as many sensors as required. In addition the sensors can measure different parameters (current meters, nutrient sensors, turbidity, and water quality).

The SIMOC systems were initially developed for the environmental management of effluent to the marine environment. However, its ease of adaptation left open a wide range of possible applications to other activities taking place in the aquatic environment, such as in control the speed of currents in diving areas; preoperational study situations and the operational prediction models. In addition, a suitable design of these systems in relation to the measured parameters and the sensor arrangement can improve the process, for instance in desalination, decreasing the production costs.