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DEMONSTRATION REPORT OF INTCATCH AUTONOMOUS BOATS IN THE DANUBE DELTA

ATHENS, SEPTEMBER 2021

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1. INTRODUCTION

The Research and Development Department of EYDAP (R&D), participated in the 5th International Conference "Water Resources and Wetlands" that held from 8 to 12 September 2021 in Tulcea, Romania. EYDAP represented by the Head of R&D, Dr. Stelios Samios and the researcher Dr. George Katsouras (Chemist). During the Conference, the autonomous boats introduced to more than 50 participants (in person) and to even more virtually with an oral presentation entitled "Integrated Ecosystem Ecology (Chlorophyll-a) of EYDAP's Reservoirs Profiles by Using Robotic Boats" emphasizing on the innovative monitoring of EYDAP's four Reservoirs in 2020 (Katsouras et al., 2021). Additionally, during the field trip on the Danube Delta, a deployment on demand of INTCATCH autonomous boat took place and the data were evaluated through appropriate applications in real time (tablet, mobile). The innovative quality monitoring strategy proved that could increase available water quality data without requiring labor-intensive and costly monitoring schemes.

Figure 1: Opening Ceremony by Prof. P. Gestescu (up right), demonstration of INTCATCH boat (up left) and presentation of EYDAP R&D research in Greek Reservoirs (down), in 5th WRW, Tulcea, Romania 09/09/2021

The President of the Romanian Limnogeographical Association ***Prof. Petre Gastescu*** as well as the General Secretary of the Organizing Committee of the Conference ***Prof. Petre Bretcan*** showed special interest in this innovative technology of intelligent monitoring of rivers and lakes. Following the demonstration an open discussion took place and all the participants expressed their interest to test INTCATCH service in their catchments. Among them, ***Dr. Piotr Klimaszyk*** President of the Polish Limnological Society, ***Dr. Martin Kainz*** President of the Austrian Society of Limnology and Vice President of the International Society of Limnology, ***Prof. Thomas Schneider*** from the Technische Universität München, Chairman of Forest Management, ***Dr. Ionut Minea*** from University of Iasi (Romania), Director of Research ***Dr. Jens C Nejstgaard*** and researcher ***Dr. Andreas Jechow*** of the Leibniz Institute of Freshwater Ecology and Inland Fisheries (Berlin), researcher ***Dr. Gabriela Morosanu*** from the University of Bucharest, Faculty of Geography/Meteorology - Hydrology Department in Romania and ***Prof. Nesho Chipev*** with ***Prof. Albena Alexandrova*** of the Institute of Neurobiology Bulgarian Academy of Sciences, from Sofia, Bulgaria.

Figure 2: Demonstration of INTCATCH service by EYDAP R&D in Danube Delta, Romania, 11/09/2021

2. THE INTCATCH SYSTEM ARCHITECTURE AND TECHNOLOGICAL FLOW

The INTCATCH system architecture consists of the boat, the electronic parts (Bluebox, circuit boards, raspberry) and the sensors (Fig. 3).

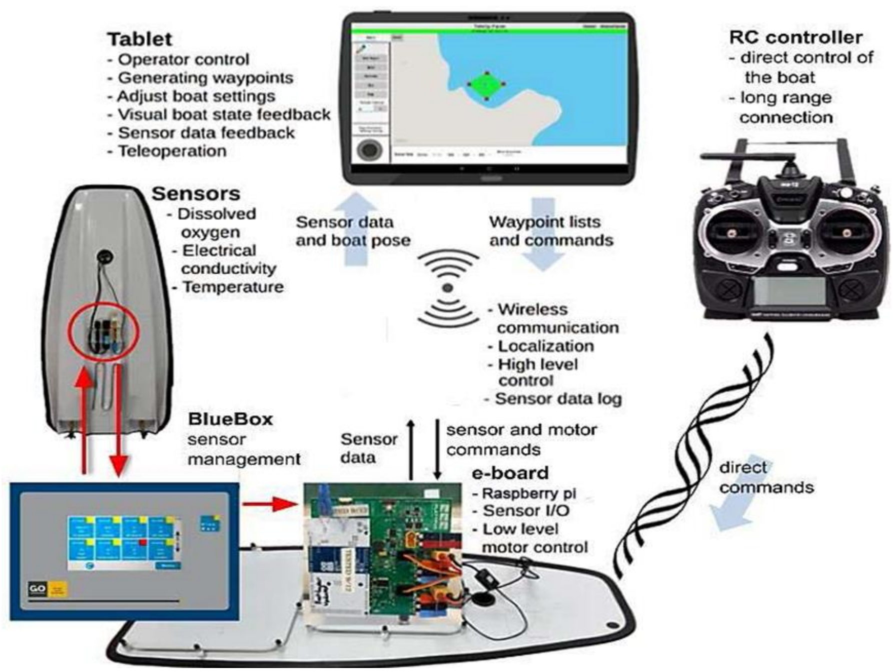

Figure 3. Architecture of the boat control system showing options for manual RC control and autonomous operation through the Control App running on the tablet

The boat has low profile to minimize wind resistance. It can be deployed in as little as 25 cm of water and has two in-water propellers with differential drive system for its navigation (Bloisi, 2018; Calisi, 2018). The main board of the circuit is GO-Systemelektronic's Bluebox which manages the sensors and the supporting boards (Knutz, 2020), stores locally in a flash memory the data coming from the sensors and sent them via serial connection to the Raspberry. They are also sent via the built-in modem UMTS (3G) to the BlueGate storage database and thus into the INTCATCH Water Information System (WAIS), where it can be used by the visualization applications (WAQUIN). The user, via a tablet, can interact with the boat using a GUI (graphical user interface) android application, to show the sensor values in real time and to receive commands from the operator (Steccanella et al., 2019; Tsalas et al., 2020), while at the same time controls all the autonomous behaviours of the platform and displays the state of the boat (e.g. position on the map).

The sensors are located beneath the boat (Fig. 3) with the basic set consist of Dissolved Oxygen (DO) and Temperature (T), pH and Electrical Conductivity (EC), while in addition it has two specialized sensors, adapted to the needs of the Service. The first is the Chlorophyll α (Chl - a) sensor, model cyclops 7, whose principle of operation is through an optical system that emits light at a specific wavelength and determines the chlorophyll from the fluorescent radiation of longer wavelengths. It is also equipped with the Intelligent Spectral Analyzer (ISA) sensor (Knutz, 2020), a spectrophotometer that, with proper calibration (Allabashi, 2019), can determine parameters of interest for reservoir water such as total nitrogen (TN), orthophosphate (o-PO4) and nitrate (NO3) and depending on the aquatic system under consideration, biochemically required oxygen (BOD), chemically required oxygen (COD), ammonia, soluble organic carbon (DOC), total organic carbon (TOC), total suspended solids (TSS) and turbidity, Color/Hazen, UV254.

3. RESULTS AND DISCUSSION

INTCATCH Innovative Monitoring Services (***http://intcatch.eu/***) since 2017 presented in six countries all over Europe, and the application of the robotic boats with their integrated sensors allowed monitoring and sampling of water quality in more than 50 lakes and rivers (Figure 5). More recently, during the 5th WRW Conference, a demonstration of EYDAP's boat took place in the Danube Delta, and the few results, presented spatially on the map of the demo site. More specifically, the site was near Danube – Sulina Branch, along the Dunarea veche (between Lacul Obreitinu Mare and Lacul Cazanel) and the data evaluated in real-time on board from the participants.

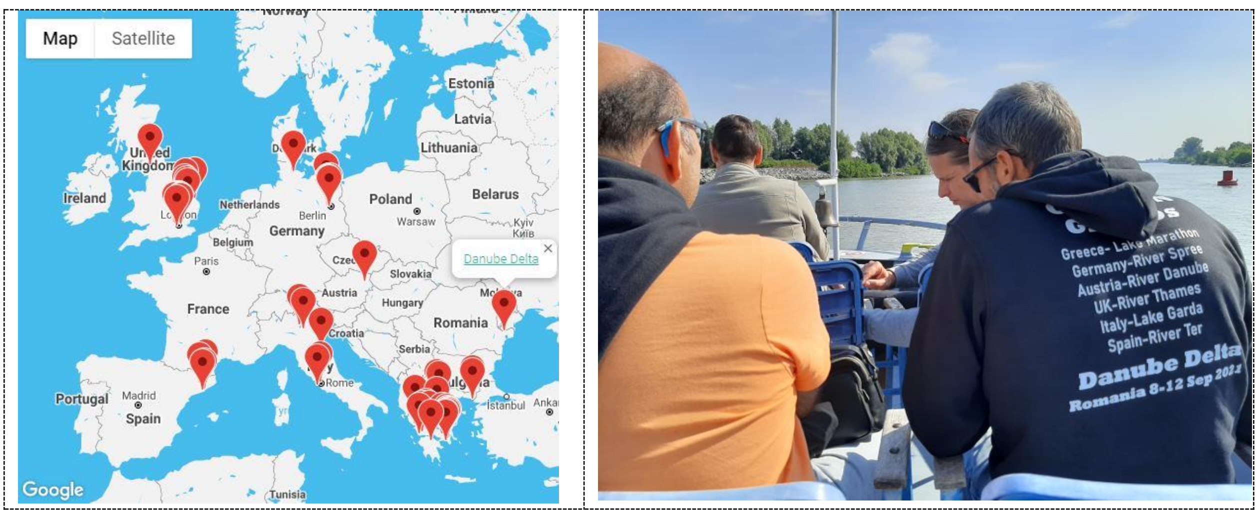

Figure 4. INTCATCH boats all over Europe

The concentration of **Chl-a** in demo site of Danube Delta (Fig. 5), ranged **from 5.0 to 10 μg/l**, with most of the values fluctuating from 5 and 7.9 μg/l, indicating a mesotrophic to eutrophic state.

Conductivity values characterize the quality of a water body and a sharp increase could be a sign of pollution. In Danube Delta ranged from **400 to 499 μS/cm** (Fig. 5).

Dissolved oxygen concentration ranged from **10.0 to 12.0 mg/**l (Fig. 6) indicating well oxygenated water.

Figure 5: Spatial distribution of chl-a and Conductivity in Danube Delta, 11/09/2021

Figure 6: Spatial distribution of Dissolved Oxygen in Danube Delta, 11/09/2021

The pH was determined at values **between 8.5 to 9.2**, with most of them varied very close to 9.0 while **temperature** in this part of Danube Delta ranged **from 22.0 °C to 22.9 °C** (Fig. 7).

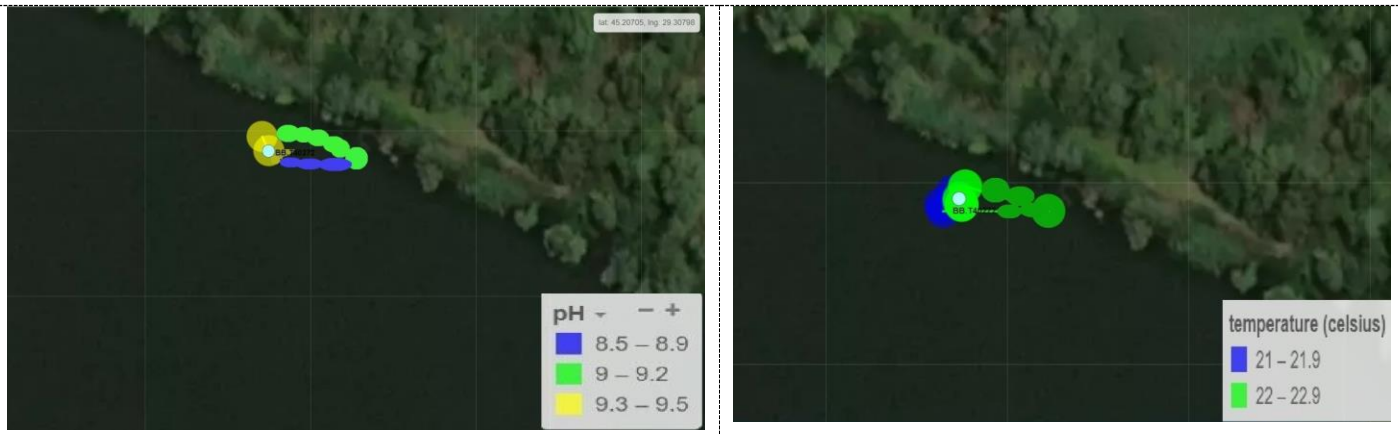

Figure 7: Spatial distribution of pH and Temperature in Danube Delta, 11/09/2021

4. CONCLUSIONS

INTCATCH Service with the technologically innovative autonomous boats for real-time monitoring of rivers and lakes, aspires to fill a gap that exists today in the Monitoring Programs of a water body and which so far are based on two monitoring ways according to the EU Water Framework Directive 2000/60:

1.The main is the systematic but time-consuming process of sampling-analysis-recording and evaluation of the results of the water quality control.

2.The second developed in recent years and is based on fixed quality control stations that are installed at limited points (e.g. near the shore of a lake or in the course of a river) and provide recorded measurements at these points.

The INTCATCH Service is not an alternative or a substitute for the above methods but was developed by the EU to offer effective solutions to the immediate detection of pollution sources through the geographical visualization of the results on the computer screen of each Stakeholder.

Figure 8: Participants testing autonomous boat in Danube Delta during the 5th WRW Conference

The demonstration of an autonomous boat in the Danube Delta during the 5th International Conference "Water Resources and Wetlands" in Tulcea, has shown that it can contribute to the most complete and best quality control of a water body, detecting in time, if necessary, possible pollution from anthropogenic activities or natural processes.

Additionally, the systematic, full scale application of autonomous boats ***could support the investigative monitoring programs of the WFD in the future*** and represent a valid rapid tool/approach ***in case of emergencies thus assisting in more effective crisis management*** (e.g. in relation to climate changes events such as floodings). The Vision is that EYDAP will provide INTCATCH service to authorities and organizations interested in assessing water quality in relation to catchment management and the traditional spot sampling protocols.

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Figure 9: Participants of 5th International Conference of Water Resources and Wetlands with INTCATCH boat, Tulcea, Romania, 8-12/09/2021

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