

AUV-2011-Underwater Robotics Experiment in the Mar Menor Coastal Lagoon

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Abstract— As a result of the meeting held at SARTI in November 2010 (<http://sites2.upc.edu/~www-sarti/web/cat/meeting/meeting.php>) we are planning to conduct an AUVs experiment in order to determine the influence domain of the saltier plume of water going out the Mar Menor lagoon towards the Mediterranean Sea through The Estacio channel. This goal, besides the relevance to understand the influence of the lagoon on the Mediterranean Sea, offers the challenge of coordinating, for first time, a fleet of AUVs from different research institutions of Spain and Portugal. Experiments like this will follow in the future. These engineering and process oriented challenges are aligned along two primary and two secondary goals: 1) Primary goals: a) Deployment of a heterogeneous mix of mobile assets to densely sample a confined meso-scale area (< 50 Sq. km). While no lower bound on this number is envisioned, we expect at least 3 vehicles in the water simultaneously; b) Obtaining, interpreting and validating science data obtained by in-situ assets including AUVs; 2) Secondary goals: a) Detection of prominent scientific features of interest in-situ by AUVs and b) Detection of such features using ship/shore based human-in-the-loop. A visible side-effect of these primary goals would also ensure that the participating institutions are able to cohesively work together to plan, launch and deploy assets and in the process understand the scientific drivers of the proposed field experiment. The AUVs planned to be involved in the experiment are: GUANAY II (SARTI, UPC), Sparus (U. of Girona), ÆGIR (UPCT), SEACON and NAUV (LSTS, U. of Porto). An Slocum Glider (SOCIB) will also be involved.

Keywords – AUV, underwater robotics

I. INTRODUCTION

The Mar Menor is a large coastal lagoon in the Iberian Peninsula and one of the largest in Europe. It is an emblematic wetland on the RAMSAR sites list for conservation providing a large quantity of goods and services to the society. Many interests from tourism to fisheries to intense agriculture in the watershed to conservation, overlap the area. The economic value of fisheries, for instance, is substantially higher in the lagoon than outside.

A major program to monitor the lagoon is being funded by the Regional Government of Murcia as a strategic project in the Science and Technology Regional Plan. The “Campus Mare Nostrum”, a joint venture of the Technical University of Cartagena and the University of Murcia, has been awarded as Campus of Excellence in the Spanish university System. This campus has the marine science and technology as one of the major challenge themes. Although the lagoon is important in itself, the SE coast of Spain is an area of large coastal oceanographic interest as shown in Fig. 1

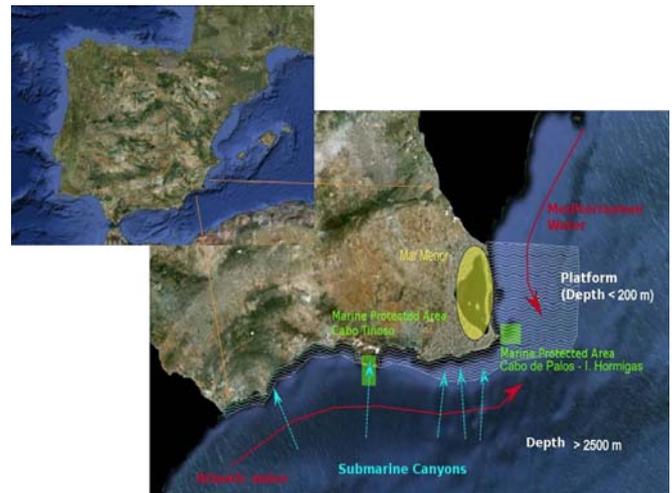


Fig. 1. Location of the Mar Menor lagoon and oceanographic singularities of the area.

The Mar Menor lagoon is located in a semiarid region of Spain with evaporation exceeding precipitation and runoff thus providing its hyper saline character (45-47 PSU) and a range of temperature spanning from 10°C to 32°C seasonally. It has 135 Km² with 22 Km long (maximum distance) and 12 Km maximum wide with a maximum depth of 6 m and average of 3.5 m. With a volume of about 580 Hm³, its water renewal time is of 423 days (1.16 years approximately). The lagoon is separated from the Mediterranean Sea by a sand bar called La Manga. The exchange of water between the Lagoon and the adjacent Mediterranean Sea is carried out by three

inlets (Fig. 2): Las Encañizadas to the North, The Estacio channel in the middle - throughout the main exchange of water occur - and Marchamalo inlet to the South.



Fig. 2. Inlets of the Mar Menor lagoon. North: The Encañizadas; Middle: The Estacio channel; South: Marchamalo inlet.

Major forcing factors of water exchange are a horizontal pressure gradient due to difference in the sea levels (in and out of the lagoon) that are forced by tides (Fig. 3) - although very low -, atmospheric pressure (Fig. 4) and Ekman type transport of water piling up or retrieving water from outside La Manga. Winds action mixes the entered Mediterranean Sea water into the lagoon (Fig. 5).

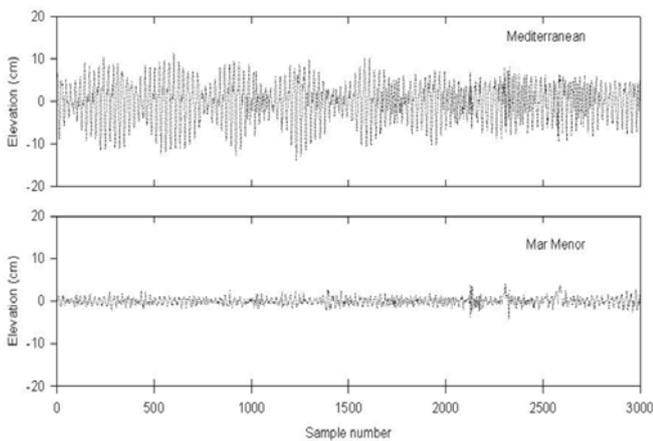


Fig. 3. Tides elevation in the Mediterranean Sea (Outside La Manga) and in the Mar Menor (inside La Manga), both in the vicinity of the main communication channel, The Estacio.

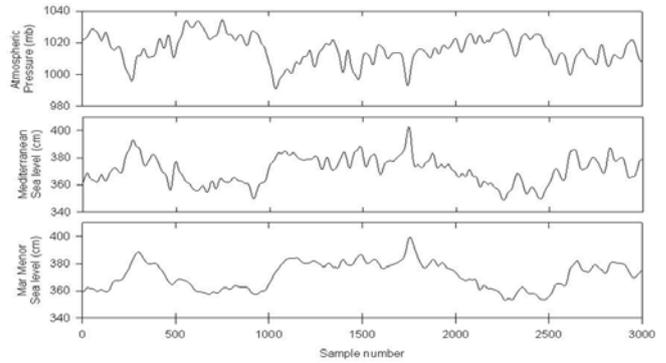


Fig. 4. Inverse barometric effect on the Mediterranean Sea and Mar Menor sea level.

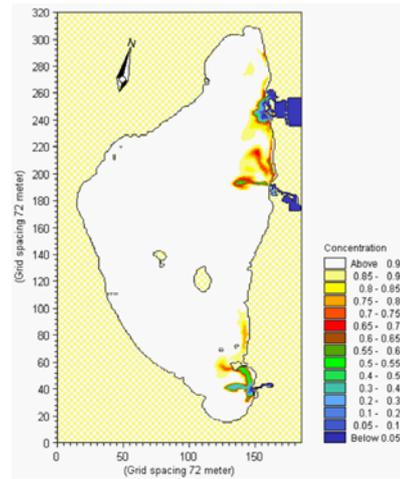


Fig. 5. Advection-diffusion numerical simulation of water exchange between the Mediterranean Sea and the Mar Menor lagoon. Dark blue color means 100% Mediterranean Sea water, white color means 100% Mar Menor sea water.

To understand the capacity of the lagoon as a biological buffer, it is critical to understand the exchange of water between the Mediterranean Sea and the lagoon. Many species are not allowed to enter into the lagoon because of the strong environmental gradient, mainly imposed by salinity; but others, already adapted to the much more stressed lagoon environment, do leave the lagoon thus providing more resistant populations to changing environmental factors in the Mediterranean (e.g. by global warming trends). The lagoon is, from this point of view, seen as a natural laboratory to understand future changes in larger water masses. The stressed environment is also genetically selecting the species thus providing a reserve of biodiversity. Lagoon water going out to the Mediterranean Sea is, by itself, an important vector of exportation of selected species to the Mediterranean Sea. To determine the three dimensional area of influence of the lagoon water in the Mediterranean Sea it is important to understand the propagation of the saline tongue leaving The Estacio Channel towards the Mediterranean Sea. Fig. 6 shows

the results of a 2D advection -diffusion numerical model when more saline water is going out of the lagoon.

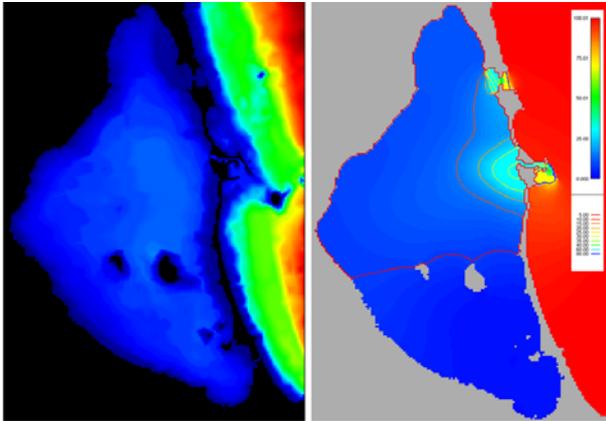


Fig. 6. Left: Bathymetry of the lagoon and the adjacent Mediterranean Sea. Maximum depth in the lagoon is 6 m, maximum depth shown in the Mediterranean Sea (red color) is 35 m. Right: 2D Advection-diffusion model output showing saltier water (about 75% lagoon water with 25% Mediterranean Sea water mixed, cyan color). Area of Influence of the saltier tongue of water is marked by yellow-orange color in the figure.

Validation of a 3D model of the saltier water tongue requires *in situ* simultaneous measurements in the area of influence in the three dimensions with the best available technology. AUVs are by now the most advanced technology available to this kind of measurements and can account for both spatial and temporal variations of water mass given their mobility. They are also cost-effective and adaptable to the changing environment in ways that traditional ship-based observations cannot.

II. SCIENTIFIC GOALS

The main scientific goal of the experiment is to determine the influence domain of the saltier tongue of water going out the lagoon through The Estacio channel towards the Mediterranean Sea.

This goal, besides the relevance to understand the influence of the lagoon on the Mediterranean Sea, offers the challenge of coordinating, for first time, a fleet of AUVs from different research institutions in Spain and Portugal. These engineering and process oriented challenges are aligned along two primary and two secondary goals:

A. Primary Goals

1. Deployment of a heterogeneous mix of mobile assets to densely sample a confined meso-scale area (< 50 Sq. km). While no lower bound on this number is envisioned, we expect at least 3 vehicles in the water

simultaneously.

2. Obtaining, interpreting and validating science data obtained by in-situ assets including AUVs, ASV's, moorings or drifters, post-facto. Using this analysis to iteratively refine the sampling process using the above noted assets in the water.

B. Secondary Goals

3. Detection of prominent scientific features of interest in-situ by AUVs
4. Detection of such features using ship/shore based human-in-the-loop.

Our initial target would be to satisfy the primary goals, which will recursively require the need and deployment of a ship/shore-side data system and to synthesize the data products for scientific analysis. A visible side-effect of these primary goals would also ensure that the participating institutions are able to cohesively work together to plan, launch and deploy assets and in the process understand the scientific drivers of the proposed field experiment.

Should the primary goals be satisfied early, we will attempt to go after the secondary engineering goals of enabling these assets to be more adaptive by virtue of sensing, detection and in-situ identification of scientific features of interest driven by local conditions at Mar Menor. Adaptation via control software or using aided human decision making tightly coupled with a vehicle future control actions would demonstrate an important science capability needed in the current generation of AUVs and ASVs.

A key outcome of this field experiment is to build a team (and consensus) towards working long-term in the Mediterranean as a viable research team to tackle interdisciplinary science and engineering problems. These goals are very aligned with institutions such as OBSEA, MBARI, SOCIB and future OOCMUR. Joint publications in peer-reviewed journals and conference events will be critical to making impact and establishing such a working relationship in the long run.

III. EQUIPMENTS

The AUVs to be involved in the experiments are shown in figure 7: 1) GUANAY II - SARTI Autonomous underwater vehicle - Technological Centre of Remote Acquisition and Data processing Systems, Technical University of Catalonia (UPC), Vilanova. 2) Sparus – VICOROB: computer vision and robotics group – Department of Electronics, informatics and automatics, University of Girona. 3) ÆGIR – Underwater Vehicles Lab – Technical University of Cartagena. 4)

SEACON and NAUV - Underwater Systems and Technologies Laboratory (LSTS), University of Porto. 5) Slocum Glider – SOCIB.



Fig. 7: AUVs to be involved in the experiment

OBSEA & SOCIB will obtain data from all mobile and immobile (e.g any available moorings) assets as well as remote sensing data freely available for the Mar Menor region and to synthesize data products available to science for analysis.

Temperature and salinity are two critical properties of seawater to be measured during the experiment. The lagoon temperature and salinity are different from that of the Mediterranean Sea. Although salinity is the main parameter to measure, it is also expected to find the saltier tongue of water going out the lagoon by measuring its temperature. Thus, all AUVs should be equipped with, at least, an external temperature sensor. AUVs equipped with ADCP, if available, would provide a detailed view of the currents and speed of the plume.

IV. STUDY AREA

It is expected that the saltier plume leaving the Estacio channel will likely move downward to the bottom, because of its higher density. Salinity maximum should depend of the flux of water going out the lagoon and distance from the mouth of the channel. Dominant winds in the area (>45% annual) are NE and Easterly. With these winds the plume should move to the South. However with SW winds (usually present in summer) the plume should move towards the North. Fig. 8 shows the area of interest for the experiment south to the Estacio channel together with a proposed set of AUV tracks to detect and measure the plume and its area of influence.

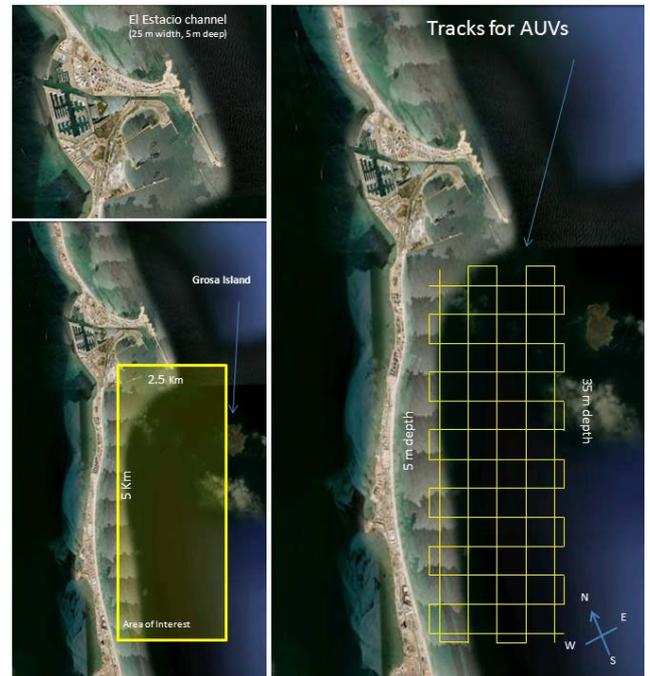


Fig. 8. The Estacio channel (top left). Area of interest for the experiment (down left). Proposed track for AUVs matching the expected area of the saltier water plume.

V. DEPLOYMENT STRATEGY

An early morning deployment would include a run of a TBD portion of the area of interest as shown in Fig. 8. Data returned from this run would be analysed approximately by 10am, by the entire team and a strategy for the deployments the remainder of the day would be articulated. Vehicles would then be deployed by the available support vessels and picked up by 4pm. Data is then uploaded to the data handling system and data products are analysed. Overnight missions where possible to record the impact of the diel-cycle on phytoplankton could be a potential extended experiment as long as safety considerations allow.