

# IN-SITU CALIBRATIONS OF OCEANOGRAPHIC SENSORS IN THE FRAMEWORK OF THE “POSEIDON” PROJECT

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## ABSTRACT

Στην παρούσα εργασία περιγράφεται η πρώτη προσπάθεια του Ε.Κ.Θ.Ε. για ποιοτική αξιολόγηση και -εάν κρίνεται σκόπιμο- βελτίωση της ποιότητας των μετρήσεων αγωγιμότητας, διαλυμένου οξυγόνου και φθορισμού χλωροφύλλης-α που συλλέγονται από τους αντίστοιχους αισθητήρες των πλωτών ωκεανογραφικών μετρητικών σταθμών (ΠΩΜΣ) του προγράμματος «ΠΟΣΕΙΔΩΝ». Στη στρατηγική που υιοθετήθηκε, οι ιδιαιτερότητες της κάθε μετρούμενης παραμέτρου υπαγόρευσαν και την τακτική συλλογής στοιχείων ώστε να είναι δυνατή η μεγιστοποίηση της κάλυψης του εύρους τιμών της κάθε παραμέτρου, με την ταυτόχρονη ελαχιστοποίηση της παρενόχλησης στις εργασίες ανέλκυσης, συντήρησης και πόντισης των ΠΩΜΣ. Η διαδικασία βαθμονόμησης που προέκυψε σταδιακά εντάχθηκε στις παραπάνω εργασίες. Η εξαχθείσα εμπειρία θα χρησιμοποιηθεί στην ανάπτυξη εργαστηρίου βαθμονόμησης οργάνων, που θα προσφέρει υπηρεσίες είτε στο πεδίο είτε στις εγκαταστάσεις του Ε.Κ.Θ.Ε.

## INTRODUCTION

The “POSEIDON” project is the N.C.M.R.’s approach to operational oceanography, consisting of real-time monitoring of atmospheric and marine conditions, and prediction modeling. The monitoring is based on a network of 11 OCEANOR Seawatch( buoys, equipped with meteorological, oceanographic and sea-state sensors. The operational use of an extended buoy network requires regular maintenance of the moorings and a continuous assessment of the quality of the obtained data. The latter can only be achieved by the development and regular operation of a comprehensive calibration procedure. This work presents the N.C.M.R.’s first attempt to gain experience on in-situ, shipborne sensor calibrations and develop the necessary methodologies to establish a calibration facility for both ashore and in-situ applications. The sensor calibration at this stage was limited to the conductivity sensors deployed at 10, 20, 30 and 40 m depth (and the one included at the current meter at 3 m depth), as well as the dissolved oxygen and chlorophyll- $\alpha$  fluorescence sensors deployed at 3 m depth.

## METHODOLOGY

The selected strategy should not only meet the quality requirements for each parameter, but should also be compatible with the presently available resources, like ship-time and equipment. Thus, the calibration process should become an integral part of the buoy retrieval, maintenance and deployment procedures. We chose the simultaneous calibration of all three sensors by setting the buoy in a “test mode” enabling the sampling of all parameters within 15-minute cycles. A minimum requirement of six to eight measurements, necessary to estimate correlation curves, enabled us to limit the sample collection time to 1.5 - 2 hours per buoy.

As the conductivity, dissolved oxygen and concentration of chlorophyll- $\alpha$  exhibit very different distributions spatially, it was not possible to follow the same sampling and calibration scheme for all parameters. Below, we describe the sampling policy selected for each parameter, with the aim to achieve the highest possible range of values within the field conditions.

### Conductivity

For conductivity, the most widely accepted procedure was selected: A control bath. The conductivity sensors from the buoy were immersed in the tank, and their measurements were compared with reference data from an SBE-19 and bottle samples. As high salinity characterizes the surface waters in the Central and South Aegean, pure surface water gave the highest possible value of conductivity. Dilution with fresh water from the ship was used to achieve lower values. In general, salinity in the bath ranged from 28 to 39 psu within a calibration cycle, and the respective conductivity (for temperature 11-17 ° C) varied from 3.6 to 5.1 mS m<sup>-1</sup>.

There was not enough time before the cruise to prepare a regular, heat-insulated bath suitable for temperature and salinity calibrations. Thus, we used whatever was readily available: a regular plastic tank of 250 lt for water or oil storage and a 1 m<sup>3</sup> tank used in the past for another experiment aboard the ship. Furthermore, due to the time shortage we used an immersion pump for stirring the water within the tank during the first experiments.

The use of a non-insulated tank and an immersion pump for stirring, caused major problems at the initial calibration experiments. There was considerable heat flux through the walls of the tank, and the immersion pump constituted a heat source within the fluid. This caused relatively high rates of temperature and thus, conductivity change, which posed the need for improving the sampling procedure (figure 1a,b,c). The immersion pump was replaced by an external, vacuum pump, which significantly lowered the heat added to the water and decreased the temperature changes. Furthermore, we adopted a different calibration strategy that was not based on the assumption that conductivity remained stable throughout the sampling. The above modifications significantly improved the behavior of the error  $\Delta C$  ( $C_{lab} - C_{instr}$ ), and made it possible to draw correlation curves and estimate calibration / correction coefficients (Figure 1d,e).

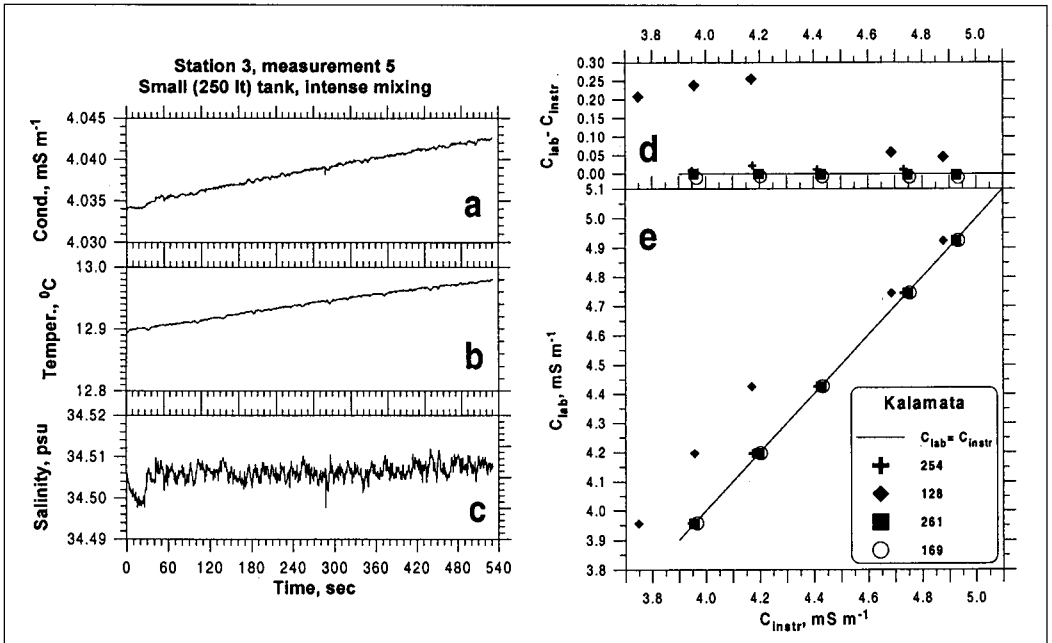


Figure 1. The side-effects of using the immersion pump in the small tank of 250 lt are displayed as time-series of conductivity (a), temperature (b) and salinity (c) in the left panel. In the right panel, the behavior of the error  $\Delta C$  before conductivity correction (d) and the correlation between reference values ( $C_{\text{lab}}$ ) and buoy values ( $C_{\text{instr}}$ ) (e) are shown. The symbols represent different sensors.

## Dissolved Oxygen

For the dissolved oxygen (D.O.) neither the surface water, nor the water collected from different depths at each buoy location could provide a high enough range of values in order to proceed to good estimates of the calibration curves. However, the deep water of Epidaurus basin provided us with large stock quantities of water with extremely low D.O. values ( $\sim 1.5 \text{ ml l}^{-1}$ ) for use at all stations. To obtain higher D.O. values, local water from each station was collected. During the later stages of the cruise, we filled the gap between high and low values by oxygenating some of the Epidaurus water. During one cycle of the actual sampling for the calibration, the buoy sensor was immersed in a small bottle containing the water sample and filled with nitrogen to avoid further oxygenation of the water by stirring. At the end of each measurement, a sample of the water was analyzed for dissolved oxygen content using the Winkler method. Multivariate linear regression was used to estimate the dependence of the measurement error on DO concentration and sensor temperature [1, 2]. In order to assess temperature dependence, we submitted the water samples to a spectrum of temperatures, by using refrigeration and heat-insulated containers.

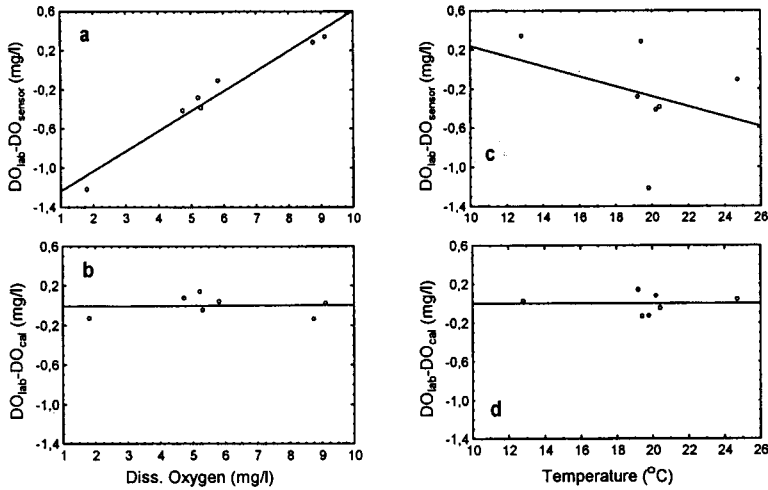


Figure 2. Dependence of measurement error on D.O. concentration (left) and sensor temperature (right), before (top) and after (bottom) the correction has been applied.

After estimation of the regression factors, we applied the corrections to the sensor's measurements and as a result, the error dependence on gas content and temperature of the seawater decreased significantly (figure 2).

### Chlorophyll- $\alpha$

Since within the euphotic zone a wide range of chl- $\alpha$  values can be observed, water from several depths was collected. Samples below the euphotic zone provided minimum values, while higher values were obtained at shallower depths. Our current calibration is well adapted to regular oligotrophic conditions of the Aegean Sea. Upon retrieval, the water samples remained under a black cover on deck for two hours to obtain ambient temperature. Subsequently, the buoy's sensor was immersed in the water sample and the fluorescence of the sample was recorded. Throughout the measurement, the sensor was covered with a black bag to avoid interference from ambient light and was constantly and gently shaken. The estimation of reference chl-a on board was performed by filtering 1.5 l of sample water through a Millipore polycarbonate membrane filter with a pore diameter 0.2  $\mu$ m. The filters were placed in plastic tubes containing 10-ml of 90% acetone. An experiment allowed us to minimize chl- $\alpha$  extraction time from the regular 12-15 hours to 3 hours. After the chl-a extraction, the samples were centrifuged and the fluorescence was measured on a very carefully calibrated TURNER AU-10 fluorometer. The fluorescence of the samples was converted to chl-a concentrations by using proper equations [3]. The concentrations of chl-a in the water samples, obtained in this way, were used for the calibration of the sensor's measurements (figure 3).

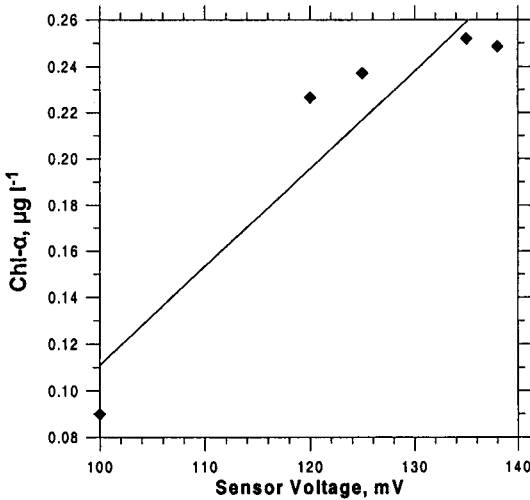


Figure 3. Correlation of Chl- $\alpha$  concentration with fluorescence sensor voltage.

## RESULTS AND DISCUSSION

After the application of the calibration equation and the deployment of the moorings, the buoys' chl-a measurements exhibit very realistic values, comparable to simultaneous lab measurements. The DO and conductivity improvements were not so impressive (mostly due to the already good calibration by the manufacturers) but were definitely promising for the next stage.

## REFERENCES

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